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Comparative Evaluation of Sealing Ability, Water Sorption, and Solubility of Two Temporary Resin-Based Restorative Materials and Zinc Oxide–Eugenol Cement: An In-Vitro Study

(Sealing Ability and Sorption of Temporary Materials)

Dr. Krishna Ajmera[1], Dr. Swapnil Kolhe[2] , Dr. Meenal Gulve[3], Dr.Surbhi Patel[4], Dr.Priyanka Kolhe[4], Dr. Shraddha Borse[5].

1. Student, Department of Conservative Dentistry and Endodontics, MGV's K.B.H Dental College and Hospital, Nashik
2. Professor, Department of Conservative Dentistry and Endodontics, MGV's K.B.H Dental College and Hospital, Nashik
3. Head of the Department, Professor, Department of Conservative Dentistry and Endodontics, MGV's K.B.H Dental College and Hospital, Nashik
4. Associate Professor, Department of Conservative Dentistry and Endodontics, MGV's K.B.H Dental College and Hospital, Nashik
5. Senior Lecturer, Department of Conservative Dentistry and Endodontics, MGV's K.B.H Dental College and Hospital, Nashik

Corresponding Author

1. Dr. Krishna Ajmera, Student, Department of Conservative Dentistry and Endodontics, M.G.V.'s K.B.H Dental College and Hospital, Nashik

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KEYWORDS

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ABSTRACT:

Introduction: Maintaining an effective coronal seal is crucial for the long-term success of root canal therapy. Temporary restorative materials are commonly placed during multi-visit endodontic procedures to prevent microbial ingress. Their effectiveness is determined not only by sealing ability but also by their resistance to water sorption and solubility.

Objectives: The present study was undertaken to compare the coronal sealing ability, water sorption, and solubility of Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement when used as temporary restorative materials.

Methods: Thirty extracted mandibular premolars were selected, and standardized access cavities were prepared. The samples were randomly allocated into three groups (n = 10) based on the material used: Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement. After thermocycling, coronal microleakage evaluation was performed using a dye infiltration technique. under a stereomicroscope. For evaluation of water sorption and solubility, thirty disc-shaped specimens (10 mm × 2 mm) were fabricated and grouped accordingly. Measurements were carried out following ISO 4049 guidelines by recording initial, saturated, and final weights.

Results: Among all groups, Group III (Zinc Oxide–Eugenol cement) demonstrated the highest coronal microleakage (mean = 2.70 ± 0.48), followed by Group II (Orafil LC) (mean = 1.50 ± 0.53), whereas Group I (Spident Temp.it) showed the least microleakage (mean = 0.30 ± 0.48).

For water sorption, Group III exhibited the highest values (mean = $8.3 \pm 0.8 \times 10^{-5}$ g/mm³), followed by Group II (mean = $6.4 \pm 0.6 \times 10^{-5}$ g/mm³), while Group I demonstrated the lowest values (mean = $3.8 \pm 0.4 \times 10^{-5}$ g/mm³).

In terms of solubility, Group III showed negative solubility (mean = $-1.3 \pm 0.2 \times 10^{-5}$ g/mm³), indicating mass gain, whereas Group II exhibited higher positive solubility (mean = $1.3 \pm 0.2 \times 10^{-5}$ g/mm³), and Group I showed the least solubility (mean = $6.0 \pm 1.0 \times 10^{-6}$ g/mm³).

Conclusions: Spident Temp.it demonstrated superior overall performance with minimal microleakage, water sorption, and solubility, followed by Orafil LC. Zinc Oxide–Eugenol cement showed comparatively inferior properties among the tested materials.

1.Introduction

Endodontic treatment primarily focuses on eliminating microbial infection from the root canal system and preventing reinfection of the periapical tissues. The success of this therapy depends not only on proper cleaning, shaping, and obturation of the canal but also on maintaining an adequate coronal seal to prevent microbial entry.[1] In clinical scenarios, completing root canal treatment in a single visit is not always feasible due to factors such as persistent infection, complex canal anatomy, or the need for intracanal medicaments. Consequently, multi-visit treatment approaches are often required.[2]

During the interval between appointments, temporary restorative materials are used to seal the access cavity. These materials serve as a protective barrier against saliva, microorganisms, and other oral contaminants while also ensuring retention of intracanal medicaments within the canal system.[3] Any compromise in the integrity of this temporary seal may lead to contamination, resulting in reinfection and adversely affecting treatment outcomes.[4]

Previous studies have reported that coronal leakage can significantly influence the success of endodontic treatment, even when the obturation is technically satisfactory.[5,6] Therefore, the effectiveness and durability of temporary restorative materials are essential for maintaining aseptic conditions during treatment procedures.[7]

An ideal temporary restorative material should exhibit adequate sealing ability, dimensional stability, resistance to dissolution, and sufficient mechanical strength to withstand intraoral conditions.[8] Zinc oxide–eugenol-based materials have been widely used due to their antimicrobial properties and ease of handling.[9] However, their tendency to disintegrate and their higher solubility in oral fluids may limit their long-term effectiveness.[10]

To overcome these limitations, resin-based temporary restorative materials have been introduced. Orafil LC, a light-cured material, offers improved marginal adaptation and reduced microleakage.[11] Spident Temp.it, being a dual-cure material, provides the additional advantage of polymerization even in areas where light penetration is limited.[12]

Despite these advancements, there is still limited literature evaluating the combined influence of sealing ability, water sorption, and solubility of these materials under standardized conditions. Hence, the present study was designed to comparatively assess these properties.

2. Objectives

1. To evaluate the coronal sealing ability of Spident Temp.it after thermocycling using the dye penetration method under stereomicroscopic evaluation.

2. To evaluate the coronal sealing ability of Orafil LC after thermocycling using the dye penetration method under stereomicroscopic evaluation.

3. To evaluate the coronal sealing ability of Zinc Oxide–Eugenol cement after thermocycling using the dye penetration method under stereomicroscopic evaluation.

4. To compare the difference in coronal sealing ability among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement after thermocycling using the dye penetration method.

5. To evaluate the water sorption of Spident Temp.it after immersion in distilled water under controlled laboratory conditions.

6. To evaluate the water sorption of Orafil LC after immersion in distilled water under controlled laboratory conditions.

7. To evaluate the water sorption of Zinc Oxide–Eugenol cement after immersion in distilled water under controlled laboratory conditions.

8. To compare the difference in water sorption among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement after immersion in distilled water.

9. To evaluate the solubility of Spident Temp.it after immersion in distilled water followed by desiccator drying under controlled laboratory conditions.

10. To evaluate the solubility of Orafil LC after immersion in distilled water followed by desiccator drying under controlled laboratory conditions.

11. To evaluate the solubility of Zinc Oxide–Eugenol cement after immersion in distilled water followed by desiccator drying under controlled laboratory conditions.

12. To compare the difference in solubility among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement after immersion in distilled water.

3. Methods

A total of 60 samples were prepared for this study. Thirty extracted human mandibular premolars were allocated for assessing coronal sealing ability, while thirty disc-shaped specimens were created to evaluate water sorption and solubility.

For the water sorption and solubility tests, the specimens were fabricated using standardized molds measuring 10 mm in diameter and 2 mm in thickness. Each material was handled precisely according to the manufacturer's guidelines. The material was carefully placed into the molds on a glass slab to ensure uniformity and reduce the entrapment of air bubbles. A cellophane strip was then positioned over the mold, and a glass slide was gently pressed on top to achieve a smooth and flat surface.

All specimens, along with the molds, were stored in an environment maintained at 37°C and 80% relative humidity for 48 hours to allow complete setting.

Groups were as follows

Group I: Spident Temp.it

Ia) Specimens evaluated for coronal sealing ability using dye penetration method

Ib) Specimens evaluated for water sorption after immersion in distilled water

Ic) Specimens evaluated for solubility after immersion in distilled water

Group II: Orafil LC

IIa) Specimens evaluated for coronal sealing ability using dye penetration method

IIb) Specimens evaluated for water sorption after immersion in distilled water

IIc) Specimens evaluated for solubility after immersion in distilled water

Group III: Zinc Oxide–Eugenol Cement

IIIa) Specimens evaluated for coronal sealing ability using dye penetration method

IIIb) Specimens evaluated for water sorption after immersion in distilled water

IIIc) Specimens evaluated for solubility after immersion in distilled water

Procedure:

Part I: Coronal Sealing Ability

Standardized access cavities were prepared, and the root canals were obturated using gutta-percha. The cavities were then restored with Spident Temp.it, Orafil LC, or Zinc Oxide–Eugenol cement. The root apices were sealed with epoxy resin, and all external surfaces were coated with nail varnish, leaving a 1 mm margin around the restoration exposed.

Specimens were stored in saline at 37°C for 7 days and subjected to thermocycling, consisting of 500 cycles between 5°C and 55°C. They were subsequently immersed in 2% methylene blue dye for 24 hours, sectioned longitudinally, and examined under a stereomicroscope at ×40 magnification.

Microleakage was evaluated using a scoring system from 0 to 3, based on the extent of dye penetration.

Part II: Water Sorption and Solubility

All disc specimens were initially dried in a desiccator at 37°C until a constant mass was obtained. The initial weight (m1) of each specimen was recorded using an analytical balance. Each sample was weighed three times, and the mean value was calculated.

The specimens were then immersed in 20 mL of distilled water at 37°C for 7 days. After immersion, the specimens were removed, gently blotted dry with absorbent paper, and weighed again to obtain the saturated mass (m2).

Following this, the specimens were reconditioned in a desiccator at 37°C until a constant mass was achieved, and the final dry weight (m3) was recorded. Each weighing was performed three times, and the mean value was calculated.

The volume (V) of each specimen was calculated using the formula:

$V = \pi R^2 h$

Water sorption (WS) and solubility (SL) were calculated using the following equations:

Water Sorption (WS) = (m2 − m3) / V
Solubility (SL) = (m1 − m3) / V

Statistical analysis

Microsoft Excel 2007/2013 was used for data coding and entry, and SPSS software (version 21.0) was used for statistical analysis. The normality of the data was assessed using the Shapiro–Wilk test. Intergroup comparisons for water sorption and solubility were performed using one-way Analysis of Variance (ANOVA) followed by a post hoc Tukey's test. Microleakage scores were analyzed using the Kruskal–Wallis test followed by Mann–Whitney U test. A p-value of less than 0.05 was considered statistically significant.

4.**Results**

According to Table 1 and Graph 1, intergroup comparison revealed that Zinc Oxide–Eugenol

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cement demonstrated the highest mean microleakage values, followed by Orafil LC, whereas Spident Temp.it exhibited the lowest microleakage. The differences among the groups were found to be statistically significant.

According to Table 2, Graph 2, and Graph 3, intragroup comparison showed that all the materials exhibited an increase in mass after immersion, indicating water sorption, followed by changes in final dry mass after desiccation. Group III (Zinc Oxide–Eugenol cement) demonstrated the highest water sorption, followed by Group II (Orafil LC), whereas Group I (Spident Temp.it) showed the least water sorption. In terms of solubility, Group II (Orafil LC) exhibited the highest values, followed by Group I (Spident Temp.it). However, Group III (Zinc Oxide–Eugenol cement) showed negative solubility, indicating a gain in mass after desiccation, which may be attributed to water absorption and retention within the material structure. The differences among the groups were found to be statistically significant.

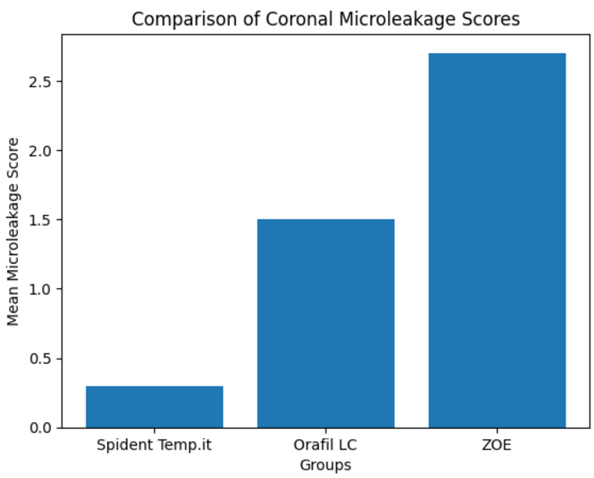
Table 1: Intergroup comparison of coronal microleakage among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement

Group	Sample Size (n)	Mean	Standard Deviation	Median
Spident Temp.it	10	0.30	0.48	0
Orafil LC	10	1.50	0.53	1.5
ZOE	10	2.70	0.48	3

Table 2: Overall intragroup comparison of water sorption and solubility in Group I (Spident Temp.it), Group II (Orafil LC), and Group III (Zinc Oxide–Eugenol cement) in terms of mean weight changes (m1, m2, and m3)

Material	Mean m1 (g)	Mean m2 (g)	Mean m3 (g)
Group I (Spident Temp.it)	0.130	0.135	0.129
Group II (Orafil LC)	0.130	0.138	0.128
Group III (ZOE)	0.130	0.145	0.132

Graph:1 Intergroup comparison of coronal microleakage among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement



Graph:2 Intergroup comparison of water sorption among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement

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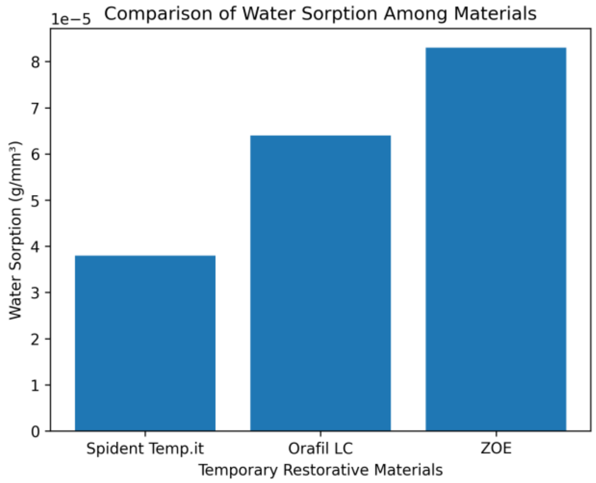
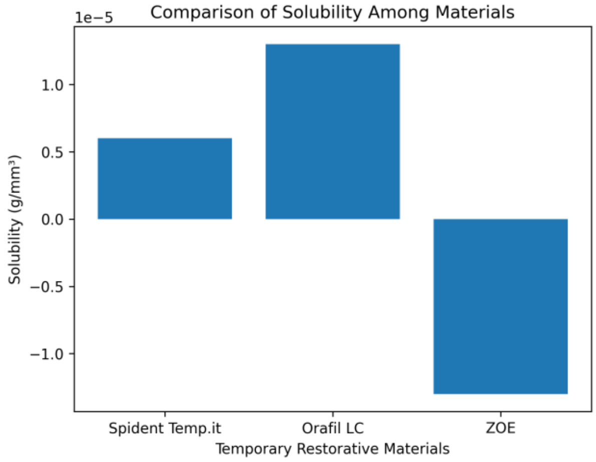


Graph: 3 Intergroup comparison of solubility among Spident Temp.it, Orafil LC, and Zinc Oxide–Eugenol cement



Amongst all experimental groups, Group III (Zinc Oxide–Eugenol cement) showed the highest coronal microleakage (Mean = 2.70 ± 0.48), followed by Group II (Orafil LC) (Mean = 1.50 ± 0.53), while Group I (Spident Temp.it) exhibited the least microleakage (Mean = 0.30 ± 0.48).

In terms of water sorption, Group III demonstrated the highest increase in mass (m2 = 0.145 g), followed by Group II (m2 = 0.138 g), whereas Group I showed the least water sorption (m2 = 0.135 g). With respect to solubility, Group II (Orafil LC) exhibited the highest solubility (m1 = 0.130 g, m3 = 0.128 g), followed by Group I (Spident Temp.it) (m1 = 0.130 g, m3 = 0.129 g).

However, Group III (Zinc Oxide–Eugenol cement) showed negative solubility (m1 = 0.130 g, m3 = 0.132 g), indicating a gain in mass after desiccation. The differences among the groups were found to be statistically significant.

5. Discussion

An ideal temporary restorative material used during endodontic procedures should provide an adequate coronal seal, resist degradation in the oral environment, demonstrate minimal water sorption and solubility, maintain dimensional stability, and tolerate occlusal forces during the inter-appointment phase.[13,14] Failure of the temporary restoration may result in microleakage, permitting the entry of saliva and microorganisms, thereby adversely affecting the outcome of root canal treatment.[15]

Coronal microleakage has been widely recognized as a key factor influencing the success of endodontic therapy. Even when obturation is performed satisfactorily, an inadequate coronal seal can allow contamination and ultimately lead to treatment failure.[16] Hence, selecting an appropriate temporary restorative material is essential to maintain aseptic conditions during multi-visit endodontic procedures.[17]

Apart from sealing ability, the physical properties of temporary restorative materials, particularly water sorption and solubility, significantly influence their clinical performance. Water sorption may cause hygroscopic expansion, which can initially enhance marginal adaptation; however, excessive absorption may weaken the material structure over time.[18] Similarly, higher solubility may lead to gradual dissolution of the material in oral fluids, resulting in marginal discrepancies and loss of seal.[19]

Zinc Oxide–Eugenol cement has long been used as a temporary restorative material due to its ease of

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handling and antimicrobial characteristics. However, it is associated with drawbacks such as increased solubility and reduced dimensional stability in moist conditions, which may compromise its long-term sealing efficiency.[20] In contrast, resin-based temporary restorative materials such as Orafil LC and Spident Temp.it have been developed to overcome these limitations by offering improved mechanical properties and enhanced resistance to dissolution.[21]

In the present study, Group I (Spident Temp.it) demonstrated the least coronal microleakage (Mean = 0.30 ± 0.48), followed by Group II (Orafil LC) (Mean = 1.50 ± 0.53), whereas Group III (Zinc Oxide–Eugenol cement) showed the highest microleakage (Mean = 2.70 ± 0.48). The superior sealing ability of Spident Temp.it may be attributed to its dual-cure mechanism, which ensures adequate polymerization even in areas with limited light penetration, thereby enhancing marginal adaptation.[22]

Regarding water sorption, Zinc Oxide–Eugenol cement showed the greatest increase in mass, followed by Orafil LC, while Spident Temp.it demonstrated the least water sorption. This may be explained by the relatively porous nature of zinc oxide–eugenol-based materials, which facilitates greater fluid uptake.[23] In contrast, resin-based materials possess a more cross-linked polymer network, resulting in reduced water absorption.[24]

In terms of solubility, Orafil LC exhibited the highest solubility, followed by Spident Temp.it. However, Zinc Oxide–Eugenol cement demonstrated negative solubility, indicating a gain in mass after desiccation. This phenomenon may be attributed to water absorption and retention within the material matrix or incomplete dehydration during the desiccation process.[25]These findings also highlight a limitation of gravimetric analysis in evaluating materials with hygroscopic behaviour.

The results of the present study are consistent with previous investigations that reported higher microleakage and water sorption in zinc oxide–eugenol-based materials compared to resin-based temporary restorative materials.[26,27] Furthermore, resin-based materials have been shown to provide improved marginal sealing and resistance to dissolution due to their superior mechanical and physical characteristics.[28]

Within the limitations of this in vitro study, it can be concluded that resin-based temporary restorative materials demonstrated better overall performance in terms of sealing ability and resistance to water sorption when compared to conventional zinc oxide–eugenol cement. Nevertheless, further clinical studies are required to validate these findings under intraoral conditions.

6.Conclusion

Within the limitations of the present study, resin-based temporary restorative materials demonstrated superior performance compared to conventional Zinc Oxide–Eugenol cement. Spident Temp.it exhibited the least coronal microleakage and water sorption, whereas Zinc Oxide–Eugenol cement showed the highest values. In terms of solubility, Orafil LC demonstrated the highest solubility, while Zinc Oxide–Eugenol cement exhibited negative solubility, indicating water absorption and retention within the material.

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