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Review Article

A COMPARATIVE EVALUATIONOF MARGINAL MICROLEAKAGEIN PROVISIONAL CROWNSCEMENTED WITH TEMPORARY LUTING CEMENT: AN IN-VITRO STUDY

Dr. Akaanksha Sharma[1*], Dr. Samarth Kumar Agarwal[2], Dr. Romil Singhal[2]

[1]MDS Third Year Student, Kothiwal Dental College and Hospital, Moradabad, Uttar Pradesh, India.

[2]Professor, Kothiwal Dental College and Hospital, Moradabad, Uttar Pradesh, India

[*]**Corresponding Author: Dr. Akaanksha Sharma,** MDS Third Year Student, Kothiwal Dental College and Hospital, Moradabad-244001, Uttar Pradesh, India **E-Mail:** akaankshasharma1@gmail.com

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ABSTRACT

Provisional restorations are essential in fixed prosthodontics as they protect prepared teeth, maintain function and esthetics, they preserve periodontal and pulpal health until definitive restoration placement. This in vitro study evaluated and compared the marginal microleakage of provisional crowns fabricated from polymethyl methacrylate (PMMA), Bis-GMA resin, and vinyl-ethyl resin when cemented with zinc oxide non-eugenol cement. Seventy-two extracted human premolars were prepared and restored with provisional crowns fabricated using the direct technique. Following cementation and thermocycling, microleakage was assessed at 7 and 15 days using methylene blue dye penetration under stereomicroscopic. All materials exhibited some degree of microleakage, which increased over time. Bis-GMA resin demonstrated the least microleakage and the best marginal seal, followed by vinyl-ethyl resin, while PMMA showed the highest Microleakage. The differences among the groups were statistically significant ($p < 0.05$). Within the limitations of this study, Bis-GMA resin provided superior marginal adaptation and sealing ability compared to the other materials tested.

Introduction

Fixed prosthodontic treatment is primarily aimed at restoring lost tooth structure, function, esthetics and patient comfort while maintaining the health of the supporting oral tissues. The success of fixed prosthodontic therapy depends not only on the definitive restoration but also on the effectiveness of the provisional phase, which serves as an important transitional stage between tooth preparation and placement of the final prosthesis[1-3]. Provisional restorations protect prepared teeth, maintain occlusal stability and function preserve periodontal health, and provide valuable information regarding esthetics, phonetics and patient comfort before fabrication of the definitive restoration[2-4].

An ideal provisional restoration should possess adequate strength, dimensional stability, acceptable esthetics and accurate marginal adaptation. Among these requirements, marginal integrity is particularly important because inadequate sealing at the tooth-restoration interface may permit the passage of bacteria, oral fluids and other substances, resulting in microleakage. Microleakage can lead to postoperative sensitivity, pulpal irritation, plaque accumulation, gingival inflammation and eventual compromise of treatment outcomes[5-7]. Therefore, the selection of a provisional restorative material with good marginal sealing ability is essential for the long-term success of fixed prosthodontic treatment[8,9].

A variety of materials are available for fabrication of provisional restorations, including polymethyl methacrylate (PMMA), bis-GMA–based resin (bis-acryl composite), polyethyl methacrylate, light-cured resins, CAD/CAM-milled materials and three-dimensional printed resins. PMMA and bis-GMA–based materials are among the most commonly used provisional materials and have been extensively investigated for their physical and biological properties[9-12].Recently, vinyl ethyl resin has emerged as a newer provisional restorative material with promising handling characteristics and dimensional stability. However, limited scientific evidence is available regarding its marginal sealing ability and resistance to microleakage when compared with established provisional materials[13-16].

The oral environment is characterized by continuous temperature fluctuations resulting from the consumption of hot and cold foods and beverages. These thermal changes may cause repeated expansion and contraction of the tooth structure, luting cement and restorative material, leading to the formation of marginal gaps and increased microleakage[17-18].Thermocycling is a widely accepted laboratory procedure used to simulate these intraoral thermal stresses and evaluate the durability and marginal integrity of restorative materials under conditions resembling the oral environment[19-20].

Although numerous studies have evaluated the microleakage behavior of PMMA and bis-GMA–based provisional materials, there is a paucity of literature regarding vinyl ethyl resin. Therefore, the present in-vitro study was undertaken to evaluate and compare the marginal microleakage of provisional crowns fabricated using PMMA, bis-GMA and vinyl ethyl resin, cemented with zinc oxide non-eugenol temporary cement, following thermocycling under standardized laboratory conditions.

MATERIALS AND METHOD

This in-vitro study was conducted on seventy-two freshly extracted human first premolars that were intact and free from caries, restorations, cracks or other structural defects. After cleaning and storage in normal saline, the teeth were mounted and ethical permission was taken from Kothiwal dental college and research centre.

All teeth were prepared for all-metal full-coverage crowns. A 0.5 mm circumferential chamfer finish line was created using a 1 mm round-end taper diamond bur, which was also used for axial reduction and smoothing of line angles. The axial walls were prepared with an approximate 6° total occlusal convergence by maintaining the handpiece parallel to the surveyor spindle and using the bur taper as a guide. The occluso-cervical height was standardized at about 4 mm, and the occlusal surface was flattened using a small wheel diamond bur.[Fig 1]

Fabrication of Provisional Crowns

The direct technique was used to fabricate provisional crowns. First, an impression of each unprepared tooth extending below the cementoenamel junction was made using polyvinyl siloxane putty in a customized tray. The samples were then divided into three groups (24 samples each) according to the provisional crown material used. The putty impressions were filled with the respective materials to fabricate the crowns.[Fig 2]

Group 1: PMMA (Polymethyl Methacrylate)

PMMA powder and liquid were mixed in a 1:2 ratio until a uniform consistency was obtained. The material was loaded into the putty impression at the dough stage and adapted onto the prepared tooth under gentle thumb pressure. After polymerization, the crown was removed, trimmed, finished and polished using acrylic trimming burs, sandpaper, pumice and a buff.

Group 2: Bis-GMA Resin

Bis-GMA resin was dispensed using an automix device and loaded into the putty impression. The impression was seated on the prepared tooth and held under gentle thumb pressure until the material reached a hard-elastic consistency. After complete polymerization, the crown was removed, trimmed, finished and polished using acrylic trimming burs and the Dentsply Enhance Finishing System to obtain a smooth, glossy surface.

Group 3: Vinyl-Ethyl Resin

Vinyl-Ethyl Resin powder and liquid were mixed in a 3:1 ratio to achieve a thick creamy consistency. The material was loaded into the impression during the rubbery stage and placed over the prepared tooth with gentle thumb pressure. After setting, the crown was removed, trimmed, finished with sandpaper and polished with pumice and a buff to achieve a smooth surface and proper contour.

Figure 1: Tooth preparation with the help of surveyor and attached custom made metal Jig

The prepared teeth were randomly divided into three groups based on the provisional restorative material used: Group I (PMMA resin), Group II (Bis-GMA resin), and Group III (Vinyl-Ethyl resin). Provisional crowns were fabricated using the direct technique with a standardized matrix and were then finished and polished according to the manufacturers' instructions.[Fig 3]

All provisional crowns were cemented using zinc oxide non-eugenol temporary luting cement. To ensure standardized cementation, a 10 kg axial load was applied using a universal testing machine. Excess cement was removed, and the specimens were stored under controlled conditions.

Figure 2: Axial loading of 10 Kgs during cementation with the help of universal testing machine

To simulate temperature changes in the oral cavity, all samples underwent thermocycling between 5°C and 55°C. This reproduced the thermal stresses caused by hot and cold foods and beverages. After thermocycling, the specimens were divided into 7-day and 15-day evaluation groups.

The entire tooth surface, except the restoration margins, was coated with nail varnish and immersed in methylene blue dye for 24 hours. The specimens were then sectioned buccolingually and mesiodistally using a diamond disc and examined under a stereomicroscope to assess dye penetration. [Fig 4]Microleakage was scored according to theTjan et al. scoring system.[Fig 5]

- Score 0: No leakage.
- Score 1: Leakage up to one-third of the axial wall.
- Score 2: Leakage up to two-thirds of the axial wall.
- Score 3: Leakage along the full length of the axial wall.
- Score 4: Leakage over the occlusal surface.

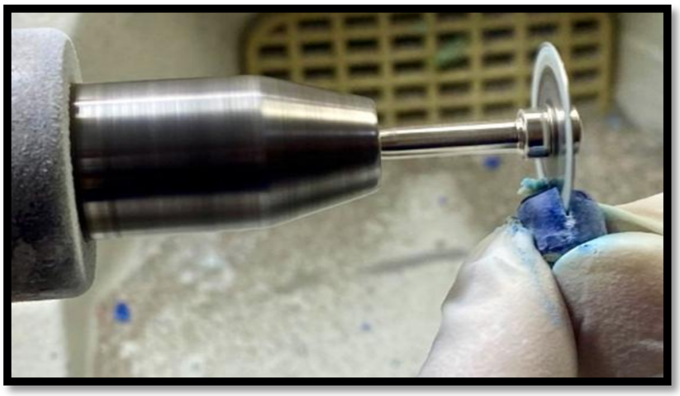
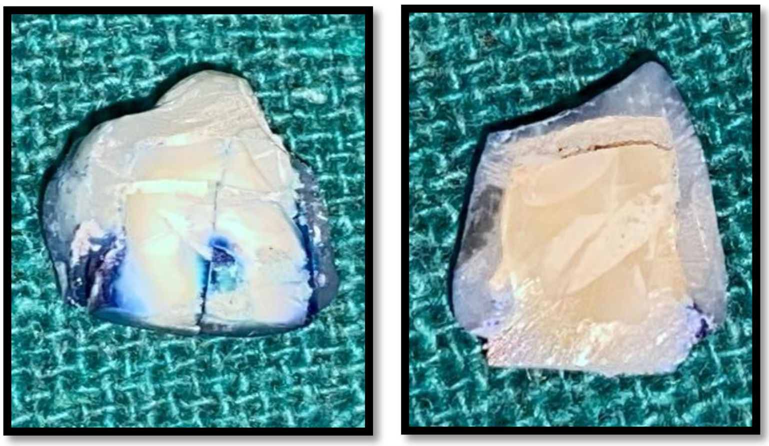


Figure 3: Sectioning of the sample with the help of diamond cutting bur



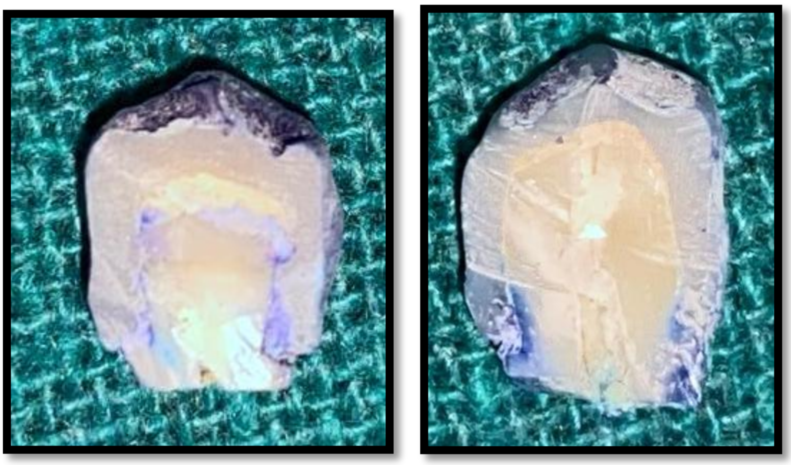


Figure 4: Sectioned samples in mesiodistal and buccolingual direction

The collected data were analyzed using SPSS software. Chi-square tests were used to compare microleakage among the groups, with statistical significance set at $p < 0.05$.

RESULTS

The results demonstrated that all provisional materials exhibited some degree of marginal microleakage at both 7-day and 15-day evaluation periods. However, significant differences were observed among the materials tested.

At the 7-day interval, PMMA showed the highest level of microleakage in both buccolingual and mesiodistal sections. [Table 1] Most specimens exhibited moderate dye penetration, indicating compromised marginal adaptation. Bis-GMA resin demonstrated the least microleakage, with the majority of specimens showing either no leakage or minimal dye penetration. Vinyl-ethyl resin displayed intermediate performance, showing better sealing ability than PMMA but slightly inferior results compared to Bis-GMA.

Table 1: Comparison of microleakage between three groups at 7 days time interval

	PMMA (Group-1 A)		BIS -GMA (Group-2 A)		Vinyl- ethyl resin (Group-3 A)		χ^2	p Value
	Frequency	Percent	Frequency	Percent	Frequency	Percent	24.5	<0.01*
GRADE - 0	0	0.0	10	83.3	6	50		
GRADE - 1	2	16.7	2	16.7	4	33.3		
GRADE - 2	10	83.3	0	0.0	2	16.7		

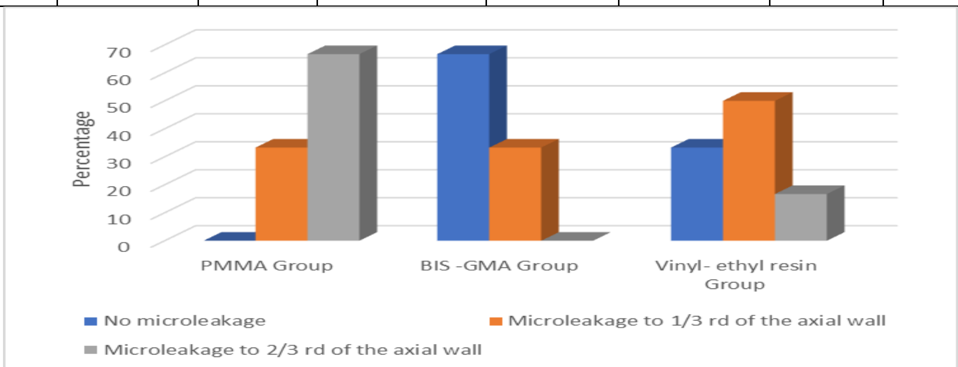


Figure 5: Showing the microleakage among each group at 7 days

At the 15-day interval, microleakage increased in all groups. PMMA exhibited severe leakage, with many specimens showing extensive dye penetration toward the axial walls. [Table 2] Vinyl-ethyl resin also demonstrated an increase in leakage over time but maintained better marginal integrity than PMMA. Bis-GMA continued to show the least microleakage and maintained superior marginal adaptation despite thermal aging.[Fig 6]

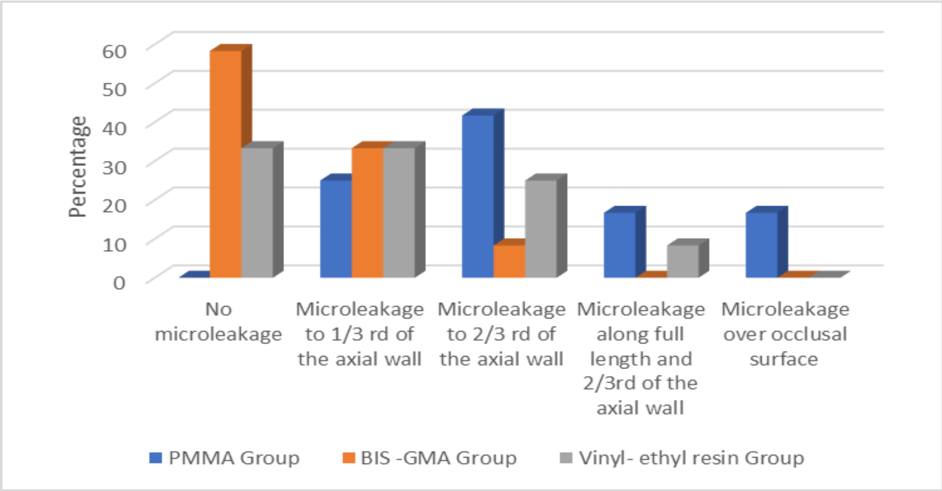


Figure 6: clearly depicts the superior performance of Bis-GMA (Group- 2 B) and the heavy leakage associated with PMMA (Group -1 B) with an intermediate performance exhibited by vinyl ethyl resin group (Group -3 B).

Table 2: Comparison of microleakage between three groups at 15 days time interval

	PMMA (Group-1 B)		BIS -GMA (Group-2 B)		Vinyl- ethyl resin (Group-3 B)		χ^2	p Value
	Frequency	Percent	Frequency	Percent	Frequency	Percent	15.57	0.04*
GRADE - 0	0	0.0	7	58.3	4	33.3		
GRADE - 1	3	25.0	4	33.3	4	33.3		
GRADE - 2	5	41.7	1	8.3	3	25.0		
GRADE - 3	2	16.7	0	0.0	1	8.3		
GRADE - 4	2	16.7	0	0.0	0	0.0		

Statistical analysis confirmed significant differences among the three groups at both evaluation intervals. Intergroup comparisons revealed that PMMA differed significantly from Bis-GMA and vinyl-ethyl resin, while Bis-GMA also demonstrated significantly better performance than vinyl-ethyl resin at several evaluation points.

Overall, the ranking of materials from best to worst marginal sealing ability was Bis-GMA resin, vinyl-ethyl resin, and PMMA.

DISCUSSION

Provisional restorations play an important role in fixed prosthodontic treatment by protecting prepared teeth, maintaining pulpal and periodontal health, preserving occlusion, and providing esthetics and patient comfort until the definitive restoration is delivered[2,6,7]. One of the most important requirements of a provisional restoration is adequate marginal adaptation, as poor marginal sealing can result in bacterial penetration, pulpal irritation, plaque accumulation, gingival inflammation, and treatment failure[8-10]. Therefore, the present in vitro study was conducted to evaluate and compare the microleakage of three provisional restorative materials: PMMA, Bis-GMA resin, and Vinyl-Ethyl resin.

PMMA has been widely used for provisional restorations because of its low cost and ease of fabrication. However, previous studies have reported that PMMA is associated with polymerization shrinkage, exothermic reaction, and dimensional instability, which can negatively affect marginal adaptation[5,12,14,17]. In contrast, Bis-GMA–based materials have gained popularity due to their reduced polymerization shrinkage, improved handling properties, and better dimensional stability[16,18,19].Vinyl-Ethyl resin is a relatively less explored material, and therefore its inclusion in the present study helped provide additional information regarding its clinical performance.

To simulate routine clinical practice, provisional crowns were fabricated using the direct technique. This technique is commonly used because it is simple, economical, and time-efficient[20,21].Standardization of tooth preparation was achieved using a dental surveyor to minimize variations among samples. Thermocycling between 5°C and 55°C was performed to simulate thermal changes occurring in the oral cavity, as previous studies have shown that thermal stresses can increase marginal leakage[21-23].

The results of the present study showed significant differences among the tested materials. At the 7-day evaluation period, PMMA demonstrated the highest microleakage on both buccolingual and mesiodistal surfaces. These findings are consistent with studies by Hung et al., Ehrenberg et al., Barghi and Simmons, and Robinson and Hovijitra, who reported greater marginal discrepancies and leakage in PMMA provisional restorations[5,12,14,17]. The increased leakage may be attributed to polymerization shrinkage and dimensional changes occurring during setting.

Bis-GMA resin exhibited the least microleakage and the best marginal adaptation at 7 days. Similar findings have been reported by Young et al., Arora et al., Baldissara et al., and Patel et al., who observed superior marginal sealing and dimensional stability in Bis-GMA–based provisional materials[8,15,18,21]. The improved performance of Bis-GMA may be due to its cross-linked polymer structure and lower polymerization shrinkage, which help maintain a better marginal seal.

Vinyl-Ethyl resin showed intermediate microleakage values, performing better than PMMA but slightly inferior to Bis-GMA resin. Although limited literature is available on this material, the present findings suggest that it provides acceptable marginal adaptation and may serve as a suitable alternative for provisional restorations.

At the 15-day evaluation, all materials showed an increase in microleakage, indicating that marginal deterioration increases with time. Similar observations have been reported by Hung et al. and Lewinstein et al., who attributed the increase in leakage to water sorption, thermal stresses, cement dissolution, and dimensional changes occurring during aging[24]. PMMA showed the greatest increase in leakage, while Bis-GMA maintained the best marginal integrity throughout the study period. Vinyl-Ethyl resin continued to demonstrate intermediate performance.

The mesiodistal surfaces generally exhibited greater microleakage than the buccolingual surfaces, particularly after 15 days. Although the exact reason for this observation remains unclear, it may be related to variations in crown adaptation or stresses generated during polymerization and thermocycling.

Within the limitations of this in vitro study, Bis-GMA resin demonstrated the best marginal sealing ability and the lowest microleakage, followed by Vinyl-Ethyl resin, while PMMA showed the highest microleakage at both evaluation periods. These findings suggest that Bis-GMA–based materials may be the preferred choice for long-term provisional restorations, whereas Vinyl-Ethyl resin may be considered a suitable alternative for short- to medium-term use. Further clinical studies with longer observation periods are recommended to confirm these findings under actual oral conditions.

Conclusion

1. Microleakage was found to be both material-dependent and time-dependent, with an increase in microleakage observed as the aging period increased. Marginal microleakage was greater on the mesiodistal surfaces than on the buccolingual surfaces for all materials tested, highlighting the importance of careful marginal adaptation in these areas.
2. Based on the findings of this study, selection of provisional crown materials should consider their marginal sealing ability, especially when long-term provisionalization is anticipated.
3. Bis-GMA resin demonstrated the least microleakage at both time intervals, indicating superior marginal sealing ability. Therefore, it is recommended for intermediate- to long-term provisional restorations.
4. Vinyl-ethyl resin showed a moderate level of microleakage and may be considered a suitable alternative for intermediate-term provisional crowns.
5. PMMA exhibited the highest microleakage at both 7 and 15 days, with a greater increase over time. Hence, its use should preferably be limited to short-term provisional restorations.

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