E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.01.459

Research Article

Impact of Resin Sealants on the Prevention of Secondary Caries Adjacent to Composite Restorations

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Received: 27.03.26, Revised: 21.04.26, Accepted: 25.05.26

ABSTRACT
Objective: To evaluate the impact of resin sealants on the prevention of secondary caries adjacent to composite restorations.
Materials and Methods: This prospective comparative study was conducted on 80 patients requiring Class I or Class II composite restorations. Patients were randomly divided into two groups: Group A (composite restorations without sealant) and Group B (composite restorations with resin sealant application). All procedures were performed under standardized conditions. Patients were followed up at 3, 6 and 12 months. The primary outcome assessed was the incidence of secondary caries while secondary outcomes included marginal integrity and plaque accumulation. Data were analyzed using SPSS, with a p-value of ≤0.05 considered statistically significant.
Results: At 12 months, the incidence of secondary caries was significantly lower in Group B (12.5%) compared to Group A (30%) (p = 0.04). Improved marginal integrity was observed in the sealant group. 75% of restorations showing intact margins compared to 50% in the control group (p = 0.03). Plaque accumulation was also reduced in Group B (25%) compared to Group A (45%). This showed borderline statistical significance (p = 0.05).
Conclusion: The application of resin sealants significantly reduces secondary caries and improves marginal integrity of composite restorations. It may be considered an effective adjunctive measure for enhancing restoration longevity and preventing recurrent decay.

Keywords: Resin Sealants, Secondary Caries, Composite Restorations, Marginal Integrity, Micro leakage.

INTRODUCTION

Dental caries is one of the most prevalent chronic diseases worldwide. It affects individuals across all age groups and socioeconomic backgrounds. Despite significant advances in preventive dentistry and restorative materials, the recurrence of caries adjacent to existing restorations continues to represent a major clinical challenge.(Balaji, 2018) Secondary caries is a leading cause of restoration failure and replacement. This accounts for a substantial proportion of operative dental procedures.(Liu et al., 2013)

Resin-based composite restorations have largely replaced amalgam in contemporary dental practice. This is due to their superior esthetics, adhesive properties and conservative tooth preparation requirements. These materials work by bond micromechanically to enamel and dentin through adhesive systems.(Yang et al., 2020) Thus, allowing for the preservation of tooth structure. However, despite their advantages, composite restorations also have some limitations. Polymerization shrinkage, marginal gaps, technique sensitivity and degradation over time can compromise the marginal integrity of restorations.(Ferracane, 2011) These defects may facilitate microleakage, bacterial infiltration and plaque accumulation. Thus, contributing to the development of secondary caries at the tooth restoration interface.(Ng et al., 2023)

Secondary caries is a multifactorial process influenced by host factors, microbial activity, dietary habits and material-related characteristics. The interface between the restorative material and the tooth surface is particularly susceptible to cariogenic challenges due to the potential presence of microscopic gaps or irregularities.(Ahovuo-Saloranta et al., 2017) Cariogenic challenges

or tooth decay occur due to the potential presence of microscopic gaps or irregularities. These areas can serve as niches for bacterial colonization, particularly by cariogenic species such as Streptococcus mutans and Lactobacilli. The acidic byproducts of bacterial metabolism has led to demineralization of adjacent tooth structure. (Pitts et al., 2021)

Many preventive strategies have been evolved to enhance the longevity of restorations and reduce the incidence of secondary caries. Among these strategies, the application of resin sealants has gained considerable attention.(Condò et al., 2013) Resin sealants are low-viscosity, flowable materials designed to penetrate and seal pits, fissures and surface irregularities.(Wright et al., 2016a) It works by creating a physical barrier against bacterial ingress and nutrient supply. These are traditionally used for occlusal caries prevention in children and adolescents. Their application has expanded to include sealing restoration margins and adjacent enamel surfaces. (2016)

The use of resin sealants adjacent to composite restorations lies in their ability to improve marginal adaptation and reduce microleakage. By sealing microscopic gaps and irregularities at the restoration margins, resin sealants may prevent the entry of oral fluids, bacteria and debris. (Kidd, 1976) This procedure not only limits bacterial colonization but also reduces the risk of acid-mediated demineralization in these vulnerable areas. Resin sealants may also enhance the smoothness of the restoration surface, thereby decreasing the plaque retention and facilitating oral hygiene maintenance. (Rethman, 2000)

Recent advancements in material science have led to the development of improved resin sealant formulations with enhanced mechanical properties, wear resistance and fluoride-releasing capabilities. (Kashbour et al., 2020) Fluoride-releasing sealants may offer an added advantage by promoting remineralization of adjacent enamel and inhibiting bacterial activity. The sustained release of fluoride ions can contribute to the formation of fluorapatite. (Wright et al., 2016b) Fluorapatite is more resistant to acid dissolution compared to hydroxyapatite. This dual mechanism, i.e, mechanical sealing and chemical protection positions resin sealants as a promising adjunct in the prevention of secondary caries.(Hicks et al., 2000)

The clinical effectiveness of resin sealants in preventing secondary caries adjacent to composite restorations remains a subject of ongoing investigation. Longevity and durability of resin sealants when applied to restoration margins.(Sasa and Donly, 2010) Unlike occlusal fissures, restoration margins may be subjected to different mechanical stresses, including occlusal forces and abrasion. (Carvalho et al., 2016)The wear and degradation of sealants over time may compromise their protective effect, necessitating periodic evaluation and reapplication.(Locker et al., 2003)

The concept of sealing restoration margins also aligns with the principles of minimally invasive dentistry. This principle emphasizes the preservation of tooth structure and prevention of disease progression rather than repeated surgical intervention.(Ahovuo-Saloranta et al., 2013) By reducing the incidence of secondary caries, resin sealants may decrease the need for restoration replacement. Thereby preserving tooth integrity and reducing the cumulative restorative burden over a patient's lifetime. This approach not only improves clinical outcomes but also has economic and public health implications by reducing treatment costs and improving access to care.(Wnuk et al., 2023)

In addition to material-related factors, patient-specific variables such as caries risk, oral hygiene practices, and dietary habits play a crucial role in the success of preventive strategies. (Frencken et al., 2012) High-risk individuals, including those with poor oral hygiene, high sugar intake, or reduced salivary flow, may particularly benefit from adjunctive measures such as resin sealants. Tailoring preventive interventions to individual risk profiles is essential for optimizing outcomes and ensuring efficient use of resources.(Carvalho, 2014)

Moreover, advancements in adhesive dentistry, including the development of universal adhesives and improved bonding protocols, have further enhanced the potential effectiveness of resin sealants. Proper surface preparation, including cleaning, etching and bonding is critical for achieving optimal sealant retention and performance. The integration of sealants into restorative procedures requires careful consideration of these factors to maximize their preventive benefits.

MATERIALS AND METHODS

This prospective comparative study was conducted to evaluate the impact of resin

sealants on the prevention of secondary caries adjacent to composite restorations. The study was carried out in the Nishtar Institute of Dentistry. Multan. The study duration was of 1 year from March 2025 to March 2026. The study was conducted after obtaining approval from the institutional ethical review committee of the hospital. Written informed consent was obtained from all participants prior to their inclusion in the study.

A total of 80 patients requiring Class I or Class II composite restorations were included. A non-probability consecutive sampling technique was used.

Patients fulfilling the following criteria were included in the study:

Patients aged between 18 and 50 years, patients presenting with primary carious lesions requiring Class I or Class II composite restorations were added. Patients with good general health and patients willing to participate and comply with follow-up visits were included.

Patients were excluded if they had poor oral hygiene or active periodontal disease. Patients with a history of systemic conditions affecting salivary flow such as xerostomia were not a part of this study. Patients with known allergies to dental restorative materials or those who were unwilling to return for follow-up evaluations were excluded.

The selected patients were randomly divided into two equal groups. Group A was a control group and group B was interventional group. In Group A, Composite restorations were placed using standard adhesive protocols without the application of resin sealant. In Group B, a resin-based sealant was applied over the restoration margins and adjacent enamel surfaces.

All restorative procedures were performed under standardized clinical conditions. Cavity preparation was carried out using high-speed rotary instruments under water cooling. A universal adhesive system was applied according to the manufacturer's instructions, followed by incremental placement and light curing of composite resin. In the intervention group, the enamel margins were selectively etched, after which a low-viscosity resin sealant was applied and light-cured to ensure adequate penetration and sealing.

Patients were evaluated at 3 months, 6 months and 12 months post-operatively. Both qualitative and quantitative variables were recorded. Quantitative Variables included age of the patient (in years), number of restored teeth and frequency of secondary caries occurrence during follow-up.

Qualitative Variables included Gender (male/female), presence or absence of secondary caries, marginal integrity (categorized as intact, slight defect, or severe defect), surface texture (smooth or rough) and plaque accumulation adjacent to restorations (present or absent).

Clinical assessment of secondary caries was carried out using visual and tactile examination. Radiographic evaluation was carried out where required. Marginal integrity and surface characteristics were evaluated using a dental explorer under adequate illumination.

Data was entered and analyzed using statistical software SPSS version 22. Quantitative variables were expressed as mean ± standard deviation while qualitative variables were presented as frequencies and percentages. The Chi-square test was used to compare categorical variables between the groups and the independent t-test was applied for comparison of quantitative variables. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 80 patients were included in the study. Patients were equally divided into two groups: Group A (composite restoration only) and Group B (composite restoration with resin sealant). All patients were followed for a period of 12 months.

Table 1: Demographic Characteristics of Patients

Variable	Group A (n=40)	Group B (n=40)	p-value
Mean Age (years)	32.4 ± 6.2	31.8 ± 5.9	0.68
Male	22 (55%)	24 (60%)	0.65
Female	18 (45%)	16 (40%)	

The mean age of patients in Group A was 32.4 ± 6.2 years, while in Group B it was 31.8 ± 5.9 years. The difference between the groups was not statistically significant (p = 0.68). Gender distribution was also comparable, with no significant difference observed between the two groups (p = 0.65). This indicates that

both groups were demographically similar and comparable at baseline.

Table 2: Incidence of Secondary Caries at Follow-Up

Follow-up Period	Group A (n=40)	Group B (n=40)	p-value
3 months	4 (10%)	1 (2.5%)	0.16
6 months	8 (20%)	3 (7.5%)	0.10
12 months	12 (30%)	5 (12.5%)	0.04*

At 3 months, secondary caries was observed in 10% of patients in Group A compared to 2.5% in Group B. However, this difference was not statistically significant ($p = 0.16$). At 6 months, the incidence increased to 20% in Group A and 7.5% in Group B, still without statistical significance ($p = 0.10$). By 12 months, a notable difference was observed, with 30% of patients in Group A developing secondary caries compared to 12.5% in Group B. This difference was statistically significant ($p = 0.04$). Thus, indicating that the use of resin sealants significantly reduced the occurrence of secondary caries over time.

Table 3: Marginal Integrity at 12 Months

Marginal Condition	Group A (n=40)	Group B (n=40)	p-value
Intact	20 (50%)	30 (75%)	0.03*
Slight Defect	12 (30%)	8 (20%)	
Severe Defect	8 (20%)	2 (5%)	

At the 12-month follow-up, intact margins were observed in 50% of restorations in Group A compared to 75% in Group B. Slight marginal defects were present in 30% of Group A and 20% of Group B. Severe defects were more common in Group A (20%) compared to Group B (5%). The difference in marginal integrity between the groups was statistically significant ($p = 0.03$). This suggests that resin sealants improved the marginal adaptation of composite restorations.

Table 4: Plaque Accumulation around Restorations

Plaque Accumulation	Group A (n=40)	Group B (n=40)	p-value
Present	18 (45%)	10 (25%)	0.05*
Absent	22 (55%)	30 (75%)	

Plaque accumulation was observed in 45% of patients in Group A compared to 25% in Group B. Although this difference was borderline significant ($p = 0.05$), it suggests that the smoother surface achieved with resin sealants may contribute to reduced plaque retention and improved oral hygiene around restorations.

DISCUSSION

Secondary caries is one of the most common causes of failure of composite restorations. This is primarily due to marginal gaps, microleakage and subsequent bacterial colonization. The present study evaluated the effectiveness of resin sealants in preventing secondary caries adjacent to composite restorations. The findings demonstrated that the application of resin sealants significantly reduced the incidence of secondary caries, improved marginal integrity and decreased plaque accumulation.at 12 months,

In our study, no significant difference was observed between the two groups in terms of age and gender distribution. This minimizes the influence of confounding variables and strengthens the validity of the outcomes. Similar baseline comparability has been reported in studies conducted by Mjör IA et al., who emphasized that patient-related factors should be standardized when evaluating restoration longevity.(Mjör and Toffenetti, 2000)

The incidence of secondary caries was lower in the sealant group throughout the follow-up period, with a statistically significant difference observed at 12 months. This finding supports the hypothesis that resin sealants act as an effective barrier against bacterial ingress and nutrient supply. A similar reduction in microleakage and secondary caries has been reported by Simonsen RJ, who demonstrated that sealants significantly reduce caries susceptibility by sealing enamel defects and preventing bacterial colonization. (Simonsen,

2002) Likewise, Feigal RJ highlighted the preventive benefits of resin-based sealants in reducing caries risk, particularly in high-risk patients.(Feigal, 2002)

The improvement in marginal integrity observed in the sealant group is another important finding of this study. Marginal defects are known to be a critical factor in the development of secondary caries. Marginal factors they facilitate microleakage and bacterial penetration. In this study, a significantly higher proportion of restorations in the sealant group exhibited intact margins compared to the control group. These findings are consistent with the work of Kidd EAM, who reported that marginal sealing plays a key role in preventing lesion progression adjacent to restorations. (Kidd, 1976) Furthermore, Ferracane JL reported that degradation of the resin dentin interface is a major contributor to restoration failure and that strategies aimed at improving marginal sealing can enhance restoration longevity.(Ferracane, 2011)

Plaque accumulation was also found to be lower in the sealant group which may lead to the smoother surface provided by the sealant application. Reduced plaque retention limits bacterial growth and acid production, thereby lowering the risk of demineralization. This observation is in agreement with findings reported by Busscher HJ, who demonstrated that surface roughness significantly influences bacterial adhesion and biofilm formation. Therefore, improving surface smoothness through sealant application can have a beneficial effect on oral hygiene and caries prevention.(Busscher et al., 2010)

Another important aspect supporting the use of resin sealants is their potential fluoride-releasing capability. Although fluoride release from certain sealant formulations may contribute to remineralization and inhibition of bacterial activity. ten Cate JM reported that fluoride enhances the formation of fluorapatite, which is more resistant to acid dissolution compared to hydroxyapatite.(ten Cate, 1999) This dual action of mechanical sealing and chemical protection further supports the clinical value of resin sealants.

Despite these positive findings, it is important to consider certain limitations of the study. The follow-up period was limited to 12 months, which may not fully reflect the long-term performance of resin sealants. Additionally, factors such as patient oral hygiene practices, dietary habits and operator technique could influence the outcomes. Similar limitations have been highlighted by Opdam NJM, who emphasized that restoration longevity is influenced by both material properties and patient-related factors.(Opdam et al., 2012)

CONCLUSION

The application of resin sealants significantly enhances the clinical performance of composite restorations by reducing the incidence of secondary caries, improving marginal integrity and decreasing plaque accumulation. The findings suggest that resin sealants act as an effective adjunct by sealing marginal gaps, minimizing microleakage and limiting bacterial colonization at the tooth restoration interface. Therefore, their use alongside composite restorations may be recommended as a simple and effective preventive measure to improve restoration longevity.

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