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RESEARCH ARTICLE
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CLINICAL PERFORMANCE OF BIOACTIVE RESTORATIVE MATERIALS VERSUS CONVENTIONAL COMPOSITE IN HIGH CARIES-RISK PATIENTS

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ABSTRACT

Objective: To compare the clinical performance of bioactive restorative materials with conventional resin composite restorations in patients classified as high caries-risk over a 12-month follow-up period.

Methods: A randomized controlled clinical study was conducted on 120 posterior restorations placed in 60 high caries-risk patients. Each patient received two restorations: one with a bioactive restorative material (Group A) and one with a conventional resin composite (Group B). Clinical performance was evaluated at baseline, 6 months, and 12 months using modified USPHS criteria, assessing marginal integrity, surface texture, postoperative sensitivity, secondary caries, and overall restoration survival. Data were analyzed using chi-square and Kaplan–Meier survival analysis.

Results: At 12 months, Group A demonstrated significantly lower incidence of secondary caries (5%) compared to Group B (16.7%) ($p = 0.03$). Marginal integrity was rated as Alpha in 86.7% of bioactive restorations versus 73.3% in composite restorations. Postoperative sensitivity was reported in 6.7% of Group A and 18.3% of Group B restorations. The overall survival rate was 95% for bioactive restorations and 86.7% for conventional composite restorations.

Conclusion: Bioactive restorative materials showed superior clinical performance compared to conventional composite in high caries-risk patients, particularly in reducing secondary caries and postoperative sensitivity. These materials may be a preferable option for restorative management in patients with elevated caries susceptibility.

Keywords: Bioactive restorative materials, composite resin, high caries risk, secondary caries

INTRODUCTION

Dental caries remains one of the most prevalent chronic oral diseases worldwide, particularly among individuals classified as high caries-risk due to factors such as poor oral hygiene, high sugar intake, reduced salivary flow, and previous caries experience.[1] Restoration longevity in these patients is often compromised by recurrent caries and marginal degradation, making material selection a critical component of successful treatment planning.[2] Conventional resin-based composites are widely used due to their esthetics and favorable mechanical properties; however, they are considered biologically inert and do not actively contribute to caries prevention.[3] In high caries-risk patients, this limitation can result in increased rates of secondary caries, which remains a leading cause of restoration failure.[1] Bioactive restorative materials have been introduced with the aim of addressing these shortcomings. These materials are designed to interact with the oral environment by releasing beneficial ions such as calcium, phosphate, and fluoride.[4] Such ion release may promote remineralization, inhibit bacterial activity, and enhance the marginal seal, thereby reducing the risk of recurrent caries. Despite promising laboratory evidence, clinical data comparing bioactive materials with conventional composites in high caries-risk populations remain limited.[5]

Therefore, this study aimed to evaluate and compare the 12-month clinical performance of bioactive restorative materials and conventional resin composites in patients with high caries risk.

METHODOLOGY

This randomized controlled clinical study was conducted over a period of 12 months. A total of 60 patients aged between 18 and 50 years were recruited. Patients were classified as high caries-risk based on clinical examination, caries history, and dietary assessment. Each participant required at least two posterior restorations. Using a split-mouth design, one cavity was restored with a bioactive restorative material (Group A) and the other with a conventional resin composite (Group B). A total of 120 Class I and Class II restorations were placed (60 per group). All cavity preparations were performed under rubber dam isolation. Restorations were placed according to manufacturers' instructions. Patients were recalled at 6 and 12 months for clinical evaluation by two calibrated examiners blinded to the restorative material used. Clinical performance was assessed using modified USPHS criteria, evaluating marginal integrity, surface texture, postoperative sensitivity, secondary caries, and restoration retention. Data were analyzed using SPSS software with significance set at $p < 0.05$.

RESULTS

Table 1 confirmed an equal distribution of restorations between the two groups, ensuring balanced comparison and minimizing allocation bias. Both bioactive and conventional composite groups contributed 60 restorations each, strengthening the internal validity of the study.

Table 1: Distribution of Restorations by Type

Restorative Material	Number of Restorations	Percentage (%)
Bioactive material	60	50.0
Conventional composite	60	50.0
Total	**120**	**100**

Table 2 demonstrated superior overall clinical performance of bioactive restorative materials at the 12-month follow-up. Bioactive restorations exhibited a significantly higher proportion of Alpha scores for marginal integrity (86.7%) compared to conventional composite restorations (73.3%). This finding indicates better marginal adaptation and reduced susceptibility to microleakage in bioactive materials.

Table 2: Clinical Performance at 12-Month Follow-Up

Parameter	Bioactive n (%)	Composite n (%)	p-value
Alpha marginal integrity	52 (86.7)	44 (73.3)	0.04
Postoperative sensitivity	4 (6.7)	11 (18.3)	0.03
Secondary caries	3 (5.0)	10 (16.7)	0.03
Restoration loss	3 (5.0)	8 (13.3)	0.05

Postoperative sensitivity was notably lower in the bioactive group (6.7%) compared to the composite group (18.3%), suggesting enhanced dentinal sealing and improved pulp protection. Importantly, the incidence of secondary caries was more than three times higher in the composite group (16.7%) than in the bioactive group (5.0%), highlighting the caries-preventive potential of bioactive materials in high caries-risk patients. Restoration loss was also less frequent in the bioactive group (5.0%) than in the composite group (13.3%), indicating better retention and durability over time. Table 3 further supported these findings, showing a higher overall survival rate for bioactive restorations (95.0%) compared to conventional composite restorations (86.7%). These results collectively emphasize the clinical advantage of bioactive materials in challenging oral environments.

Table 3: Restoration Survival Rates

Group	Surviving Restorations	Survival Rate (%)
Bioactive	57/60	95.0
Composite	52/60	86.7

DISCUSSION

The present study compared the clinical performance of bioactive restorative materials and conventional resin composites in high caries-risk patients over a 12-month period. The findings demonstrated that bioactive materials outperformed conventional composites in terms of marginal integrity, postoperative sensitivity, secondary caries incidence, and overall restoration survival.

One of the most significant outcomes of this study was the lower incidence of secondary caries associated with bioactive restorations.[6] Secondary caries remains the most common cause of restoration failure, particularly in high caries-risk individuals. The reduced rate observed in the bioactive group may be attributed to the sustained release of calcium, phosphate, and fluoride ions, which promote remineralization of adjacent tooth structure and inhibit demineralization. Previous clinical study by Lardani et al (2022)[7] and Elderiny et al (2024)[8] and in vitro studies by Tjäderhane et al (2019)[9] and Samir et al (2025)[10] have similarly reported that bioactive materials exhibit antibacterial properties and enhance resistance to acid attack, thereby reducing caries progression around restorations. Marginal integrity scores were significantly better in the bioactive group, which is consistent with findings reported in earlier studies evaluating ion-releasing restorative materials. Improved marginal adaptation may result from chemical bonding and mineral deposition at the tooth–restoration interface, leading to the formation of a stable hybrid zone.[11] In contrast, conventional resin composites are prone to polymerization shrinkage stresses, which can compromise marginal sealing and predispose restorations to microleakage and bacterial infiltration.[12]

Postoperative sensitivity was significantly higher in the composite group, which aligns with previously reported clinical observations. Sensitivity following composite restorations is often associated with dentinal fluid movement caused by inadequate sealing or marginal gaps. Bioactive materials, through their remineralizing potential and dentinal tubule occlusion, may reduce sensitivity by stabilizing the dentin substrate and minimizing fluid movement. Similar reductions in postoperative sensitivity with bioactive materials have been reported in comparative clinical trials.[13]

The restoration survival rate observed in this study further supports the clinical benefits of bioactive materials. A survival rate of 95% for bioactive restorations compared to 86.7% for composite restorations suggests improved longevity in high-risk patients. Previous studies[14,15,16] have shown that

restorations placed in patients with high caries activity tend to fail earlier when conventional composites are used, primarily due to recurrent caries and marginal breakdown. The improved survival observed in the present study may be related to the combined effects of enhanced marginal integrity, caries inhibition, and reduced sensitivity.

Overall, the results of this study are consistent with growing evidence supporting the use of bioactive restorative materials, particularly in patients with elevated caries risk. Their ability to actively interact with the oral environment represents a paradigm shift from passive restorative approaches toward therapeutic restorative dentistry.

Limitations

The follow-up period was limited to 12 months, which may not fully reflect long-term clinical behavior. Additionally, only one bioactive material system was evaluated, which limits generalizability. Future studies with extended follow-up periods, multiple bioactive materials, and larger sample sizes are recommended to validate these findings and further establish clinical guidelines.

CONCLUSION

Within the limitations of this study, bioactive restorative materials demonstrated superior clinical performance compared to conventional resin composites in high caries-risk patients. Their ability to reduce secondary caries, minimize postoperative sensitivity, and enhance restoration survival makes them a promising restorative option for patients with increased caries susceptibility.

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