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Investigating the Causes of Failure in Posterior Amalgam and Composite Restorations: A Cross-Sectional Study

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A B S T R A C T

Introduction: Understanding the reasons for retreatment of dental restorations is crucial to preventing potential tooth failure. Due to limited information on retreatment causes in our region, this study aims to compare the factors leading to the failure of posterior amalgam and composite restorations.

Materials & Methods: This cross-sectional, observational study was conducted on patients referred to the restorative department of Ilam Faculty of Dentistry and private clinics who required retreatment of existing posterior restorations. Failure criteria for posterior restorations were evaluated based on established reference guidelines.

Results: The study found that secondary caries had an odds ratio (OR) of 3.08 (95% CI: 2.85 – 3.29; $p < 0.001$), indicating a strong association with restoration failure. Additionally, restoration fractures were significantly correlated with retreatment, with an adjusted OR of 2.50 (95% CI: 2.46 – 2.86; $p < 0.001$).

Conclusion: Secondary caries emerged as the most common reason for retreatment, regardless of whether composite or amalgam materials were used. Restoration fractures also significantly contributed to the need for retreatment. Therefore, it is essential to consider factors such as restoration material, classification, and the number of restoration levels to reduce the likelihood of retreatment.

Keywords: Dental Restoration Failure, Dental Amalgam, Composite Resins, Retreatment

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Introduction

Dentists spend a significant amount of time each year replacing failed restorations. It is estimated that 50% of a dentist's time is devoted to replacing defective restorations. Studies have shown that, on average, about one-third of all existing restorations at any given time may be considered failed for various reasons (1, 2).

When a restoration is replaced, the size of the cavity is typically enlarged by 0.2-0.5 mm, weakening the remaining tooth structure. As restorations are replaced, the cavities become larger, making both the tooth and the restorations more fragile (3). While some teeth can withstand multiple restorative replacements without requiring endodontic or crown treatments, placing effective, long-term restorations is crucial to reducing the overall cost of dental care (4).

Research indicates that secondary decay around amalgam restorations is the most common reason for retreatment, with many studies identifying it as the primary factor (1). However, studies by Okasa (5) and Gharechahi (6) in 2024 suggest that tooth fracture may be an even more frequent cause of replacement.

Dental composites also have limitations. Proper isolation is crucial due to their high technical sensitivity (7). Additionally, they exhibit greater wear, especially in high-stress areas and over time in regions lacking marginal enamel for bonding (7, 8). The distinction between composite and amalgam in restoration failure is not well understood (9, 10).

Understanding the reasons for dental restoration retreatment can help prevent future tooth failures. Given changes in people's attitudes, dental knowledge, and the desire for different types of posterior restorations, this study aims to identify the causes of failure in posterior amalgam restorations in both vital and non-vital teeth, as well as in composite restorations.

Materials and methods

This cross-sectional study utilized electronic dental record (EDR) data from patients referred to the restorative department of the Dental School and various private clinics. Patients were monitored for the need for retreatment of existing restorations in posterior teeth.

Factors such as age, gender, tooth location, jaw position, type of restoration, reasons for inadequate treatment, and factors related to the causes of posterior restoration failure—including amalgam blue, marginal ditching, secondary decay, proximal overhang, incorrect proximal contact, loss of contour, cusp fracture, wear, staining, and restoration fracture—were examined for their potential impact on treatment success.

The causes of failure of posterior amalgam restorations were investigated due to the large number of samples in both vital and non-vital teeth. Additionally, the causes of failure in posterior composite restorations were analyzed, regardless of whether the tooth was vital or not.

Patients with systemic, bone, or periodontal diseases were excluded from the study. Upon collecting the data, the final conclusion highlighted that the failure rate in non-vital posterior amalgam restorations was attributed to specific variables. Identifying the variable most strongly associated with the highest failure rate was crucial, as this information could be used for retraining and informing other dentists.

Univariate data analysis was conducted to identify the best distribution with the lowest AIC, considering a P value of less than 0.2 as statistically significant. All significant variables from the univariate analysis were included in a multivariate model. The software utilized for data analysis was STATA version 12 (STATA Corporation, College Station, TX).

Results

In the composite group, the average age was 39.5 ± 8.29 years, while in the amalgam-vital group, it was 36.72 ± 8.73 years.

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Regarding the failure of posterior amalgam restorations in vital teeth, 44% of failures were attributed to secondary decay, 2% to proximal overhang, 14% to marginal ditching, 18% to amalgam blue, 10% to cusp fracture, 14% to restoration fracture, 6% to loss of contour, 12% to incorrect proximal contact, and 6% to wear.

In amalgam restorations for non-vital teeth, the results indicate that 30% of failures were due to secondary decay, 2% to proximal overhang, 6% to marginal ditching, 26% to amalgam blue, 20% to cusp fracture, 56% to restoration fracture, 12% to loss of contour, 6% to incorrect proximal contact, and 12% to occlusal surface wear.

In posterior composite repairs, the majority (64%) of failures were attributed to secondary caries. Unlike in the case of amalgam restorations, proximal overhang and marginal ditching did not significantly contribute to the failure of posterior composite repairs.

Other causes of failure in composite restorations included 10% due to staining, 16% to cusp fracture, 34% to restoration fracture, 12% to loss of contour, 12% to incorrect proximal contact, and 8% to excessive wear of the occlusal surface.

Table 1. Frequency of Factors Contributing to Restoration Failure.

Variables	Composite	Amalgam -vital	Amalgam –non vital	P-value
Age, (years) (mean ± SE)	39.5 (8.29)	36.72 (8.73)	1.03 (1.02 – 1.05)	0.35
Sex (%)				
Female	13 (26)	20(40)	17 (34)	
Male	37 (74)	30 (60)	33 (66)	0.33
Secondary caries (%)				
Yes	32(64)	22(44)	15 (30)	
No	18 (36)	28(56)	35 (70)	0.001*
Proximal overhang (%)				
Yes	0 (0)	1 (2)	1 (2)	-
No	50 (0.2)	49 (98)	49 (98)	0.60
Amalgam Blue (%)				
No	50 (100)	41 (82)	37 (74)	-
Yes	0 (0)	9 (18)	13 (26)	<0.001*
Restoration Fracture (%)				
No	33 (66)	43(86)	22 (44)	-
Yes	17 (34)	7 (14)	28 (56)	<0.001*
Loss of Contour (%)				
No	44(88)	47 (94)	44 (88)	-
Yes	6 (12)	3 (6)	6 (12)	0.51
Proximal Improper contact (%)				
No	44 (88)	44 (88)	47 (94)	-
Yes	6 (12)	6 (12)	3 (6)	0.51
Wear (%)				

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Yes	4(8)	0(0)	6(12)	-
No	46 (92)	50 (100)	44 (88)	0.05*
Cuap Fracture (%)				
No	42 (84)	45 (90)	40 (80)	-
Yes	8 (16)	5 (10)	10 (20)	0.37
Staining				
No	45 (90)	50 (100)	50 (100)	-
Yes	5 (10)	0 (0)	0 (0)	<0.001*

*Significant

Table 2. Univariate Regression Analysis of Factors Related to Restoration Failure.

Variables	Time Ratio (95% CI)	P-value
Age, (years)	1.01 (0.97 – 1.08)	0.65
Secondary caries	3.01 (2.85 – 3.19)	<0.001*
Proximal overhang	1.70 (0.86 – 2.89)	0.59
Restoration Fracture	2.49 (2.46 – 2.76)	<0.001*
Loss of Contour	1.16 (1.14 – 2.05)	0.001*
Proximal contact Incorrect	1.37 (1.27 – 1.65)	0.05*
Dental Wear	1.35 (1.20 – 2.75)	0.07
Cusp Fracture	1.54 (1.25 – 2.78)	0.001*
Staining	2.06 (1.98 – 1.19)	<0.001*

*Significant

Univariate analysis using the logarithmic distribution confirmed a significant association between secondary caries and failure (TR: 3.01; 95% CI: 2.85 – 3.19; $p < 0.001$), indicating an increased risk of failure with the presence of secondary caries (Table 2).

Table 3. Multivariate Analysis of Factors Related to Restoration Failure.

Variables	Time Ratio (95% CI)	P-value
Secondary caries	3.08 (2.85 – 3.29)	<0.001*
Restoration Fracture	2.50 (2.46 – 2.86)	<0.001*
Loss of Contour	1.31 (1.14 – 2.25)	0.001*
Cuap Fracture	1.59 (1.15 – 2.78)	0.001*
Staining	2.06 (1.98 – 1.19)	<0.001*

*Significant

After adjusting for other variables in the multivariate model, the adjusted TR for secondary caries was 3.08 (95% CI: 2.85 – 3.29; $p < 0.001$; Table 3).

Discussion

This study revealed that the primary cause of failure in composite and amalgam-vital restorations was secondary caries, consistent with numerous previous studies (11-13) that have identified secondary caries as a significant factor in restoration failure. However, these results contradict the findings of Bokhari and Frost, who proposed tooth fracture as the most common cause of amalgam failure (14, 15).

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In the current study, marginal ditching was identified as the third most common reason for retreatment of restorations. However, previous research has indicated that it ranks higher, as the second leading cause of retreatment (16, 17). Additionally, our study found that proximal overhang is among the least common causes of failure, whereas one foreign study cited it as the third most common cause of amalgam restoration failure (18). These findings underscore the importance of proper cavity preparation, correct application of the matrix and wedge, and precise reconstruction of physiological and anatomical contours.

In this study, incorrect proximal contact was identified as the fourth most common cause of vital amalgam failure. In contrast, the studies by Kimyai et al. (19) and Arandi et al. (10) reported it as the second most common reason for amalgam restoration failure. This discrepancy highlights the variability in findings across different studies and emphasizes the need for further research to understand these variations.

Furthermore, understanding the reasons for placing and replacing restorations is essential, alongside factors such as treatment planning, cavity preparation, the choice and characteristics of restorative materials, proper isolation of the area, and maintenance of oral hygiene—all of which contribute to the success of the restoration (20). Over time, this knowledge can lead to economic benefits and help prevent future failures.

Changes in dental restorative treatment patterns, driven by factors such as shifts in disease prevalence (21), the introduction of new restorative materials and techniques, and evolving attitudes of dental patients toward restorative treatments, may influence the reasons for retreatment. These changes could potentially lead to findings that differ from those of previous studies.

Limitation

This scientific study is subject to limitations stemming from the small sample size, incomplete recording of re-treatment instances, and the omission of some important variables.

Conclusion

The most common reason for retreatment of restored teeth in composite and vital amalgam cases was secondary caries, while restoration fracture was identified as the predominant cause of replacement in non-vital amalgam cases. Given these prevalent causes of restoration failures based on the type of restoration material, it is crucial to properly classify and assess restoration levels during placement and to improve diagnostic accuracy during patient visits. Future research should consider factors such as patients' oral and dental hygiene, caries susceptibility, dietary habits, and the age of restorations, while also ensuring a sufficiently large sample size to enhance reliability.

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Conflict of interest

The authors declare no conflict of interest.

Authors’ contributions

FF developed and designed the evaluation, collected the clinical data (NA), and drafted the manuscript. FF and ESh participated in the study's conception and design, supervised the study, and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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