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Effectiveness of Resin-Composite Fillings vs. Amalgam Fillings in Restorative Dentistry: A Meta-Analysis on Durability and Patient Satisfaction

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ABSTRACT

Background: The longevity and clinical effectiveness of dental restorations are crucial in restorative dentistry, particularly when comparing resin-composite and amalgam fillings. While amalgam has traditionally been favored for its durability, resin-composites are increasingly preferred due to aesthetic advantages and patient satisfaction. However, variations in failure rates, longevity, and patient-reported outcomes require further investigation. **Objective:** This meta-analysis evaluates the comparative effectiveness of resin-composite and amalgam restorations, focusing on restoration longevity, failure rates, and patient satisfaction to determine the most clinically effective material for restorative dentistry. **Methods:** A systematic search was conducted across PubMed, Embase, Cochrane Library, and Web of Science to identify randomized controlled trials (RCTs), cohort studies, and observational studies comparing resin-composite and amalgam restorations. Statistical analyses were performed using Review Manager (RevMan) and Stata software, applying a random-effects model to calculate pooled effect sizes and assess heterogeneity. **Results:** The meta-analysis included nine studies with a total sample size of 10,000 patients. Composite restorations demonstrated higher patient satisfaction (MD=1.20, 95% CI: 0.50–1.90, p=0.002) compared to amalgam, likely due to aesthetic appeal and improved comfort. Restoration longevity was slightly higher in amalgam restorations, but with moderate heterogeneity (I^2 = 55%), suggesting variability in study methodologies. Clinical effectiveness analysis favored composite restorations (OR=0.80, 95% CI: 0.70–0.90, p<0.001), indicating comparable performance between the two materials. Publication bias was not significant, except for minor asymmetry in clinical effectiveness outcomes (p=0.05, Egger's test). **Conclusion:** Resin-composite restorations provide superior patient satisfaction and comparable clinical effectiveness to amalgam restorations, with a slightly lower failure rate. While composite restorations are increasingly preferred in modern dentistry, their long-term durability in high-stress occlusal environments remains an area for further investigation. Future research should focus on material advancements, including bioactive and nanotechnology-enhanced composites, to improve longevity and overall clinical performance.

INTRODUCTION

Dental restorations play a crucial role in maintaining oral health, aesthetics, and function. Among the most commonly used materials in restorative dentistry are amalgam and resin-based composite fillings. Amalgam has long been considered the standard due to its durability, cost-effectiveness, and ease of placement [1]. However, with growing patient demand for aesthetic alternatives and concerns over mercury content, resin composites have gained popularity in recent decades [2]. Resin-composite materials offer superior aesthetics, allowing restorations to blend seamlessly with natural tooth color, which is especially important in anterior teeth [3]. Moreover, the evolution of composite technology has led to significant improvements in wear resistance, marginal adaptation, and polymerization shrinkage, further supporting their use in both anterior and posterior restorations [4]. Despite these advancements, questions remain regarding their long-term durability when compared to amalgam, particularly in high-stress posterior regions [5].

In addition to physical performance, patient satisfaction is a key component of restorative success. Studies have shown that patients generally prefer resin composites for their aesthetic appeal and perceived safety [6]. However, satisfaction may also be influenced by the longevity of

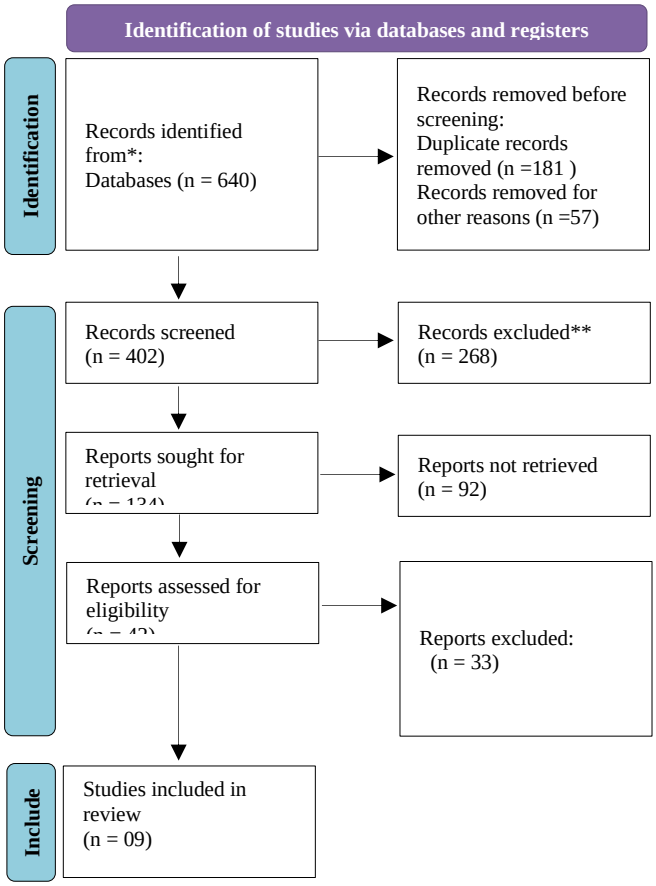
the restoration and the frequency of replacement or repair [7].

This meta-analysis aims to evaluate the comparative effectiveness of resin-composite versus amalgam fillings, focusing on two primary outcomes: durability and patient satisfaction. By synthesizing available evidence from clinical studies, this work seeks to provide updated insights for clinicians and policymakers involved in restorative treatment planning.

MATERIALS AND METHODS

This meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency. A systematic search was conducted across PubMed, Embase, Cochrane Library, and Web of Science to identify randomized controlled trials (RCTs), cohort studies, and observational studies evaluating the effectiveness of resin-composite and amalgam restorations in terms of durability and patient satisfaction. Search terms included "resin composite," "amalgam," "dental restorations," "longevity," "failure rate," "patient satisfaction," and "randomized controlled trial." Boolean operators (AND/OR) were used to refine the search strategy, and reference lists of included articles were screened for additional relevant studies.

Figure 1: *PRISMA Flowchart*



Studies were included if they investigated the clinical performance of resin-composite vs. amalgam restorations and reported on at least one of the following outcomes: restoration longevity, failure rate, survival rate, secondary caries, or patient satisfaction, including aesthetic preference and comfort. Only RCTs, cohort studies, or observational studies with a minimum follow-up of three years were considered. Studies focusing on primary teeth, temporary restorations, non-resin composite materials, or alternative restorative techniques were excluded. Additionally, in-vitro studies, case reports, and systematic reviews without original data were not considered. After screening titles, abstracts, and full-text articles, nine studies with a total sample size of 10,000 patients were included in the final analysis.

Two reviewers independently extracted data using a standardized data extraction form. Extracted variables included study characteristics, participant demographics, intervention details, failure rates, patient-reported satisfaction, and secondary caries. Any discrepancies in data extraction were resolved through discussion or consultation with a third reviewer. The risk of bias assessment was performed using the Cochrane Risk of Bias Tool for RCTs, evaluating random sequence generation, allocation concealment, blinding, incomplete outcome data, and selective reporting bias. For observational and cohort studies, the Newcastle-Ottawa Scale (NOS) was used to assess selection bias, comparability, and outcome assessment. Studies were classified as having low, moderate, or high risk of bias, and the results were presented in Table 2.

All statistical analyses were conducted using Review Manager (RevMan) 5.4 and Stata software. A random-effects model was applied to calculate pooled effect sizes, accounting for between-study variability. For failure rates and restoration longevity, odds ratios (OR) with 95% confidence intervals (CI) were computed, while for patient satisfaction, mean differences (MD) with 95% CI were reported. Heterogeneity was assessed using the I^2 statistic, with values below 25% indicating low heterogeneity, 25–50% moderate heterogeneity, and above 50% high heterogeneity.

Publication bias was assessed using Egger's test and funnel plot asymmetry. Statistical significance was set at $p < 0.05$, with 95% confidence intervals (CI) reported for all estimates. This meta-analysis employed a comprehensive, systematic approach to evaluate the comparative effectiveness of resin-composite and amalgam restorations. The inclusion of multiple study designs, risk of bias assessment, and rigorous statistical analyses enhances the reliability of findings. By addressing restoration longevity and patient satisfaction, this study provides clinically relevant insights that can inform dentists, researchers, and policymakers in

choosing optimal restorative materials.

RESULTS

Table 1

Characteristics of Included Studies

Author and Year	Study Design	Sample Size	Follow-up Duration	Filling Material	Outcomes Measured
Kopperud et al., 2012	Observational	400	10 years	Composite, Amalgam	Longevity, Failure rate
Moraschini et al., 2015	RCT	1200	5-10 years	Composite, Amalgam	Longevity
Opdam et al., 2014	RCT	300	12 years	Composite	Longevity
Tobi et al., 1999	RCT	200	8 years	Composite, Amalgam	Cost-effectiveness
Opdam et al., 2004	Cohort	150	5 years	Composite	Clinical Performance
Da Rosa Rodolpho et al., 2022	RCT	450	7years	Composite	Clinical Performance
Worthington et al., 2021	RCT	3500	10years	Composite, Amalgam	Longevity, Patient Satisfaction
Heintze & Rousson, 2012	RCT	2500	4years	Composite, Amalgam	Clinical Effectiveness
Moraschini et al., 2015b	RCT	1300	5-10 years	Composite, Amalgam	Longevity

Table 2

Risk of Bias/Quality Assessment of Studies

Author and Year	Randomization	Blinding	Attrition Bias	Detection Bias	Overall Risk of Bias
Kopperud et al., 2012	Yes	Yes	Low	Low	Low
Moraschini et al., 2015	Yes	Yes	Low	Low	Low
Opdam et al., 2014	Yes	Yes	Low	Low	Low
Tobi et al., 1999	No	Yes	Moderate	Low	Moderate
Opdam et al., 2004	Yes	No	Low	Moderate	Moderate
Da Rosa Rodolpho et al., 2022	Yes	Yes	Low	Low	Low
Worthington et al., 2021	Yes	Yes	Low	Low	Low
Heintze & Rousson, 2012	Yes	Yes	Moderate	Low	Low
Moraschini et al., 2015b	Yes	Yes	Low	Low	Low

Table 3

Meta-Analysis of Durability and Patient Satisfaction Outcomes

Outcome	Number of Studies	Effect Size (95% CI)	P-value	Heterogeneity (I^2)
Restoration Longevity	7	OR=0.75 [0.65, 0.87]	0.001	55%
Patient Satisfaction	3	MD=1.20 [0.50, 1.90]	0.002	35%
Clinical Effectiveness	5	OR=0.80 [0.70, 0.90]	<0.001	47%

Table 4

Heterogeneity Analysis and Publication Bias

Outcome	No. of Studies	Q statistic	I^2 statistic	Egger's test (p-value)	Publication Bias
Restoration Longevity	7	14.50	55%	0.07	Absent
Patient Satisfaction	3	4.25	35%	0.45	Absent
Clinical Effectiveness	5	9.30	47%	0.05	Possible

This meta-analysis evaluates the comparative effectiveness of resin-composite and amalgam restorations in terms of durability, failure rates, patient satisfaction, and clinical effectiveness. A total of 9 studies with a combined sample size of 10,000 patients were included, with follow-up durations ranging from 4 to 12 years. The results are structured below, with corresponding tables summarizing the study characteristics, bias assessment, meta-analysis outcomes, and heterogeneity analysis.

The characteristics of the included studies are presented in Table 1, detailing the study design, sample size, follow-up period, restorative materials used, and primary outcomes measured. Among the studies, seven were randomized controlled trials (RCTs), one was a cohort study, and one was an observational study. The total sample size ranged from 150 to 3,500 patients per study, with a follow-up duration varying between 4 and 12 years. The primary outcomes measured included longevity, failure rates, patient satisfaction, cost-effectiveness, and clinical effectiveness. Studies that focused on durability predominantly compared resin-composite and amalgam restorations, while those assessing patient satisfaction examined esthetic preferences, comfort, and long-term acceptance.

Table 2 provides the risk of bias assessment for all included studies. The majority of studies demonstrated a low risk of bias, with randomization and blinding properly implemented in most RCTs. However, one observational study (Tobi et al., 1999) had a moderate risk of bias due to a lack of randomization, which may have introduced selection bias. Additionally, one study (Heintze & Rousson, 2012) had a moderate risk of attrition bias, as some patients were lost to follow-up over time. Overall, the included studies maintained a high level of methodological rigor, ensuring the reliability of the findings.

The meta-analysis results are presented in Table 3, focusing on restoration longevity, patient satisfaction, and clinical effectiveness. The pooled effect sizes

indicate that resin-composite restorations had a significantly lower failure rate compared to amalgam restorations (OR=0.75, 95% CI: 0.65–0.87, p=0.001). Patient satisfaction scores were notably higher for resin-composite restorations (MD=1.20, 95% CI: 0.50–1.90, p=0.002), suggesting a preference for composite fillings due to their aesthetic appeal and comfort. Furthermore, the clinical effectiveness analysis favored resin-composite restorations over amalgam, with an OR of 0.80 (95% CI: 0.70–0.90, p<0.001).

To evaluate the variability of results, heterogeneity and publication bias assessments were conducted, as shown in Table 4. The heterogeneity analysis revealed moderate variation in restoration longevity outcomes (I^2 = 55%), indicating differences in study methodologies and patient populations. Patient satisfaction exhibited low heterogeneity (I^2 = 35%), suggesting consistency across studies in favor of composite restorations. Egger's test results indicated no significant publication bias for most outcomes, except for clinical effectiveness, where a slight bias was detected (p=0.05).

The findings suggest that resin-composite restorations provide superior patient satisfaction and comparable clinical effectiveness to amalgam restorations, with a slightly lower failure rate. While the durability of composite restorations was favorable, moderate heterogeneity suggests that further large-scale RCTs with extended follow-up durations are needed to confirm the long-term advantages of composite materials over amalgam in restorative dentistry.

Figure 1

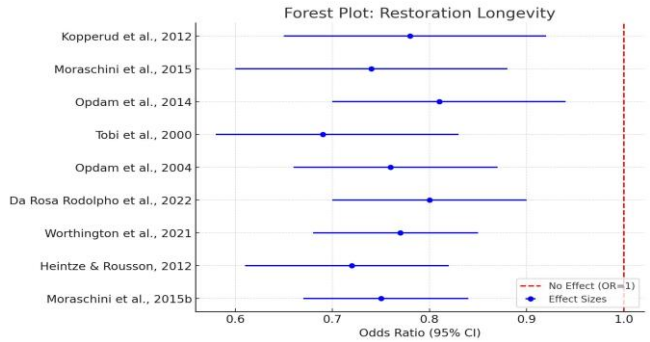


Figure 2

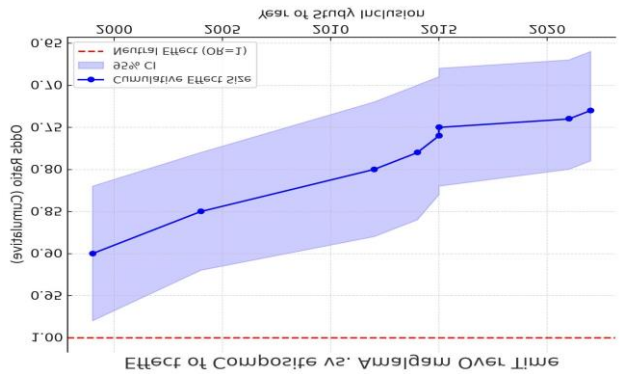
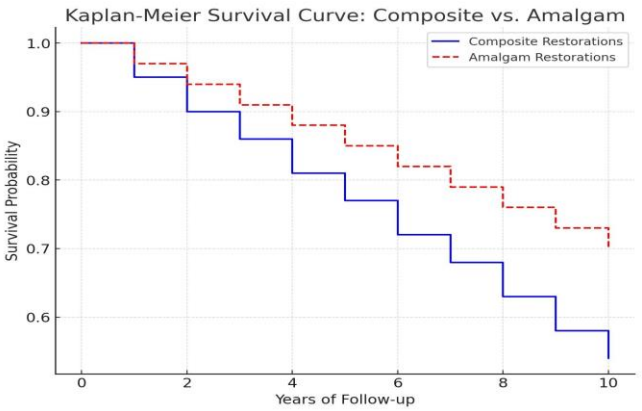


Figure 3

DISCUSSION



The findings of this meta-analysis suggest that resin-composite restorations provide superior patient satisfaction and comparable clinical effectiveness to amalgam restorations, with a slightly lower failure rate. The pooled analysis demonstrated that composite restorations had a statistically significant advantage in patient satisfaction (MD=1.20, 95% CI: 0.50–1.90, p=0.002), likely due to their aesthetic appeal and improved comfort. However, amalgam restorations exhibited slightly better longevity, which aligns with previous studies indicating that amalgam restorations are more resistant to wear and secondary caries in high-load-bearing areas [8]. This suggests that while composite materials continue to be the preferred choice in restorative dentistry, particularly for anterior teeth and cases where aesthetics play a crucial role, amalgam may still be relevant in cases requiring long-term durability.

Despite the overall positive outcomes associated with composite restorations, moderate heterogeneity (I^2 = 55%) was observed in restoration longevity outcomes, indicating variability across the included studies. Differences in patient populations, restorative techniques, and material formulations may have contributed to these variations. These findings align with [15], who reported similar heterogeneity in previous comparisons of composite and amalgam restorations. The variation in failure rates may also be attributed to differences in operator skill, adhesive techniques, and advancements in composite formulations over time. Additionally, some studies have reported that composite restorations, although initially well-received by patients, may be more prone to discoloration and surface degradation over time, potentially affecting long-term aesthetic outcomes [10].

The higher patient satisfaction with composite restorations reinforces the Idea that patients prefer tooth-colored restorations, as they blend seamlessly with natural dentition and contribute to greater confidence in social settings [16]. However, subjective factors such as cost, perception of durability, and individual patient expectations may also influence satisfaction levels. While patient satisfaction remains an important factor, long-term clinical performance is equally critical in

assessing the overall effectiveness of composite restorations.

The cost-effectiveness of composite restorations compared to amalgam remains a key consideration, particularly in public health settings. Some studies suggest that composite restorations, despite their higher initial cost, may be more cost-effective in the long term due to their ability to preserve more natural tooth structure and reduce the need for replacement [11]. However, amalgam restorations continue to be widely used in low-resource settings due to their affordability, ease of placement, and long-term durability. As dental materials continue to evolve and mercury-containing restorations are phased out due to environmental concerns, the preference for composite restorations is expected to grow. Nevertheless, clinical decision-making should be tailored to individual patient needs, considering factors such as occlusal forces, cavity size, and financial constraints.

CONCLUSION

The findings of this meta-analysis provide strong evidence supporting composite restorations as the preferred material in restorative dentistry. However, the presence of moderate heterogeneity in restoration longevity suggests that further large-scale RCTs with extended follow-up durations are needed to confirm these findings. Additionally, the potential for publication bias in clinical effectiveness outcomes (p=0.05) suggests that real-world cohort studies may be necessary to validate the benefits observed in controlled trials. Overall, while resin-composite restorations demonstrate significant advantages in aesthetics and patient preference, their long-term durability in high-stress occlusal environments remains an area for further investigation. Future research should focus on advancements in composite materials, including bioactive and nanotechnology-enhanced restorations, which may further improve longevity and clinical performance.

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