



Comparison of the Long Term Clinical Performances of Repaired versus Replaced Resin-Based Composite Dental Restorations: A Meta-Analysis of Clinical Trials

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CLINICAL SIGNIFICANCE

Healthcare professionals may opt to perform repairs on composite resins instead of completely replacing them. It has been noted that the efficacy of long-term clinical outcomes is comparable between the two options.

ABSTRACT

Objectives: When a composite resin restoration partially fails, dentists face the decision of replacing the entire restoration or repairing the affected area. This study aims to compare clinical outcomes between repairing and replacing dental composites through a meta-analysis of randomised clinical trials.

Materials and Methods: In June 2023, an extensive search across multiple databases (PubMed, Web of Science, Scopus, Cochrane Library, Open Grey) was conducted, focusing on marginal adaptation, anatomy, secondary caries, and colour of composite restorations. United States Public Health Service criteria-derived Alpha scores were examined, and odds ratios along with 95% confidence intervals were employed for comparisons. Data analysis was executed using Cochrane's RevMan 5.4.1 software (The Nordic Cochrane Centre, Copenhagen, Denmark).

Results: Only two studies met the eligibility criteria and were included in the analysis. Both studies were deemed to have a high risk of bias. Notably, no statistically significant differences emerged between the groups undergoing repair or replacement of composite restorations in terms of marginal adaptation (OR=0.50, 95% CI: 0.06, 3.96; p=0.51), anatomy (OR=0.69, 95% CI: 0.28, 1.68; p=0.42), and secondary caries (OR=0.47, 95% CI: 0.09, 2.54; p=0.38). However, the replacement group exhibited a higher OR when it came to colour (OR=0.19, 95% CI: 0.06, 0.65; p=0.008).

Conclusion: Both repairing and replacing dental composites exhibit comparable clinical outcomes for marginal adaptation, secondary caries, and anatomy. However, replacement offers improved colour stability in long-term assessments. Nevertheless, due to study limitations, further research is essential to comprehensively ascertain the benefits of both approaches.

1. Introduction

Over the last three decades, there has been a noticeable rise in the use of dental composites for the treatment of dental caries and the restoration of posterior teeth.¹ These materials have become a preferred alternative to amalgams.^{2,3} However, it should be noted that resin-based composite materials have a relatively shorter lifespan than amalgams and are more susceptible to failure due to recurrent caries, discoloration, and deterioration.⁴

When a partial restoration of composite resin fails due to secondary caries, fractures, or other factors, selecting the optimal approach to address the localized defect becomes crucial. Dentists can choose between fully replacing the restoration or repairing the specific affected area. While some may opt for replacement, repairing the restoration can be a more beneficial option.⁵ Repairing the restoration preserves healthy tooth structure and minimizes any negative effects on tooth longevity that may arise from enlarging the preparation area during full replacement. Additionally, repairing the restoration saves time and can prevent potential harm to the dentine-pulp complex that may occur during a larger repair.⁶

When faced with a flawed composite restoration, the decision to either replace or repair it rests largely on the clinician's judgment. This choice is often based on the knowledge and skillset, as well as clinician's clinical experience and expertise.⁷ In contemporary dental practice, there is a growing inclination towards less invasive procedures. Consequently, dental institutions worldwide have integrated the teaching of restorative repair techniques into their curriculum, during preclinical and/or clinical years.⁸

Several clinical studies have examined the clinical performance

performance of dental composites based on United States Public Health Service (USPHS) criteria, comparing repair versus replacement. Therefore, this study aims to conduct a meta-analysis of randomized clinical trials to qualify and quantify the evidence regarding clinical outcomes between repairing and replacing dental composites.

2. Materials and Methods

2.1. Guidance and eligibility criteria

This meta-analysis was performed according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).⁹ A well-defined review question was developed by using the patient population, intervention, comparison, outcome and study design (PICOS) frame-work. The following PICO framework was developed for a systematic review of the existing literature regarding the repair or replacement of damaged composite restorations:

Population (P): Patients who have restorations with localized, marginal, anatomical deficiencies, and/or secondary caries adjacent to composite resin restorations

Intervention (Cases) (I): Repair

Comparison (Control) (C): Replacement

Outcome (O): Marginal adaptation, surface roughness, secondary caries, marginal stain, teeth sensitivity, anatomic form, and luster

Study design (S): Clinical or Randomized Clinical Trials

"In patients with restorations featuring localized, marginal, anatomical deficiencies, and/or secondary caries adjacent to

composite resin restorations (P), does repair (I) compared to replacement (C) result in comparable or different outcomes in terms of marginal adaptation, surface roughness, secondary caries, marginal stain, teeth sensitivity, anatomic form, and luster (O), based on clinical or Randomized Clinical Trials (S)?”

The following types of studies were considered: firstly, the study had to investigate the effect of repair versus replacement on the longevity of composite restorations; secondly, only studies analysing resin-based composite restorations were included. Furthermore, adherence to the USPHS criteria for restoration assessment was obligatory, and lastly, the study design had to be a clinical trial.

Exclusion criteria included the following:

1. Studies that lacked a comparison between repair and replacement.
2. Studies that did not evaluate resin based-composite restorations.
3. Studies which combined amalgam and composite samples
4. Studies that examined restorations using methods other than United States Public Health Service (USPHS) criteria.
5. Studies that had an unavailable full text.
6. Short communication, review, case report, or case series.
7. Studies published in a language other than English.

There were no limitations imposed on the type of restoration, publication date, ethnicity, gender, or age.

2.2. Information sources and search strategy

In June 2023, an examiner (M.U) conducted a thorough search across multiple electronic databases, including PubMed, Web of Science, Scopus, Cochrane Library, and Open Grey. The search strategy employed a combination of Mesh terms such as "Composite Resins" and free-text terms like "Composites," "Repair," "Longevity," "Durability," and "Minimal Invasive

Table 1. Search strategies in information sources

Database	Search strategy
PubMed	((Composite Resin[Title]) OR (Composite[Title])) AND ((Repair[Title]) OR (Longevity[Title]) OR (Durability[Title]) OR (Replacement[Title]))
Web of Science	TI=((Composite Resin OR Composite) AND (Repair OR Longevity OR Durability OR Replacement))
Scopus	TITLE(composite) AND TITLE(repair) OR TITLE(longevity) OR TITLE(durability) OR TITLE(replacement)
Cochrane Library	#1 ("composite resin"):ti,ab,kw AND (repair):ti,ab,kw
Open Grey	#2 ("Composite") AND ("Repair") ((Composite Resin) OR (composite)) AND ((Repair) OR (Longevity) OR (Durability) OR (Replacement))

Treatment." The specific search methodology is outlined in Table 1. Additionally, to ensure a comprehensive approach, two researchers (J.F.B.M, F.P.H) meticulously examined the reference lists of all retrieved papers to identify any further relevant studies.

2.3. Study selection and data collection process

Following the application of predetermined inclusion and exclusion criteria, two independent reviewers (J.F.B.M and F.P.H) conducted the selection of relevant articles. To ensure accuracy, reference management software (EndNote® X9 Thomson Reuters, Philadelphia, PA, USA) was utilized to identify and eliminate any duplicate entries. Efforts also included contacting the corresponding author(s) if any additional information was required from the text. The reviewers (J.F.B.M and F.P.H) agreed upon the final selection of candidate studies. From each selected study, the following information was extracted: (1) publication details (journal, title, authors, date, and country), (2) sample characteristics (ethnicity, sample size, age, and gender of the participants), (3) repair-related features (repairing technique, materials used for repair, and the protocols followed), and (4) qualitative and quantitative results.

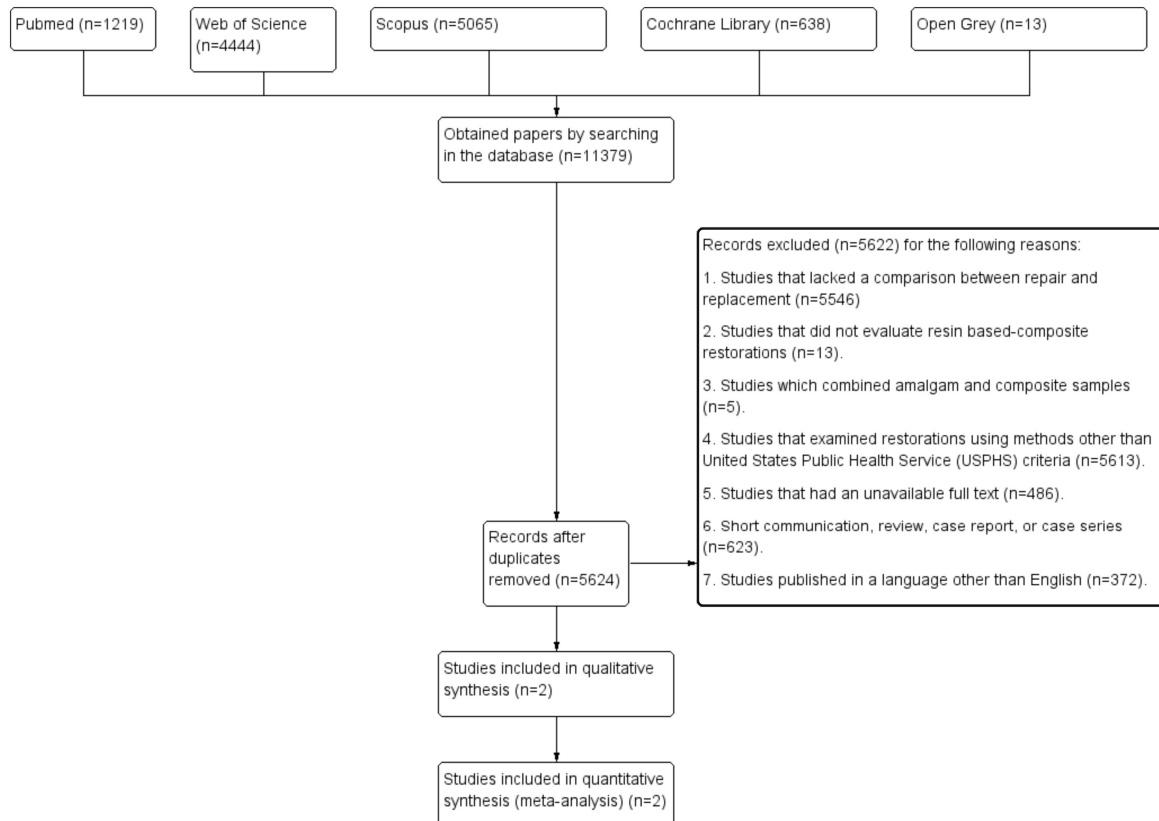


Fig 1. Flow diagram of the studies involved in the qualitative and quantitative analyses

2.4. Risk of bias within studies

To assess the risk of bias of individual studies, the revised Joanna Briggs Institute (JBI) critical appraisal tool for randomized controlled trials was used.¹⁰ The assessment was carried out independently by two reviewers (*.*., *.*.). The risk of bias was evaluated based on the Joanna Briggs guidelines scoring system and cutoff points. Studies that scored below 49% were considered to have a "high risk of bias," those scoring between 50 to 69% were considered to have a "moderate risk of bias," and those scoring over 70% were considered to have a "low risk of bias" (based on questions 1 to 10, as recommended by Barker, et al.¹⁰)

2.5. Summary measures

The study focused on marginal adaptation, anatomy, secondary caries, and colour as the primary outcome parameters of interest. The prevalence of alpha scores based on modified USPHS criteria was taken into account. For the purpose of contrasting the impact of repair and replacement, the odds ratio (OR) along with its corresponding 95% confidence intervals (95% CI) were employed, given that the primary outcome had a dichotomous nature.

2.6. Synthesis of results

To calculate the overall estimated effects and produce forest plots, the meta-analysis software of the Cochrane Collaboration (RevMan 5.4.1, The Nordic Cochrane Centre, Copenhagen, Denmark) was used. Methodological heterogeneity was assessed according to variability in risk of bias within the study and study design, while clinical heterogeneity was evaluated by comparing discrepancies among cases, controls, and study outcomes. The Chi-squared, Tau-squared, and Higgins I² tests were used to assess statistical heterogeneity. Heterogeneity was classified based on I² test results: <30% not significant; 30%-50% moderate; 50%-75% substantial, and 75%-100% considerable.¹¹ Even if statistical homogeneity was obtained, the random-effects model was preferred with 95% confidence intervals as the meta-analysis model due to a lack of clinical and methodological homogeneity.¹² In all tests, a random-effects model was used, and the level of significance was set at p < 0.05.

2.7. Risk of Bias Across Studies

A funnel plot analysis could not be performed due to the

inclusion of fewer than 10 studies.

2.8. Grade Analysis

The Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system was employed to assess evidence quality and establish recommendation strength. This involved generating a Summary of Findings (SoF) table through GRADEpro GDT, an online software developed by the GRADE Working Group.¹³

3. Results

3.1. Study Selection

A total of 11379 records (1219 from Pubmed, 4444 from Web of Science, 5065 from Scopus, 638 from Cochrane Library, and 13 from Open Grey) were obtained. Following duplicate removal, the number of studies was reduced to 5,624. From this pool, only 2 clinical studies^{14,15} satisfied the eligibility criteria and were included in the qualitative and quantitative syntheses (Fig 1).

3.2.Characteristics of the included studies

Both studies were clinical trials with sample sizes of 28 (12 male, 16 female)¹⁴ and 34 (14 male, 20 female)¹⁵ subjects. Participants' ages spanned from 18 to 80 years in both trials. The follow-up periods were 10 years¹⁴ and 12 years¹⁵. Filtek Supreme and Adper Prompt L-Pop, both by 3M ESPE in the USA, served as the composite resin and bonding materials across both studies.

3.3. Risk of bias within the studies

Both studies were classified as possessing a high risk of bias. These biases were primarily linked to aspects such as selection and allocation, assessment, and participant retention, as outlined in Table 2.

3.4. Results of individual studies

At follow-up, all groups exhibited marginal adaptation scores below 50%. Notably, only the replacement group achieved an anatomy score exceeding 50% in Fernandez, et al.¹⁴. Conversely, in the study of Estay, et al.¹⁵, the anatomy scores remained below 50%. Estay, et al.¹⁵ assessed roughness and recorded scores of 7% for repair and 46% for replacement groups. Concerning colour,

Table 2. The revised Joanna Briggs Institute (JBI) critical appraisal tool for randomized controlled trials that was used to assess the risk of bias in individual studies.

		INTERNAL VALIDITY													
		Bias related to: Selection and Allocation, Assessment, and Participant retention											Statistical Conclusion Validity		
		Domain	Selection and Allocation			Administration of intervention/exposure			Assessment, detection, and measurement of the outcome			Participant retention			
STUDY ID	OUTCOME		Question	1	2	3	4	5	6	7	8	9	10	11	12
Fernandez, et al. ¹	MA	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	MA	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	AN	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	AN	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	SC	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	SC	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	CO	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	CO	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
Estay, et al. ²	MA	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	MA	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	Y	N	Y	N/A
	AN	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	AN	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	Y	N	Y	N/A
	SC	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	SC	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	Y	N	Y	N/A
	CO	Repair	Y	U	N	N/A	N/A	N/A	U	Y	Y	N	N	Y	N/A
	CO	Replacement	Y	U	N	N/A	N/A	N/A	U	Y	Y	Y	N	Y	N/A

MA: Marginal Adaptation, AN: Anatomy, SC: Secondary Caries, CO: Colour, Y: Yes, N: No, U: Unclear, N/A: Not Applicable

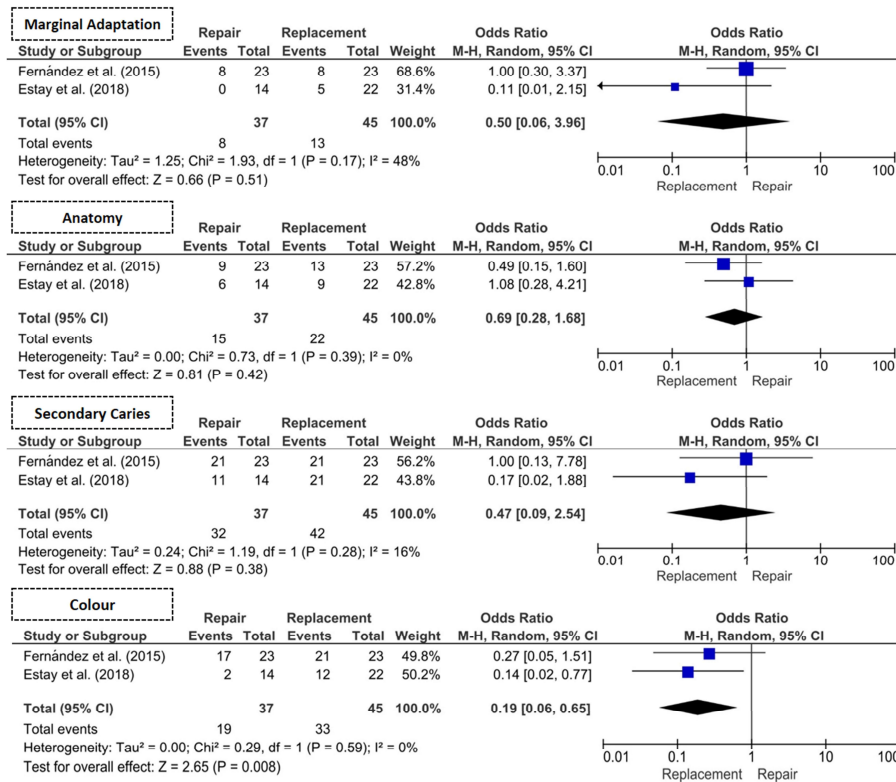


Fig 2. Forest plot presentations of all outcomes

replacement showed scores of 92%¹⁴ and 55%¹⁵, while repair attained 75%¹⁴ and 13%¹⁵ in the respective studies. Tooth sensitivity was only evaluated by Estay, et al.¹⁵ and it was found to be 100% in both repair and replacement. For secondary caries, all groups had more than 80% alpha scores. Luster was only evaluated by Estay, et al.¹⁵ and scores of 13% and 41% were recorded in the repair and replacement groups, respectively (Table 3).

3.5. Synthesis of results

The current meta-analysis did not find any significant difference between the groups that underwent repair versus replacement in terms of marginal adaptation (OR=0.50, 95% CI: 0.06, 3.96; p=0.51), anatomy (OR=0.69, 95% CI: 0.28, 1.68; p=0.42), and secondary caries (OR=0.47, 95% CI: 0.09, 2.54; p=0.38). However, the replacement group showed a higher OR in terms of colour (OR=0.19, 95% CI: 0.06, 0.65; p=0.008) (Fig 2).

No significant heterogeneity was observed for the outcomes of anatomy (Tau²=0.00, Chi²=0.73, I²=0%, p=0.39), secondary caries (Tau²=0.24, Chi²=1.19, I²=16%, p=0.28), and colour (Tau²=0.00, Chi²=0.29, I²=0%, p=0.59). Moderate heterogeneity was found for marginal adaptation (Tau²=1.25, Chi²=1.93, I²=48%, p=0.17). While there was no notable heterogeneity within the studies, the use of a random effects model was needed in all quantitative analyses due to methodological heterogeneity arising from differing follow-up periods (Fig 2).

3.6. Grade Analysis

The GRADE approach initially regards clinical studies as high-quality evidence. However, the quality of evidence may be

diminished by five factors: risk of bias, inconsistency, indirectness, imprecision, and publication bias. Conversely, three factors - large effect, dose-response, and all plausible confounding - may enhance evidence quality. Regrettably, the studies included were characterized by a high risk of bias, resulting in a low rating for all outcomes. Consequently, the confidence level in the cumulative evidence assessment based on GRADE criteria was categorized as low for all outcomes (Fig 3).

4. Discussion

Minimal intervention procedures suggested by researchers, such as restoration repair, can be an effective method to prevent the unnecessary removal of healthy tooth structure.⁵ This approach aligns with the minimally invasive principles and can significantly help in preserving the natural tooth structure. These treatments can not only extend the lifespan of the restored teeth, but also prevent the need for more invasive procedures in the future.⁶ By opting for these alternative treatments, patients can experience a more conservative approach to dental care while maintaining optimal oral health.

It has been observed that many general practitioners spend a considerable amount of their productive time replacing restorations, which often leads to a "re-restoration cycle." This cycle can be detrimental to the overall health of the tooth as it leads to larger restorations and an increase in the surface area of the restorations.¹⁶ Furthermore, complete replacement of the restoration may cause potential pulp and dentin reaction to thermal, chemical, bacterial, or mechanical stimuli. This reaction

Table 3. Results of individual studies included in the qualitative synthesis (n=2)

Study	Group	Initial Sample size	Lost to follow-up	Frequency of alpha scores in the following period						
				MA	A	R	CO	S	SC	L
Fernandez, et al.	Repair	25	2	36%	40%	-	75%	-	93%	-
	Replacement	25	2	35%	57%	-	92%	-	93%	-
Estay, et al.	Repair	15	1	0%	27%	7%	13%	100%	80%	13%
	Replacement	22	-	23%	41%	46%	55%	100%	96%	41%

MA: Marginal adaptation, A: Anatomy, R: Roughness, CO: Colour, S: Sensitivity, SC: Secondary Caries, L: Luster

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Replacement	Risk with Repair				
Marginal adaptation (MA) assessed with: Alpha Score follow-up: mean 11 years	29 per 100	17 per 100 (2 to 62)	OR 0.50 (0.06 to 3.96)	82 (2 RCTs)	⊕⊕○○ Low ^a	Repair may result in little to no difference in marginal adaptation.
Anatomy (AN) assessed with: Alpha Scores follow-up: mean 11 years	49 per 100	40 per 100 (21 to 62)	OR 0.69 (0.28 to 1.68)	82 (2 RCTs)	⊕⊕○○ Low ^a	Repair may result in little to no difference in anatomy.
Secondary Caries (SC) assessed with: Alpha Scores follow-up: mean 11 years	93 per 100	87 per 100 (56 to 97)	OR 0.47 (0.09 to 2.54)	82 (2 RCTs)	⊕⊕○○ Low ^a	Repair may result in little to no difference in secondary Caries.
Colour (CO) assessed with: Alpha Scores follow-up: mean 11 years	73 per 100	34 per 100 (14 to 64)	OR 0.19 (0.06 to 0.65)	82 (2 RCTs)	⊕⊕○○ Low ^a	Repair may result in a reduction in colour.

a. Most information is from studies with high risk of bias

Fig 3. Summary of Findings table

can result in additional stress on the tooth, depending on the size and depth of the existing restoration.¹⁷ It is important to consider the potential consequences of restoration replacement before proceeding with any such procedure.

Resin composite materials have made significant progress, but they still have some drawbacks. Composite restorations can fail due to various reasons such as secondary caries, fracture, marginal deterioration, discolouration, abrasion, and marginal clearance.¹⁸ Quality criteria for clinical acceptability are defined using different scales, and composite restorations are considered defective if they have secondary caries, chipping, or fracture of the restoration or tooth, or if there are marginal defects, such as gaps between the tooth surface and the restoration.¹

One of the main reasons why restorations may need to be replaced is due to secondary caries. However, if this issue is detected early on, there is a greater chance of successfully treating the problem.¹⁹ In addition, repairing composite resins with inadequate occlusal or proximal anatomy can improve prognosis and correct contact issues. This meta-analysis showed that there was no significant difference in the long-term formation of secondary caries whether composite restorations were repaired or replaced.

The results of the present study show that there is no major difference in the long-term clinical outcomes of replaced or repaired composite restorations when it comes to marginal adaptation. One downside to using the USPHS criteria is that it cannot differentiate whether marginal deterioration is due to the repaired area or the original restoration when conducting a clinical assessment of marginal adaptation. However, this deterioration can be offset by performing a marginal seal simultaneously.²⁰ Restoration repairs can also improve the stability of composite resin margins over time. Fernandez, et al.¹⁴ observed significant improvement in both groups after the first year, followed by similar deterioration until reaching a similar state 10 years later. Additionally, scores moved from Alpha to Bravo, indicating that the restorations remained clinically acceptable but declined in their marginal adaptation.

In the process of restoring a damaged tooth, it is essential to consider the anatomy of the composite resin employed. The proper functionality of the tooth is directly dependent on the shape and quality of the composite resin utilized. Inadequately shaped composite resins can result in complications such as food getting stuck, and insufficient contact, which can lead to further damage.¹⁹ However, according to this meta-analysis, both repair

and replacement methods have shown similar long-term anatomical success rates in clinical settings.

Over time, resin-based composite resins tend to undergo a colour change due to the softening of the resin matrix caused by water absorption.²¹⁻²³ According to this meta-analysis, replaced composites exhibit better colour stability than repaired ones. This could be due to the fact that the newly made composite is less exposed to external factors in the oral environment as the entire composite is replaced. On the other hand, the old composite structure at the border of the repaired composite may be more susceptible to discolouration.

The study exhibited certain limitations that must be taken into account. Firstly, due to the lack of available research on the subject, only two clinical studies were included in the meta-analysis. Secondly, the high heterogeneity across the studies, particularly in the duration of follow-up, was another limitation that should be acknowledged. It should be noted that a potential limitation of the study is that it solely considered research conducted in the English language, thus introducing the possibility of language bias. However, despite these limitations, the study offers substantial evidence due to its reliance on clinical studies, which stands as a notable strength of this research.

5. Conclusion

The findings of the study have shown that when it comes to marginal adaptation, secondary caries, and anatomy, both repairment and replacement procedures have similar performance. However, the replacement was observed to yield better results in terms of colour in long-term clinical evaluations. Nevertheless, it is important to consider the limitations of the study, such as the heterogeneity between the studies and the limited number of studies. Hence, the strength of evidence derived from the present study is limited. Consequently, providing a definitive clinical recommendation regarding the efficacy of the two methods being compared is difficult. It is crucial to conduct more comprehensive clinical studies to gather a more thorough understanding of the effectiveness of each method.

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CRediT Author Statement

J.F.B.M. : Investigation, Data Curation, Writing - Review & Editing, M.U. : Investigation, Data Curation, F.P. : Methodology, Formal analysis, Investigation, Writing - Original Draft, Supervision, Project administration

Conflict of Interest

The authors declare that no conflict of interest is available

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