Can repair increase the survival of failed restorations when compared with replacement? Systematic-Review and Meta-Analysis

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Abstract

Background: The aim of this systematic review was to collect and compare survival data of repair and replacement techniques for restoration failure in both dentitions.

Methods: To conduct a systematic review to gather and compare survival data between repair and replacement techniques in failed restorations of primary and permanent teeth. The systematic searches were performed in PubMed/MEDLINE, Scopus, Web of Science, Embase, ProQuest and OpenSigle databases. Two independent calibrated reviewers (kappa=0.87) assessed as inclusion criteria: (1) Repair or replacement studies, (2) success, longevity, or survival data, (3) randomized clinical controlled trials; and for the exclusion criteria (1) Loss to follow-up over 30%, (2) less than 12 months follow-up, (3) anterior teeth. The risk of bias was assessed by the RoB 2 tool, and the certainty of the evidence was assessed using the GRADE tool. Meta-analysis was conducted considering the treatment's survival rate.

Results: We identified 4,070 potentially relevant publications, after removing duplicates and assessing title and abstracts, 2,115 studies were ineligible because they were not about repair and replacement, did not have percentage survival data, or were not RCTs. Seven remaining articles were assessed for the exclusion criteria, and we found all papers for full-text analysis. Three studies were included in the quantitative analysis, all evaluating permanent dentition. A standard follow-up time between studies was collected, and the pooled survival rate between studies was 99% after three years. There was no statistically significant difference between approaches and no heterogeneity between studies. All included studies had a high risk of bias. The certainty of evidence for the outcome measure of success between repair and replacement interventions in failed restorations is very low.

Conclusion: The longevity for both techniques appers to be similar. However, the certainty of evidence is very low, and the trials have a high rick of bias.

Introduction

Constant adversity in public health worldwide remains the high prevalence of caries disease, affecting 2.4 billion people with permanent dentition and 621 million children with deciduous dentition [1]. Dental restorations are the most commonly performed procedure by dental surgeons [2]. Consequently, restorative failures often occur due to the influence of factors mainly related to the patient and the restored tooth, with fracture of the restorative material or the presence of caries lesions around the restorations (secondary caries lesions) being shared in this context [3].

Considering a failed restoration, the dental professional has two treatment possibilities: removing all the old restorative material and applying a new restoration, known as replacement [4]; or a minimal intervention dentistry (MID) approach, consisting in add some restorative material, seal the margins, or polishing/monitoring, characterized as restoration repair [5]. There is no scientific evidence indicating when repair or replacement of failed restorations should be performed in deciduous or permanent teeth [6, 7].

Although the restoration replacement invariably causes the cavity enlargement to remove the underlying material, leading to weakening of the tooth and possible pulpal complication, this technique has mainly been used [9]. In contrast, the repair, considered a "contemporary approach," is in line with minimal intervention dentistry (MID), limiting the size of the restorative intervention and reducing the risk of pulpal complications [10], has shown promising results. Studies with up to 10 years of follow-up indicate that this technique can considerably increase the survival of restorations in permanent teeth [4, 11–13].

However, studies that have addressed the long-term success and behavior of replacement and repair in the deciduous dentition still have an uncertain outcome. As such, synthesis of the available data employing a systematic review would help to understand the expected longevity of repair versus replacement and possible factors associated with their failure. Therefore, this systematic review summarizes the evidence on replacement and repair techniques for restorations performed in patients who have had failed restorations in relation to longevity and what associated factors might influence it..

Material And Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [14] (Appendix 1) and was registered in the PROSPERO platform (CRD42021238063).

All this paper was conducted by two independent and duplicate reviewers and in case of doubt or disagreement, a third experienced reviewer performed the tiebreaker.

Search Strategy

The literature search was conducted using Medline (PubMed), Scopus, Web of Science, and Embase databases to identify relevant published papers. In addition to these, we performed a systematic search in OpenSigle (OpenGray) and in ProQuest for grey literature. There were no restrictions regarding language or year of publication.

We developed a search strategy to find relevant studies regarding our PICO question (Participants, Intervention, Comparison, Outcome), namely P: Children and adults presenting with restorative failure, I: Repair, C: Replacement, O: Restoration survival. Using a controlled vocabulary (Mesh terms), synonyms and related terms were selected and associated with Boolean operators, resulting in the search strategies for each database:

PubMed	((Success OR Survival OR Longevity) AND (Repair* OR refurbish* OR seal* OR Replacement) AND (amalgam OR "composite resin*" OR "resin composite*" OR compomer* OR "polyacid modified composite resin*" OR "polyacid-modified composite resin*" OR "dental restoration*" OR "glass ionomer cement*" OR "glass-ionomer cement*" OR GIC) AND (dental OR Dentistry OR teeth OR tooth OR molar))
Scopus	TITLE-ABS-KEY ((success OR survival OR longevity) AND (repair* OR refurbish* OR seal* OR replacement) AND (amalgam OR "composite resin*" OR "resin composite*" OR compomer* OR "polyacid modified composite resin*" OR "polyacid-modified composite resin*" OR "dental restoration*" OR "glass ionomer cement*" OR "glass-ionomer cement*" OR gic) AND (dental OR dentistry OR teeth OR tooth OR molar))
Web of Science	TS=((Success OR Survival OR Longevity) AND (Repair* OR refurbish* OR seal* OR Replacement) AND (amalgam OR "composite resin*" OR "resin composite*" OR compomer* OR "polyacid modified composite resin*" OR "polyacid-modified composite resin*" OR "dental restoration*" OR "glass ionomer cement*" OR "glass-ionomer cement*" OR GIC) AND (dental OR Dentistry OR teeth OR tooth OR molar))
Embase	('success'/exp OR success OR 'survival'/exp OR survival OR 'longevity'/exp OR longevity) AND (repair* OR refurbish* OR seal* OR 'replacement'/exp OR replacement) AND ('amalgam'/exp OR amalgam OR 'composite resin*' OR 'resin composite*' OR compomer* OR 'polyacid modified composite resin*' OR 'polyacid-modified composite resin*' OR 'dental restoration*' OR 'glass ionomer cement*' OR 'glass-ionomer cement*' OR gic) AND ('dental'/exp OR dental OR 'dentistry'/exp OR dentistry OR 'teeth'/exp OR teeth OR 'tooth'/exp OR tooth OR 'molar'/exp OR molar)
OpenSigle	((Success OR Survival OR Longevity) AND (Repair* OR refurbish* OR seal* OR Replacement) AND (amalgam OR "composite resin*" OR "resin composite*" OR compomer* OR "polyacid modified composite resin*" OR "polyacid-modified composite resin*" OR "dental restoration*" OR "glass ionomer cement*" OR "glass-ionomer cement*" OR GIC) AND (dental OR Dentistry OR teeth OR tooth OR molar))
ProQuest	((Success OR Survival OR Longevity) AND (Repair* OR refurbish* OR seal* OR Replacement) AND (amalgam OR "composite resin*" OR "resin composite*" OR compomer* OR "polyacid modified composite resin*" OR "polyacid-modified composite resin*" OR "dental restoration*" OR "glass ionomer cement*" OR "glass-ionomer cement*" OR GIC) AND (dental OR Dentistry OR teeth OR tooth OR molar))

The results from the different databases were cross-checked using the EndNote reference manager program and eliminated manually to eliminate possible duplicates.

Study Selection and Eligibility Criteria

Using the search strategy, initially, potentially relevant publications were screened for inclusion based on title and abstract using the inclusion criteria: (1) Repair or replacement studies, (2) success, longevity, or survival data, (3) randomized clinical controlled trials. For the exclusion criteria (1) Loss to follow-up over 30%, (2) less than 12 months follow up, (3) anterior teeth.

Two independent reviewers participated in all phases of study screening and eligibility (Kappa = 0.87). All disagreements were resolved by discussion, and a third reviewer was consulted when necessary. When studies had the same sample, we considered the longer follow-up or the most complete data set.

Data Extraction

For each selected paper, the following information was systematically extracted: 1) Publication details such as authors, year and country of publication; 2) Study design; 3) Technique used (Repair or Replacement); 4) Sample characteristics such as number and age of participants, tooth type, number of faces involved and cavity type; 5) Material used; 6) Number and experience of operators; 7) Setting; 8) Outcome information such as evaluation criteria, survival percentage and follow-up time. In case of inconclusive or missing data, we contacted the authors through the e-mail address.

Risk of Bias Assessment

The RoB 2 tool assessed the risk of bias in randomized clinical trials [15], which approaches a fixed set of bias domains, focusing on different aspects of study conduct, reporting, and design. Each potential reason for bias can be rated as a 'high' or 'low' risk of bias or "having some concerns".

Certainty of the evidence

Two reviewers assessed the certainty of the evidence using the GRADE tool (Grading of Recommendations, Assessment, Development, and Evaluation) in duplicate. The assessment was based on the risk of bias domains, inconsistency, indirectness, and publication bias, resulting in a high, moderate, low, or very low certainty of evidence. [16]

Data synthesis and statistical methods for the meta-analysis

A narrative synthesis was conducted to firstly describe the details of the studies, participant and intervention characteristics, and the results of the included articles. Then a meta-analysis was performed using fixed or random-effects models considering the failure of restoration as the outcome.

Heterogeneity between studies was statistically evaluated using the Chi-square test (Q test) and its inconsistency (I2). Values of I2 were classified as: not relevant heterogeneity (0–40%), moderate heterogeneity (30–60%), substantial heterogeneity (50–90%), and considered homogeneity (75–100%).

All analyses were performed using meta and metafor packages in the RStudio, version 1.3.95 (PBC, Boston, USA). The risk ratio and 95% confidence interval for pairwise comparison were calculated.

Results

Study Selection

Based on the systematic literature search, we identified 4,070 potentially relevant publications. After the removal of 1,948 duplicates, a total of 2,122 studies were identified. From the first evaluation of the abstracts and titles, 2,115 studies were ineligible because they were not about repair and replacement, did not have percent survival data, or were not clinically randomized studies. Seven remaining articles were assessed for the exclusion criteria, and we found all papers for full-text analysis. Three manuscripts matched the eligibility criteria, included in this systematic review, and used for the quantitative synthesis [5, 18, 19]. Four articles had the same sample but different assessment times and were excluded. Figure 1 presents the PRISMA flowchart.

Study characteristics

The main characteristics of the included studies are shown in Table 1. The three included studies refer to permanent dentition, with no randomized clinical trials on deciduous teeth comparing restoration repair and replacement. All included studies performed the procedures in class I and II types of cavities. The participants' age ranged from 18 to 80 years old.

Table 1
Characteristics of included studies in the systematic review according to Survive of Repair or Replacement

Study	Place of origin	N patients	N teeth replace	N teeth repair	Kind of Repair	Material Repair	Material Replace	Evaluation criteria	Follow-up	Survive repair 3 years follow-up	Survive replace 3 years follow-up
J Estay et al., 2018 [18]	Chile	34	43	35	Repair/Control	CR/AMG	CR/AMG/GIC + AMG	USPHS / Modified Ryge criteria	12 years	94,3%	100%
J Martin et al., 2013 [19]	Chile	32	40	43	Sealant repair/Control	RS	CR/AMG	USPHS / Modified Ryge criteria	5 years	97,7%	97,5%
G Moncada et al., 2009 [5]	Chile	66	42	148	Sealant repair/ Repair/ Refurbishment/ Control	RS/CR/ AMG	CR/AMG	USPHS / Modified Ryge criteria	3 years	100%	100%
*USPHS: United States Public Health Service; CR: Composite Resin; AMG: Amalgam; RS: Resin Sealant; GIC: Glass Ionomer Cement.											

Among the included studies, the operators were trained dentists, the procedures were always performed in a dental clinic, and two operators performed the repairs and replacements. The material of choice to repair the restorations was resin sealant in one study, composite resin, and amalgam in another. Two studies used composite resin and amalgam for replacement, while the third study used glass ionomer with amalgam, composite resin, and amalgam. In contrast, in the third study, all the above materials were used. Some data such as treatment longevity were inconclusive in the primary articles, so the authors were contacted in order to supply the data for analysis.

The criteria used to evaluate the quality and survival of repair and replacement were United States Public Health Service (USPHS) and modified Ryge criteria. The follow-up of the studies was 3 to 12 years, and all trials were performed in Chile.

Risk of bias assessment

The Rob 2 tool was used for the final risk of bias analysis, shown in Appendix 1, of all three studies included in the RCT. All included studies had a high risk of bias. The detection bias, selection bias, and reporting bias levels presented an increased risk of bias, while performance bias presented an uncertain risk of bias for all three papers. Concerning selection bias, two studies were considered low risk, one was considered high risk of bias, and all three were considered an unclear risk of performance bias. Only one study was considered at high risk of detection bias. Because all studies were unregistered, they were considered to have a high risk of reporting bias. All included studies were considered at low risk of attrition bias. Other types of biases were not analyzed.

Certainty of the evidence

The certainty of evidence for the outcome measure of success between repair and replacement interventions in failed restorations is very low. The main reason for downgrading was the high risk of bias from two primary studies due to selection and detection bias and the low imprecision of the studies due to the reduced sample size. The certainty of the evidence and the reason for downgrading are presented in Table 2.

<div align="center">

Table 2
Certainty of evidence and reason for downgrading

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Certainty assessment							Nº of patients		Effect	
Nº of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	REPAIR	REPLACEMENT	Relative (95% CI)	Absolute (95% CI)
SUCCESS (follow-up: 3 years)										
3	randomised trials	very serious a	not serious	not serious	serious b	none	226/132 (171.2%)	125/132 (94.7%)	RR 2.19 (0.29 to 16.56)	1.000 more per 1.000 (from 672 fewer to 1.000 more)
CI: confidence interval; RR: risk ratio										
Explanations										
a. High risk of bias in the random sequence, allocation and reporting bias of studies.										
b. Low sample size										

Data Synthesis

The analyses were performed according to the survival reported in the primary randomized clinical trials. After contacting the authors to provide the quantitative data, three studies were included in the meta-analysis. We used data from a similar follow-up time in all studies because each study had a different final follow-up time. It was impossible to perform subgroup or sensitivity studies due to the total number of studies included in this paper.

Therefore, we analyzed data from three studies evaluating the risk ratio of failure between repair and replacement at a 3-year follow-up. We found no difference between the groups (2.19; 95%CI 0.29 to 16.56) (Appendix 2). There was no heterogeneity (I²=0%) which was not statistically significant (p = 0.36).

Publication bias could not be conducted due to the low number of studies.

Discussion

This systematic review and meta-analysis aimed to analyze the survival rate of repair compared to replacement of failed restorations. In line with the minimal intervention dentistry, restoration repair does not advocate complete restoration removal. The repair intervention can use monitoring, sealing, polishing, and finishing the old restoration, or even adding adhesive restorative material where applicable. Replacement is required to remove all adjacent material to make a new restoration. [4, 5]

The conducted meta-analysis has shown no difference in restorations' survival comparing repair or replacement. However, we suggest that in future trials tooth survival after repair and replacement would be also used as an outcome. In cases of restorations replacement, part of healthy tooth tissue is unintentionally removed. Therefore, the more often the failed restoration is replaced; there is a higher chance of pulp exposure leading to endodontic treatment, and in the future even tooth loss, known as the "death spiral". [17]

A limitation of any systematic review is that quality depends on the primary studies' design, conduction, and reporting. The primary studies in this review compared different repair techniques with replacement; however, in the same article, there could be two or more groups performing various types of repair compared to only one replacement group, which may overestimate or underestimate the outcome of the repair and influence the results of our meta-analysis, thus becoming a limitation of the manuscript.

We found no randomized clinical studies comparing the repair technique with replacement in primary teeth in the literature, which invalidates our results for this type of dentition. Similarly, few studies were found in permanent teeth, showing that this technique is poorly studied. We suggest that randomized clinical studies be performed on children to evaluate the longevity of both methods for primary dentition. The authors call the attention that well-conducted studies should also be performed on permanent teeth so that other analyses, such as subgroup or sensitivity, can be done in the future.

It is essential to highlight that all studies included in this meta-analysis had a high risk of bias. The most prevalent type of bias among the studies was selection, performance, detection, and reporting bias. Not reporting how randomization, allocation, and blinding of participants was performed shows us that the way it was conducted and the results of these papers may be questionable and not having registered the randomized clinical trials on the ClinicalTrials platform. And because the studies are dependent on the results of the primary RCTs, this may be a limitation of all systematic reviews.

Two reasons for the downgrade of the certainty of the evidence of this systematic review and meta-analysis were the risk of bias and imprecision of the studies. The selective bias in a randomized clinical trial is a crucial bias to be avoided. The authors of the primary studies do not adequately report the randomization process nor the allocation concealment. Another vital bias to be avoided is the performance bias, which did not occur in the primary studies. All

studies failed to report blinding the operators, which may influence the final result of your research. Moreover, due to the low sample size, it is not feasible to provide a clear certainty of the evidence since the result of our meta-analysis may change if a new study with a high sample size would be eligible. These were the reasons why the certainty of the evidence was downgraded as very low.

Many professionals may still be afraid to use the repair technique, mainly because it is associated with minimal intervention. However, as this study shows, the repair restoration's longevity compared to a more invasive procedure is similar. As professionals seek the best for the patient associated with the best available evidence, the repair technique for failed restorations should be more widely implemented and used. The results of this systematic review and meta-analysis may influence future choices within public and private services, so they should be considered.

Conclusions

This systematic review and meta-analysis confirm that the technique of repairing failed restorations is similar to the replacement approach in permanent teeth and is a viable option due to its minimally invasive procedure that proposes to preserve healthy tooth tissue. However, it is essential to emphasize that we should consider the high risk of bias presented in the primary studies, and these results were based on very low certainty of evidence.

Declarations

conflict of interest with respect to the authorship or publication of this work.

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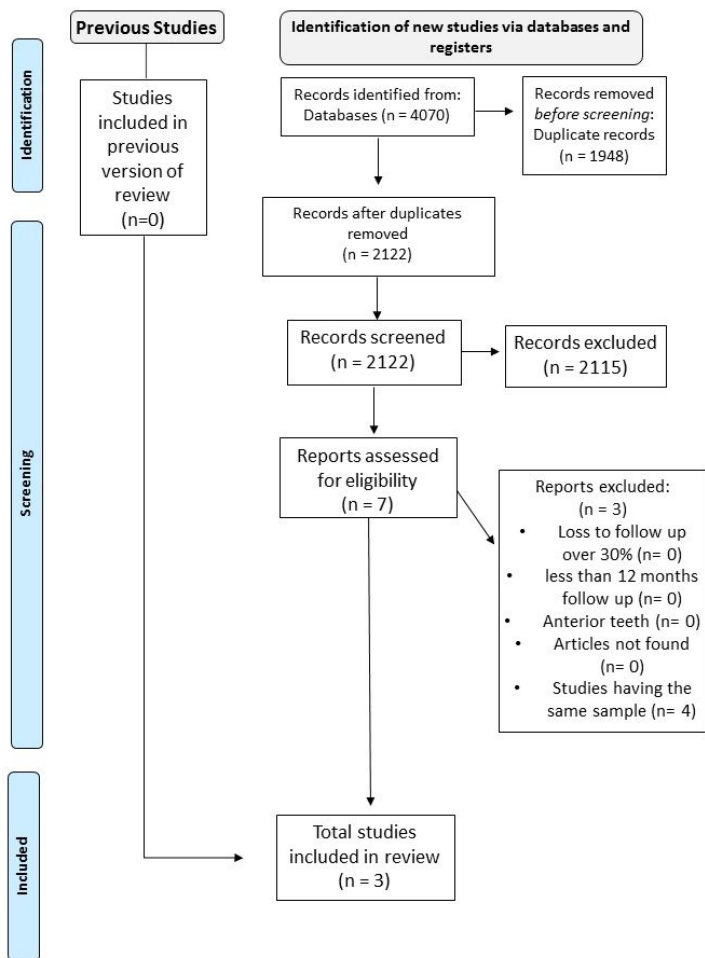
Figures

Figure 1

Flowchart proposed by PRISMA for Systematic Review

Supplementary Files

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- APPENDIX1RiskofbiasAnalysisRob2.docx
- APPENDIX2ForestplotSurvivalRepairandReplacement3years.docx