

Review Article

An overview of composite versus amalgam for dental restorations

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Received: 02 January 2021

Accepted: 18 January 2021

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ABSTRACT

When any loss of the tooth structure happens, it's restoration using different filling materials is essential to compensate for the defective parts. Among the most commonly used dental restorative materials, dental amalgam & composite resins prevail. We have searched the relevant studies that compared composite resins and amalgam restorations to review them in different aspects including the clinical, economic, biocompatibility and patients' perspectives. Regarding the clinical perspective, most of the reviewed investigations showed that composite resin restorations were associated with higher failure rates and developed dental caries more than restorations made by the amalgam alloys. There were no significant differences noticed between the two materials regarding the side effects as both caused nearly similar neurological and renal affection. Based on the findings from previous studies, we could only notice that some studies reported that microalbuminuria may be associated with composite resins. We have also found that patients' satisfaction with the amalgam restorations was low due to the potential development of some side effects that were attributable to lead intoxication. In conclusion, we recommend that further investigations should be conducted.

Keywords: Dentistry, Composite Resin, Amalgam, Biocompatibility

INTRODUCTION

Dental caries or tooth decay is widely known as a pathological process of continuous demineralization involving the hard tissues of the affected teeth followed by remineralization to compensate for what has been lost.

The severity of the disease would be determined by the balance between the two processes.^{1,2} Previous studies showed that oral health is correlated with the quality of the individual's lifestyle in many aspects as the socioeconomic status and the surrounding atmosphere which can impact the patients' health.^{3,4} Although many therapeutic advances have been made in the field, dental

caries still affects a large portion of the population in low, middle, and high-income countries as it impacts around 60-90% of children at school age and most of the adults.⁵ It has also been estimated that it is the most frequently reported oral disorder in many Latin-American and Asian countries.

The management of dental caries is based on the early diagnosis of the condition followed by the installment of a proper intervention that aims at delaying the restorative measures by arresting, preventing, or even preventing dental caries from causing any further damage.⁶ However, when the damage is inevitable, restoration is indicated using filling materials to compensate for the defect and preserve the potential functions of the affected tooth. Indications for placement restorations occur most frequently with primary dental caries where such lesions occur most frequently on the posterior occlusal aspect of the tooth.⁷ On the other hand, the prevalence of placement restorations following secondary caries has been estimated to be 60% among the regular dental care practices. Moreover, no significant associations were estimated between the anatomical location of dental caries, the oral microflora, biocompatibility and the effects of the applied filling materials.⁸

Among the used materials for dental restorations, amalgams and composite resins have been widely used in this field. Amalgam restorations are made of metallic alloys, being efficient and in-expensive for the past 150 years. Many research materials have investigated the efficacy and safety of this material, being the most

feasible and cost-effective restorative modality for posterior teeth. However, many concerns have been raised regarding their safety and un pleasant look, and therefore, they are no longer widely used and many alternatives have been proposed.⁹⁻¹¹ Composite resins on the other hand, were originally developed to meet patients' demands of having tooth colored restorations. Such composites are formed of particles that are embeded in resin matrix and have been reported to have many advantages and applications.¹² We have searched the relevant studies that compared composite resins and amalgam restorations to review them in different aspects including the clinical, economic, and patients' perspectives.

METHODS

We performed an extensive literature search of the Medline, Cochrane, and EMBASE databases using the medical subject headings (MeSH) or a combination of all possible related terms. Studies comparing composite resin and amalgam restorations in different aspects including the clinical, economic, biocompatibility and patients' perspectives; were screened for relevant information. We did not pose any limits on date, language, or publication type. A PRISMA flow diagram illustrates the results of the search, screening, and selection of studies for inclusion (Figure 1).

Author, kind of study, aim, methodology, variables and results of the reviewed studies are summarized in Table 1.

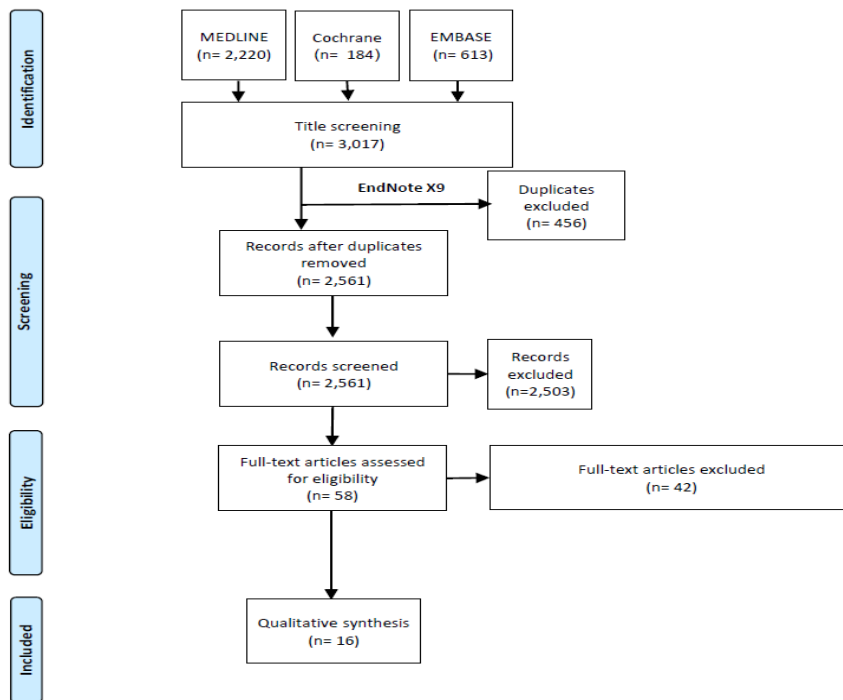


Figure 1: PRISMA flow diagram of study inclusion.

Table 1: Author, kind of study, aim, methodology, variables and results of the reviewed studies.

Author	Kind of study	Aim	Methodology	Results
Alcaraz et al¹	SR/MA	To examine the effects of direct composite resin fillings versus amalgam fillings for permanent posterior teeth, primarily on restoration failure.	Searched the Cochrane Oral Health Group's Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE via OVID, EMBASE via OVID, and LILACs via BIREME Virtual Health Library. They applied no restrictions on language or date of publication when searching the electronic databases. They contacted manufacturers of dental materials to obtain any unpublished studies.	Results reinforce the benefit of amalgam restorations and the results are particularly useful in parts of the world where amalgam is still the material of choice to restore posterior teeth with proximal caries
Barregard et al²¹	RCT	To compare the amalgam or resin composite (white fillings)--used for caries treatment during 5 years of follow-up.	Children 6-10 years of age (n = 534) with two or more posterior teeth with caries but no prior amalgam restorations, were randomized to one of two treatments--amalgam or resin composite (white fillings)--used for caries treatment during 5 years of follow-up.	The increase in microalbuminuria may be a random finding, but should be tested further. The results did not support recent findings in an observational study of an effect of low-level mercury on tubular biomarkers in children.
Bernardo et al¹³	RCT	To compare the longevity of amalgam and composite.	The authors randomly assigned one-half of the 472 subjects, whose age ranged from 8 through 12 years, to receive amalgam restorations in posterior teeth and the other one-half to receive resin-based composite restorations. Study dentists saw subjects annually to conduct follow-up oral examinations and take bitewing radiographs.	Amalgam restorations performed better than did composite restorations. The difference in performance was accentuated in large restorations and in those with more than three surfaces involved.
Cunningham et al¹⁶	CS	To evaluate the clinical performance of three posterior composites and two amalgams over 3 years.	Three hundred and nine composites and 200 amalgams were reviewed at the 3-year recall. The following parameters were assessed: fractures, gingival condition, interproximal contacts, marginal adaptation, staining and colour match.	Overall, the materials Occlusion and P-30 were considered to be performing adequately. The clinical handling, colour match and radiopacity of Clearfil Posterior were considered to be unsatisfactory.

Continued.

Author	Kind of study	Aim	Methodology	Results
Heintze et al ²⁷	CS	To examine the correlation between clinical wear rates of restorative materials and enamel and the results of six laboratory test methods.	Individual clinical wear data were available from clinical trials that were conducted by TRAC Research Foundation together with general practitioners. For each of the n=28 materials (21 composite resins for intra-coronal restorations [20 direct and 1 indirect], 5 resin materials for crowns, 1 amalgam, enamel) a minimum of 30 restorations had been placed in posterior teeth, mainly molars.	The clinical wear of composite resins is mainly dependent on differences between patients and less on the differences between materials. Laboratory methods to test conventional resins for wear are therefore less important, especially since most of them do not reflect the clinical wear.
Hendriks et al ¹⁵	CS	To evaluate the behaviour of posterior composite restorations.	232 Class I or II restorations in premolars and molars were made by three operators in a group of forty-nine adult patients. Each patient underwent one or two series of four restorations.	The results showed that the material, tooth type and evaluation year all have an influence on the anatomic form and the colour match of the restoration. The behaviour of the three composites with respect to colour match, marginal adaptation and marginal staining was acceptable. For anatomic form, however, only the behaviour of the microfilled composite Estic MF was still acceptable after 3 years.
Jones et al ²⁸	QI	To document themes from patients' collective, subjective experience; and explore links between illness and dental amalgam.	Seven focus groups involved 35 participants selected by random, criteria sampling from the computerized patient records of one medical practice.	Participants reported that the experience was costly both financially and socially, and wanted health professionals to be more open to considering mercury in a causal role for chronic illness.
Kemaloglu et al ²⁰	RCT	To compare the performance and postoperative sensitivity of a posterior resin composite with that of bonded amalgam and to evaluate whether resin composite could be an alternative for bonded amalgam.	Twenty patients in need of at least two posterior restorations were recruited. Authors randomly assigned one half of the restorations to receive bonded amalgam and the other half to composite restorations.	Both resin composite and bonded amalgam were clinically acceptable. Postoperative sensitivity results tend to decrease more in composite restorations rather than amalgams. Therefore

Continued.

Author	Kind of study	Aim	Methodology	Results
Letzel et al ¹⁷	CS	To calculate the 4-year survival rates for Occlusin restorations in all centres of the multicentre trial, and to analyse the reasons for failure of restorations in this trial.	In a multicentre clinical trial consisting of 12 centres, 232 amalgam and 932 composite Class I and Class II restorations were placed in 447 adult patients.	The main Type 2 reasons for failure of the restorations of Occlusin were pulpal involvement(16 restorations) and primary caries (9 restorations). The overall 4-year survival of Occlusin restorations relative to Type 1 and to Type 1 + Type 2 reasons for failure was 96 per cent and 93 per cent respectively. The centre was found to have a significant influence on the survival rate in both analyses.
Marell et al ³⁰	QI	To explore the experiences of illness and the encounters with health care professionals among women who attributed their symptoms and illness to either dental restorative materials and/or electromagnetic fields.	Thirteen women (aged 37-63 years) were invited to the study and a qualitative approach was chosen as the study design, and data were collected using semi-structured interviews.	Patients with environmental intolerance seek an explanation of their illness. Even if a medical answer cannot be given, an illness story and a positive consultation can be created, which could contribute to recognition and provide a sense of coherence for the patients.
Maserejian et al ¹⁴	RCT	To test the hypothesis that dental restoration materials affect children's growth.	Children (n=218 boys, n=256 girls) aged 6 to 10 yrs at baseline with ≥ 2 decayed posterior teeth were randomized to amalgam or composites (bisphenol-A-diglycidyl-dimethacrylate composite for permanent teeth, urethane-dimethacrylate compomer for primary teeth) for treatment of posterior caries throughout follow-up.	There were no significant differences in physical development over 5 years in children treated with composites or amalgam.
Norman et al ¹⁹	CS	To compare the posterior composite resin and the amalgam.	Eighty class I and class II light-cured posterior composite resin restorations were compared with 43 class I and class II amalgam restorations during a 5-year period after	The results of this clinical study showed that both materials were satisfactory during the time period and that the only significant

Continued.

Author	Kind of study	Aim	Methodology	Results
			placement.	statistical differences are a poorer marginal integrity for the amalgam and a greater wear rate for the composite resin.
Shenker et al²⁴	RCT	To evaluate a sub-population of the New England Children's Amalgam Trial (NECAT) for in vitro manifestations of immunotoxic effects of dental amalgam.	A randomized clinical trial in which children requiring dental restorative treatment were randomized to either amalgam for posterior restorations or resin composite. A total of 66 children, aged 6–10 years, were assessed for total white cell numbers, T-cell, B-cell, neutrophil and monocyte responsiveness over a five-year period.	This study confirms that treatment of children with dental amalgams leads to increased, albeit low level, exposure to mercury. In this exploratory analysis of immune function, amalgam exposure did not cause overt immune deficits, although small transient effects were observed 5–7 days post restoration.
Sjursen et al²⁹	QI	To explore how patients with health complaints attributed to dental amalgam experienced and gave meaning to changes in health complaints before, during, and after removal of all amalgam fillings.	A semistructured qualitative interviews were conducted with 12 participants from the treatment group in a Norwegian amalgam removal trial. Interviews took place within a couple months of the final follow-up 5 years after amalgam removal.	Patients were very happy to have had all their amalgam fillings removed, but they did not believe that they could credit all the positive changes to the amalgam removal. For some participants, this also meant that they thought they might be moving toward a personal acceptance of their health complaints.
Woods et al²²	RCT	To evaluate urinary mercury in children 8–18 years of age in relation to number of amalgam surfaces and time since placement over a 7-year course of amalgam treatment.	Five hundred seven children, 8–10 years of age at baseline, participated in a clinical trial to evaluate the neurobehavioral effects of dental amalgam in children. Subjects were randomized to either dental amalgam or resin composite treatments. Urinary mercury and creatinine concentrations were measured at baseline and annually on all participants.	Urinary mercury concentrations are highly correlated with both number of amalgam fillings and time since placement in children. Girls excrete significantly higher concentrations of mercury in the urine than boys with comparable treatment, suggesting possible sex-related differences in mercury handling and susceptibility to mercury toxicity.

Continued.

Author	Kind of study	Aim	Methodology	Results
Woods et al ²³	CS	Urinary concentrations of glutathione S-transferases (GSTs) To evaluate alpha and pi as biomarkers of renal proximal and distal tubular integrity, respectively, and albumin as a biomarker of glomerular integrity in children and adolescents 8-18 years of age over a 7-year course of dental amalgam treatment.	Five hundred seven children, 8-12 years of age at baseline, participated in a clinical trial to evaluate the neurobehavioral and renal effects of dental amalgam in children. Subjects were randomized to either dental amalgam or resin composite treatments.	No significant effects of dental amalgam mercury on measures of renal tubular or glomerular functional integrity during a prolonged course of dental amalgam treatment in children and adolescents from 9 to 18 years of age.

DISCUSSION

A clinical review regarding the efficacy of composite resin versus amalgam restorations

Many previously published randomized controlled trials have assessed and compared the clinical relevance between the composite resin and the amalgam restoration approaches. Regarding the failure rate, the Casa Pia study reported that more failure rates were reported in the composite group (129/892) more than in the amalgam one.¹³ Although the NECAT trial found no significant differences in the restoration failure rates between the two groups, higher failure frequencies could still be noticed in the composite group.¹⁴ Similar results that favored the amalgam restoration approaches were also reported by previous split-mouth studies.¹⁵⁻¹⁸ On the other hand, other split-mouth studies showed that similar rates were seen in the two study groups as reported by Cunningham et al.¹⁶ and Norman et al.¹⁹ Therefore, we can conclude that amalgam restorations can achieve better success rates than the resin composite group. This is consistent with the results of a Cochrane meta-analysis study which analyzed the failure rates in 331 composites and 127 amalgam restorations and found that the overall success rates were significantly more associated with the amalgam group than the composite one ($p < 0.0001$).¹

Regarding the development of secondary dental caries, the results of the NECAT study showed that 95 patients in the composite group developed dental caries and only 46 patients in the amalgam one with no statistical significance.¹⁴ Statistical significance was reported by the Casa Pia study which favored the amalgam restoration approaches in being less frequently associated with the development of dental caries.¹³ Similar results that favored the amalgam restoration approaches were also seen among other studies.¹⁶⁻¹⁹ On the other hand, Hendriks et al reported that composite restorations were significantly less frequently associated with secondary caries in the amalgam group.¹⁵ The Cochrane review has also analyzed this outcome, 2333 patients, in the composite group and 1703 patients in the amalgam one,

and the results favored the amalgam group indicating that the incidence of dental caries would be more frequent with resin composite restorations.¹ The NECAT and Casa Pia trials have also compared the two restoration approaches in terms of restorations fractures. In the NECAT trial, only two patients out of 753 in the composite group and three out of 509 in the amalgam one experienced fractures of restorations.¹⁴ On the other hand, higher frequencies were noticed in the Casa Pia study in both groups as 16 events were recorded in the composite ($n=829$) and amalgam ($n=856$) groups each.¹³ The combined meta-analysis of both studies showed no significant difference between the two groups. Regarding the postoperative pain, Kemaloglu et al reported that no significant differences were estimated between the two groups measures at two weeks, six, and 12 months intervals. Although the authors did not provide any evidence about the raw VAS scores of the participants, they reported significantly more favorable VAS scores among the restorations with composite resin at a 36-month follow-up period.²⁰

An overview of the safety of composite resins versus amalgam restorations.

Beyond the clinical efficacy perspective, many other aspects should also be considered when comparing the two restoration. Data from the Cochrane review study compared several side effects between the two groups from several trials. Regarding the neurobehavioral assessment, variable outcomes were assessed. Both groups showed a higher Rey auditory verbal learning test (RAVLT) at 7 years follow-up when compared to the baseline during treatment and the mean scores in the composite group were slightly higher. Similar results were also estimated for visual memory and learning tests, coding, symbol search, digit span, and finger windows. Renal functions were also assessed by previous investigations. In the NECAT study which included 490 children, the authors reported that no statistical significance was found between the two groups in terms of serum levels of biomarkers or higher levels of biomarkers in one group over the other. On the other

hand, the authors found significantly higher rates of microalbuminuria in the patients with the amalgam group at three and five follow-up intervals. However, the authors justified that the significance of this finding should be furtherly investigated as microalbuminuria can frequently occur in the general population and many factors can induce it as fever, heavy exercises, and infections.²¹ Similarly, the Casa Pia trial also found no significant correlation between the application of either composite and the effect of urinary porphyrin excretion. However, the authors found no significant differences regarding microalbuminuria between the two groups.²² Urinary mercury excretion has been also assessed with the amalgam restoration procedures. Woods et al in a comparative trial reported that high mercury levels in the urine were significantly associated with the number of fillings and the interval between installment and assessment.²³ The authors also found that female patients exhibited higher amounts of mercury in their urinary samples which is indicative of gender impact on this feature, therefore, further investigations should be conducted for better assessment. The meta-analysis of the cochrane review showed that for both groups the creatinine-adjusted urinary albumin levels increased dramatically during the first three years, up to a mean of 9.9 for the composite group and 9.0 for the amalgam one. This could be in favor of using the amalgam restoration approaches in patients with impaired kidneys, however, at a 7-year follow-up, data showed that no significant differences were noticed between the composite (mean=6.8) and the amalgam (mean=6.5) groups. Therefore, no conclusion could be drawn regarding this outcome, and further investigations are needed for a better judgment.¹ Shenker et al conducted a randomized trial to compare composite and amalgam restorations in terms of immune functions and alterations.²⁴ The authors found that although some decline was noticed in the T-cells and monocytes counts at the 5-7 days from restoration with amalgam, no significant differences were noticed after 6, 12, and 60 months of follow-up. Regarding physical development, no significant differences were noticed between the two groups in terms of growth charts and percentiles, neither for boys nor girls.¹

Economic evaluation and the patient's perspective

Data from the NECAT trials showed that amalgam restoration in the posterior permanent tooth cost 169\$ at a Canadian level achieving a mean of 11 years of the useful time when compared to the cost consumed by the composite resin (mean cost=210\$) for a mean useful time interval of 8 years.²⁵ A previous meta-analysis estimated that a mean of 7.8 amalgam restorations would be required for a 7.9-year-old boy as these restorations have been proven to take more time to fail than the composite resins which will require a mean of 10.7-lifetime replacements for the same child. This can lead to huge lifetime savings and discounts when using amalgam restoration approaches. The same analysis estimated this

discount to be 682\$ for amalgam restorations and 1,191\$ for resin composites in Canadian costs.²⁵ Similar estimation of costs for both materials was also done in the United Kingdom as research shows that lifetime costs were 1997£ that is ranging between 303.7£ for amalgam restorations to 709.85£ for resin composite restorations.²⁶ In the United States, the costs were even higher as research estimates show that the average lifetime costs for a premolar restoration to be 2,108\$ and 2,187\$ for a molar tooth.^{25,26} However, none of these investigations put in their mind the possibility of any anticipated discounts. The meta-analysis by CADTH showed that a total of 1,322\$ and 2,251\$ for amalgam and resin composite restorations, respectively, were the undiscounted costs at a case base scenario. In the same context, the undiscounted costs at a crown case scenario were found to be 1,046\$, and 1,128\$ for the amalgam and resin composite restorations, respectively.²⁵ These data should be carefully interpreted as there might have been some miscalculations. Amalgam restorations have also been estimated to contribute a total of 2.51 kg from a total of 4,470 kg of Hg that is estimated to be in the annual Canadian surface water load of Hg. Therefore, special instruments in the dentistry field have been used to reduce the amounts of Hg that is released from the amalgam materials and prevent the possible contamination of the surface water.

This process comes to an annual estimated cost of 16.63\$ million for the Canadian clinics of dentistry.²⁵ On the other hand, composite resins might require extra effort and time to prepare for the restoration process & the polymerization of the intact resin.¹¹ However, the time loss for this process has been estimated to be ranging between 23.7-36.0 minutes for resin composites and 27.3-41.5 minutes for amalgam restorations. This can affect the anticipated outcomes of the healthcare providers.²⁵

Regarding the patients' perspectives and opinions, previous studies showed that some patients reported unfavorable outcomes and discomforts regarding both modalities.²⁷⁻³⁰ Patients reported that dental amalgam restorations were associated with undesirable outcomes that required consulting a family physician and/or dentist to help them with such events and help establish a proper diagnosis and management and in some cases, remove the restorations that were used. The side events were variable in severity and ranged from idiopathic dissatisfaction to suffering from Hg poisoning as reported by the patients. It is worth mentioning that evidence also showed that more pleasant levels were associated with dealing with more professional dentists that can handle such situations with suitable alternatives.

Some studies also showed that whenever patients identified amalgam restorations as the cause of their illnesses, they were directed to remove it while other patients did not consider the procedure because of the anticipated costs.²⁷⁻²⁹

CONCLUSION

Most of the evidence we found in this review suggests that composite resins are associated with higher rates of restorations failure and the development of secondary dental caries than amalgam restorations. Studies suggest that amalgam restoration materials should be the choice for treating the proximal dental caries in high risk patients. Based on findings from previous studies, we could not determine any favorable significant events of either of the materials over the other in terms of neurological affection and kidney functions even though some reports showed that microalbuminuria may be associated with composite resins. We have also found that patients' satisfaction with the amalgam restorations might be low due to the potential development of some side effects that are attributable to lead intoxication.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

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Cite this article as: Gomaa MS, Jameel TK, Saeed SK, Alhadhrmi LJ, Qutub RH, Sindi RB, et al. An overview of composite versus amalgam for dental restorations. *Int J Community Med Public Health* 2021;8:959-68.