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Longevity of dental amalgam

Longevidade do amálgama dentário

Longevidad de la amalgama dental

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ABSTRACT

Objective: To carry out an integrative literature review collecting findings on the longevity of dental amalgam, comparing them with composite resin. **Methods:** The PubMed, Virtual Health Library (VHL) and LILACS databases were used to search for scientific articles. For the literature search, the following keywords were applied: Amalgam, Dental Restorations, Survival, Longevity, Failure. All descriptors were combined with each other using the Boolean operator “AND” and following the description of the MeSH/DeCs terms. After applying the eligibility criteria, nine articles were selected. **Results:** Several properties influence the longevity of amalgam restorations, with survival and failure rates of amalgam restorations varying across studies, with disagreements over the superiority of composite resin or dental amalgam. The main cause of failures in restorations is secondary caries and, in some cases, only repair with amalgam in restorations appears as a solution instead of the complete replacement of the material. **Final considerations:** Knowing that amalgam is still present in the clinical practice of some professionals, as well as in the oral cavity of a large portion of the population, the replacement or repair of these restorations must be evaluated individually, without the bias of toxicity or release of mercury by the material.

Keywords: Dental Amalgam, Longevity, Dental Restorations, Permanent, Dental Restoration Failure.

RESUMO

Objetivo: Realizar uma revisão integrativa da literatura coletando achados sobre a longevidade do amálgama dentário, comparando-os com a resina composta. **Métodos:** As bases de dados PubMed, Biblioteca Virtual em Saúde (BVS) e LILACS foram utilizadas para a busca de artigos científicos. Para a busca na literatura, foram aplicadas as seguintes palavras-chave: Amalgam, Dental Restorations, Survival, Longevity, Failure. Todos os descritores foram combinados entre si usando o operador booleano “AND” e seguindo a descrição dos termos MeSH/DeCs. Após a aplicação dos critérios de elegibilidade, nove artigos foram selecionados. **Resultados:** Várias propriedades influenciam a longevidade das restaurações de amálgama, com taxas de sobrevivência e falha de restaurações de amálgama variando entre os estudos, com divergências sobre a superioridade da resina composta ou amálgama dental. A principal causa de falhas nas restaurações é a cárie secundária e, em alguns casos, apenas o reparo com amálgama em restaurações aparece como solução ao invés da substituição completa do material. **Considerações finais:** Sabendo que o amálgama ainda está presente na prática clínica de alguns profissionais, assim como na cavidade bucal de grande parcela da população, a substituição ou reparo dessas restaurações deve ser avaliado individualmente, sem o viés da toxicidade ou liberação de mercúrio pelo material.

Palavras-chave: Amálgama Dentário, Longevidade, Restauração Dentária Permanente, Falha de Restauração Dentária.

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RESUMEN

Objetivo: Realizar una revisión integrativa de la literatura recogiendo hallazgos sobre la longevidad de la amalgama dental, comparándolos con la resina compuesta. **Métodos:** Se utilizaron las bases de datos PubMed, Biblioteca Virtual en Salud (BVS) y LILACS para la búsqueda de artículos científicos. Para la búsqueda bibliográfica se aplicaron las siguientes palabras clave: Amalgam, Dental Restorations, Survival, Longevity, Failure. Todos los descriptores se combinaron entre sí utilizando el operador booleano "AND" y siguiendo la descripción de los términos MeSH/DeCs. Después de aplicar los criterios de elegibilidad, se seleccionaron nueve artículos. **Resultados:** Varias propiedades influyen en la longevidad de las restauraciones de amalgama, con tasas de supervivencia y fracaso de las restauraciones de amalgama que varían entre los estudios, con desacuerdos sobre la superioridad de la resina compuesta o la amalgama dental. La principal causa de los fracasos en las restauraciones son las caries secundarias y, en algunos casos, solo aparece como solución la reparación con amalgama en las restauraciones en lugar de la reposición completa del material. **Consideraciones finales:** Sabiendo que la amalgama aún está presente en la práctica clínica de algunos profesionales, así como en la cavidad bucal de gran parte de la población, el reemplazo o reparación de estas restauraciones debe evaluarse individualmente, sin el sesgo de toxicidad o liberación de mercurio por el material.

Palabras clave: Amalgama Dental, Longevidad, Restauración Dental Permanente, Fracaso de la Restauración Dental.

INTRODUCTION

With the expansion of new treatments and innovative materials in dentistry, dental aesthetics has become something of great importance for the population, and is often associated with oral health (REZENDE MCRA e FAJARDO RS, 2016).

Knowing that aesthetics is considered subjective and may change according to a number of factors, such as time, culture and psychological issues (ROCHA CKF et al., 2021), a few years ago, polished and shiny gold or amalgam restorations were considered beautiful. However, restorative materials that resemble the tooth, such as composite resin, have been considered more aesthetic for a significant time (FRANCCI CE, et al., 2014).

Dental amalgam is a metal alloy used as a type of restorative material for over 160 years in dentistry, and there are also some reports of its use from 659 A.D (ALCÂNTARA ICG, et al., 2015). The first material to be called amalgam was named by Iohannes Stocker in Germany (MOLIN C, 1992; VALLE VMF, 2001).

The American Dental Association (ADA) explains that amalgam is a material made up of 65% silver, 29% tin and 6% copper, also containing zinc, gold and mercury in unspecific amounts. In the 1970s, changes occurred in the composition of amalgam that provided better properties for the material, with the appearance of alloys with a high copper content, having up to 30% of copper in the composition (CHAIN MC, 2013).

On the other hand, in 1843 was obtained acrylic acid, having this discovery as the basis for the evolution of the material that would later be called "composite resin" (MORAES MAS, et al., 2003). Acrylic resin, despite being widely used, presented some challenges in terms of adhesion to the tooth structure. Thus, in the 1950s, these composites evolved thanks to the development of the acid etching technique, which improved the retention of these resins (CHAIN MC, 2013). In this way, the evolution has only been growing, given that over the years, and until the present moment, there have been modifications in the material to optimize its properties (SILVA JMF, et al., 2008).

The need to replace amalgam restorations with composite resin in dental offices has been widely discussed (PEDRINI D, et al., 2009). Therefore, it is extremely important that the dentist understands the positive and negative characteristics of each material and compares them, in order to choose which restorative material to use or the real need to replace restorations, based on the individual needs of the patient and working conditions and equipment available in the clinical environment (ESTAY J, et al., 2018; BERNARDO M, et al., 2007). Therefore, the objective of this research was to carry out a literature review collecting findings on the longevity of dental amalgam, comparing them with composite resin.

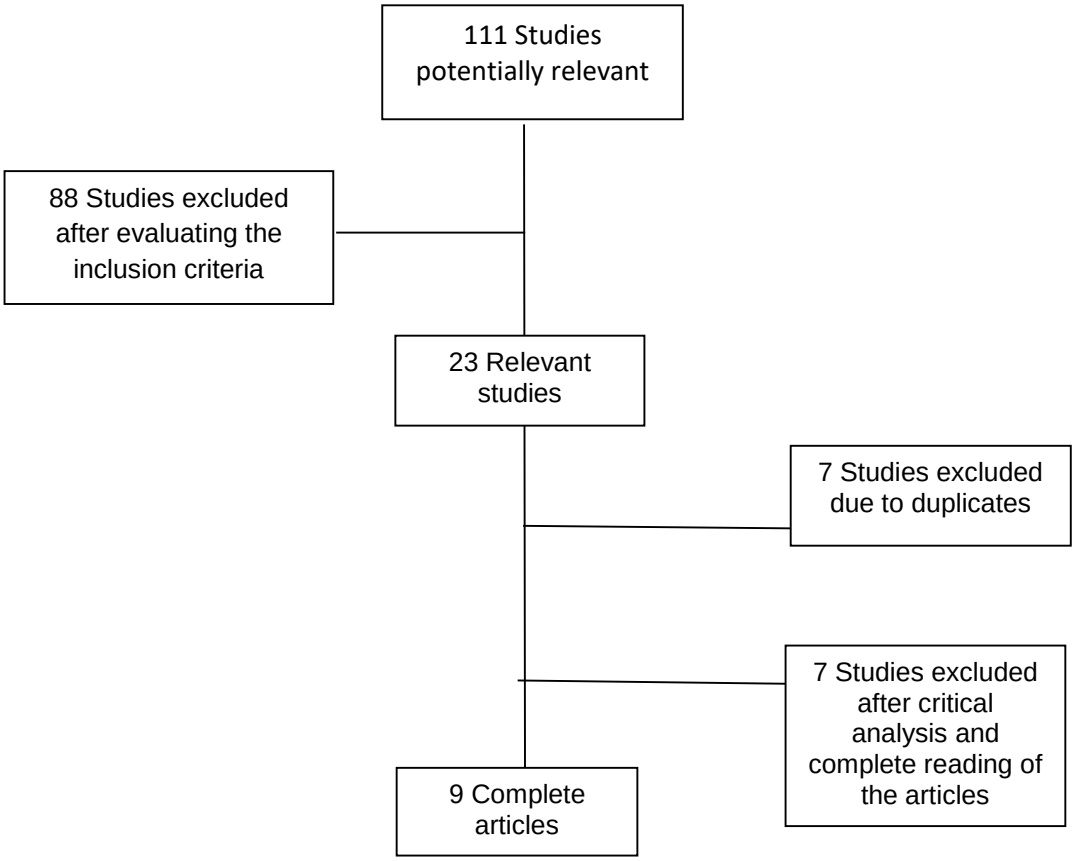
MÉTHODS

This is an integrative literature review on the longevity of amalgam restorations. PubMed, Biblioteca Virtual em Saúde (BVS) and LILACS databases were used to search for scientific articles. For the literature search, the following keywords were applied: Amalgam, Dental Restorations, Survival, Longevity, Failure. All descriptors were combined with each other using the boolean operator “AND” and following the description of MeSH/DeCs terms.

In total, 111 results were found. However, as inclusion criteria, articles from the last 22 years were considered, which were randomized clinical trials and in vitro studies. Articles classified as literature reviews, systematic reviews, final papers, dissertations and theses were excluded. After using the filters, 23 results were found.

Afterwards, a pre-selection of the articles was made, where the title and abstract of the studies were read. At that first moment, those that dealt with the subject to be addressed were considered and 7 were excluded due to duplicity. Only then was the analysis and complete reading of the articles made to select them. Thus, a total of 9 articles were included in the review, as shown in the flowchart in **Figure 1**.

Figure 1 - Flowchart of the selection process of articles for integrative review.



Source: Silva ARJ, et al., 2023.

RESULTS AND DISCUSION

A summary of the objectives and main results of all nine studies included in this review was performed to facilitate understanding of the readers and were organized in descending order of year of publication (from 2020 to 2003) in **table 1**.

Table 1 - Results found in the literary search.

AUTHOR/YEAR	AIM	MAIN RESULTS
JARDIM JJ, et al., 2020	To compare the survival of restorations placed in deep carious lesions after selective removal of carious tissue to soft dentin over a period of 5 years and to assess whether the type of material used (amalgam or composite resin) affected the survival of the restorations.	Similar survival rates were found regardless of the type of restorative material and the carious tissue removal technique used.
ESTAY J, et al., 2018	To clinically evaluate posterior amalgam and composite resin restorations over a period of 12 years, investigating the influence of repair on longevity and comparing their clinical conditions with control groups.	After 12 years, what stood out when compared with baseline assessments were significant differences in marginal color, gloss, marginal fit, anatomy, and roughness of the amalgam restorations. Furthermore, roughness was seen to be significantly higher in composite resin restorations than in amalgam restorations.
ESTAY J, et al., 2017	To clinically evaluate posterior amalgam and composite resin restorations over a period of 12 years, comparing the behavior of restorations that received repair with the control group.	No differences were found in the longevity analysis when comparing the group that received the treatment with the control group. There was better marginal adaptation performance in composite resin restorations in the control group and in anatomy of amalgam restorations in the remodeled group.
MONCADA G, et al., 2015	To evaluate the effectiveness of repair of localized clinical defects in amalgam restorations that were initially scheduled for restoration replacement.	The use of minimally invasive techniques to increase the longevity of restorations has had positive results when observing the clinical parameters of a restoration after 10 years.
FERNÁNDEZ EM, et al., 2011	Observe amalgam and composite restorations with localized defects where sealing, repair, and restoration were used as a treatment to increase the longevity of the restoration, and thus estimate the mean survival time.	The average survival time for restorations that received an alternative treatment to total replacement of the restorative material was considered reasonable, and this increase in longevity could exist through minimal intervention.
BERNARDO M, et al., 2007	To compare the longevity of amalgam and composites through a randomized clinical trial.	Survival rates of amalgam restorations were higher when compared to composite resin restorations, in addition to having a lower failure rate. There is also a significant difference in these survival rates when the restorations have more faces and when the size is larger.

AUTHOR/YEAR	AIM	MAIN RESULTS
SONCINI JA, et al., 2007	To compare the replacement rates of composite and amalgam restorations in primary and permanent posterior teeth over five years.	52% of composite restorations in deciduous posterior teeth were replaced due to recurrent caries, a higher number than replacements of amalgam restorations. In permanent posterior teeth, the amount of repairs was greater than replacements and, also, in greater quantity in composite resin restorations when compared to amalgam restorations.
QVIST V, et al., 2004	To compare the longevity and cariostatic effects of conventional glass-ionomer and amalgam restorations in primary teeth.	The median survival time for ionomer restorations was estimated at 42 months. That of the amalgam could not be estimated, but it is known to have exceeded 7.8 years. Therefore, the conventional glass ionomer was not the most appropriate for restorations of deciduous teeth, mainly due to the amount of failures it can present.
VAN NIEUWENHUYSEN JP, et al., 2003	To investigate the adequation of extensive amalgam and composite resin restorations in the clinical routine.	The average survival time of amalgam was higher than that of composite resin, however, in relation to the failures that this type of restoration can present, secondary caries were more frequently observed.

Source: Silva ARJ, et al., 2023.

Evaluating a study with follow-up of amalgam and composite resin restorations for 12 years, it was found that in the group of amalgam restorations, when comparing the initial evaluation and the first year with the 12-year examination, there were significant differences in marginal coloration, brightness, marginal adaptation, anatomy and roughness, in addition to more roughness of restorations made of composite resin than of restorations made of amalgam, stating that there is a difference in how these materials react in the oral environment over time, since the biofilm, diet and mouth brushing are difficult factors to cause these changes in metallic alloys (ESTAY J, et al., 2018).

Accordingly, another study also with a 12-year follow-up compared the survival rate of amalgam and composite resin, finding that more failures were found in restorations in which amalgam was used. However, when comparing the groups to each other, no difference was found in the longevity of the restorations and that, over time, a similar trend of degeneration was seen, in parameters such as brightness, roughness, anatomy and marginal coloration, for both groups. It is also worth mentioning that a better performance was seen in the marginal adaptation of composite resin in the control group and in the amalgam anatomy in the remodeled group (ESTAY J, et al., 2017).

On the other hand, evaluating the survival of restorations according to the type of material used, one study in which the sample consisted of 722 amalgam restorations and 115 composite resin restorations verified that 48% of the restorations worked well and 28% failed, of those that failed 28% of the restorations were amalgam and 30% composite resin (VAN NIEUWENHUYSEN JP, et al., 2003).

In addition to this, another evaluated 1748 restorations in posterior permanent teeth over a period of 7 years, with a survival rate of 94.4% for amalgam and 85.5% for composite resin, showing higher rates mainly in small restorations and with only one surface (BERNARDO M, et al., 2007).

Amalgam restorations had a longer median survival time, showing 12.8 years, while composite resin restorations had 7.8 years. In addition, regarding the most common failures, most fractures were in composite resin restorations, with some differences between the rates: 18% (VAN NIEUWENHUYSEN JP, et al., 2003) and 12.7% (BERNARDO M, et al., 2007), but with secondary caries being the main cause.

For children from 6 to 10 years old, secondary caries is as an important factor for replacement of restorations in deciduous posterior teeth. Over a 5-year study period, it was found that in permanent posterior teeth there were more repairs done in composite resin restorations (2.8%) than in amalgam restorations (0.4%). Thus, the authors direct, through these findings, to the longevity of amalgam as superior to that of restorations made in composite resin (SONCINI JA, et al., 2007).

Comparing, over 10 years, 13 replaced and 17 repaired amalgam restorations, it was observed that parameters such as marginal adaptation and roughness were similar, with the exception of the anatomical shape, which was explained by the fact that the repair was not able to completely restore the anatomy of the tooth. In this way, the restorations had clinical aspects considered acceptable, however, what caught the attention of the researchers was the increase in performance using a minimally invasive clinical procedure (repair), a technique that will reduce the amount of healthy tissue lost and patient stress (MONCADA G, et al., 2015). Therefore, the minimally invasive treatments will increase the longevity of restorations, without necessarily having their total replacement as a treatment of choice (FERNÁNDEZ EM, et al., 2011).

Regarding the technique used during the treatment of carious lesions, 61 amalgam restorations and 111 composite resin restorations after 5 years were analyzed, and it was observed that there is no significant difference in the success rates of restorations made in soft or hard dentin, and that the type of restorative material used did not affect the longevity of the restorations, with a survival rate of 83% for amalgam and 75% for composite resin (JARDIM JJ, et al., 2020).

The longevity of restorations can be influenced by some factors such as the technique used, skill, use of suitable materials and the patient's oral hygiene (MIGGIANO R, 2017). Amalgam represents more than 90% of restorations that have been present in the mouth of patients for more than 10 years, with a longevity many times greater than that of composite resins. Studies estimate that the average survival time of amalgam restorations is 11.8 years (KIM K, et al., 2013).

Secondary caries is pointed out as a frequent reason for replacing restorations (VAN NIEUWENHUYSEN JP, et al., 2003; BERNARDO M, et al., 2007; SONCINI JA, et al., 2007), in which this injury stood out as the reason for failure in the restoration, especially when the material used was composite resin. Secondary caries is defined as a carious lesion that occurs adjacent to the restoration, having the same etiology as primary caries, that is, it is caused by an imbalance in the des-remineralization process (MALTZ M, et al., 2016). It is known that there are 2 mechanisms for the occurrence of this type of injury, a “wall injury” when there is infiltration of bacteria and/or fluids between the restorative material and the tooth, or an “external injury” when there is a primary attack on the tooth external surface of the tooth (SILVA BB e MALTZ M, 2004). However, the lesion is more closely related to local conditions that favor the formation of an accumulation of cariogenic microorganisms than a microleakage that is not clinically detectable (OZER L, et al., 1997).

Secondary caries may be associated with the roughness presented in the restorations, since roughness is identified as a criterion that influences the accumulation of biofilm and bacterial adhesion, since surface irregularities make cleaning difficult, which consequently can lead to the formation of lesions caries and interfere with the longevity of the restorative material (CAZZANIGA G, et al., 2015). Therefore, the importance of finishing and polishing after completion of the restoration, reducing surface roughness and consequently the accumulation of microorganisms, thus making it possible to achieve a good rate of treatment longevity (BURITY EKT, et al., 2023).

Roughness can be seen both on the surfaces of amalgam and composite resin restorations, therefore, it is also worth noting that the use of composite resin is extremely technically sensitive and must be used in good working conditions and in the presence of optimal equipment to improve survivability and lower failure rates (ESTAY J, et al., 2018). Dental amalgam has the advantages of longevity, low cost, wear resistance, easy handling and biocompatibility. On the other hand, resin composites have the fundamental advantages of low toxicity, good biological biocompatibility, excellent aesthetics and adhesion to dental tissues. However, composite resins suffer from wear and color changes when they spend a long time in the mouth, have little resistance to degradation and suffer plastic deformation, causing permanent dimensional changes, which

occur when their limits are exceeded, requiring a lot of technical knowledge in choosing the appropriate material. for each particular case (SILVA NETO JMA, et al., 2021).

There are situations in which amalgam restorations are replaced unnecessarily, and the best course of action is their maintenance or repair, thus avoiding a repetitive restorative cycle with loss of healthy tooth tissue, in addition to being a conservative procedure, it can increase the longevity of the restorative material. (MONCADA G, et al., 2015; DE CENA JA, et al., 2016).

However, an analysis found a favorable trend for composite resin restorations over 13 years, from 2004 to 2016. In the study it was observed that in the period from 2004 to 2008 the material of choice was amalgam and from 2012 there was a "turn of the key" and the amount of composite resin used in restorations skyrocketed (ZABROVSKY A, et al., 2018). Thus, it is clear that the use of amalgam has been unusual in clinical practice, because despite its advantages, the material will also present several shortcomings, among them are: unsightly, greater loss of healthy tooth tissue during cavity preparation, requires macromechanical retention and presence of mercury (ALEXANDER G, et al., 2014). In addition, although its longevity is considered much greater compared to composite resin (BARATIERI LN, et al., 2012), there are studies disagree showing a survival rate for composite resin calculated at 82.2% for 10 years, versus 79.2% for amalgam, which implies an improvement in the longevity of composite resin restorations when used, if a well-applied technique and quality materials (SHITSUKA C, et al., 2014).

At the present time, there has been a lot of discussion about the toxicity of dental amalgam, since there is mercury in its composition. Mercury is the only liquid metal at room temperature, spreading in spherical globules, volatizing easily and toxically, in which exposure to its different forms can cause serious damage to human health (ESTRADA M, 2018). It is important to correctly dispose of amalgam in the form of solid waste, which must be done in hermetically sealed and super resistant containers, in order to reduce the risk of environmental pollution. In October 2013, the Minamata Convention on Mercury stated that the gradual reduction of dental amalgam should be done. In addition, studies have advocated the use of materials that can replace amalgam whenever they are available (BERLIN M, 2020).

On the other hand, the International Dental Research Association states that the levels of mercury released in an amalgam filling are well below the 6 µg/d limit set by the US Department of State and Environmental Protection Agency (AJIBOYE AS, et al., 2020; NATIONAL CENTER FOR ENVIRONMENTAL ASSESSMENT, 1995).

The Brazilian Federal Council of Dentistry, in September 2022, also declared in a note that dental amalgam has mercury in an inorganic form, in which it is considered less dangerous, and which is still considered safe, and should not be replaced by other restorative materials with the justification of mercury contamination (MORAES RR, 2022; DODES JE, 2001). Brazil was one of the countries that signed the Minamata Convention on Mercury. In view of this, the Ministry of Health published technical opinion guiding the use of dental amalgam.

Therefore, it was declared that the removal of the amalgam restoration must be evaluated on a case-by-case basis and, when indicated, the following protocols must be followed: complete use of PPE by the dentist and patient, absolute isolation and conventional suction cup over the isolation, use of a filter or particle separator, use of a carbide drill or diamond tip, sectioning the amalgam crosswise to remove it in blocks, with the aim of minimizing mercury inhalation, and changing the rubber sheet for restoration in composite resin (MINISTÉRIO DA SAÚDE, 2022).

A study investigates the increase in the release and concentration of mercury in vitro in an artificial saliva solution when exposed to magnetic resonance imaging, it was demonstrated that the release of mercury from dental amalgam was greater after exposure to magnetic resonance imaging, based on the results achieved, it is also mentioned that differences are likely to occur compared to in vivo due to variation in composition and continuous salivary flow, however, because they remain in the same volume of artificial saliva during exposure to magnetic resonance imaging and for 24 hours later, it is likely that the mercury concentration in real saliva is lower than in this study, as in vivo saliva is continuously replenished.

The total amount of mercury released may also be greater, possibly reducing the mercury concentration gradient and decreasing the release rate compared to in vivo, however it is concluded that the amount of mercury released is very unlikely to be clinically significant and remaining well. below safe ingestion levels, mercury release from dental amalgam should therefore not be a clinically significant concern during MRI scans, even for patients with many amalgam fillings (ALISSON JR, et al., 2022).

Most dentists believe they have adequate knowledge of methods to manage amalgam residue. During the Minamata World Convention in late November 2019, among the items debated was a complete ban on amalgam worldwide by 2024, although it may be the last year that dentists will stop placing amalgam, the impact on the environment will need be managed for many more years and most countries are not technically or financially prepared for this change in practice, this will lead to decisions that will affect alternatives for the management of mercury waste arising from the removal of existing amalgam fillings (MORAES RR, 2022; AJIBOYE AS, et al., 2020; NATIONAL CENTER FOR ENVIRONMENTAL ASSESSMENT, 1995).

Education in a technological and globalized society must enable dentistry professionals to work with scientific and technological knowledge, developing skills to operate them, review them and rebuild them wisely, being able to employ practices that guide hospitals and dental clinics through environmental education that can shed a new light on mercury contamination and its impacts on health and the environment, which is not only guided by market and technological alternatives, but which points to clinical transformations that allow facing and minimizing the causes of socio-environmental degradation, which has its most explicit translation in the destruction of the environment. At this point, it is worth noting that dentistry professionals, in general, do not have in their curricula disciplines that highlight the conservation of the environment and the possible impacts generated by its clinical practice, which is a necessary fact of correction (MORAES RR, 2022; AJIBOYE AS, et al., 2020; NATIONAL CENTER FOR ENVIRONMENTAL ASSESSMENT, 1995).

There are several properties that influence the longevity of amalgam restorations and their understanding is essential to understand the functioning of this material over time, as verified by the studies included in this review. Survival and failure rates of amalgam restorations varied between studies, with disagreement over the superiority of composite resin or dental amalgam. Secondary caries appeared as the main cause of restoration failures and, moreover, only amalgam repair appears as a solution to some clinical problems in restorations compared to complete replacement of the material.

FINAL CONSIDERATIONS

Dental amalgam is still present in the clinical practice of some professionals, as well as in the oral cavity of a large portion of the population. The longevity of this material varies according to some situations, but secondary caries is the main reason for failure. The replacement or repair of these restorations must be evaluated individually, but without the bias of toxicity or release of mercury by the material. As a limitation of the study, it can point out some divergences between the works found in the results obtained for the evaluated materials, as well as the small number of articles found with adequacy to the eligibility criteria for this literature review. The future perspective points to more randomized clinical trials that evaluate properties of composite resins recently launched on the market and the development of new materials with increasingly improved properties and excellence.

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