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Review

Usage, Longevity, and Biocompatibility of Amalgam Restorations

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Abstract

Dental amalgam serves as a filling or restorative material for dental cavities due to either caries, mechanical injury, or other reasons. No other restorative material is known for having the ability to marginally seal, which develops over time once the restoration is inserted in the mouth and leads to minimal microleakage. Dental amalgam may still be the primary restorative material used for load-bearing restorations in several regions. posterior dentition has been reevaluated thanks to long-term evidence from longitudinal research. The environment in which dental amalgam restorations are put determines how long they will last. The median survival periods for posterior amalgam fillings in research done in primary care ranged from seven to fifteen years. Amalgam can be safely used as a biomaterial for adults and children who are at least six years old, according to the United States Food and Drug Administration (US FDA). Mercury concentrations in the blood, plasma, saliva, breast milk, hair, brain, and liver have been studied in patients who have undergone amalgam fillings and they have been found to be below those that have a negative impact on health. Despite their rarity, the US FDA notes that some persons are allergic to DA and may experience allergic responses after having their teeth restored with this substance.

Keywords: *dental amalgam, longevity, restorative dentistry, biocompatibility*

Introduction

Dental amalgam (DA) serves as a filling or restorative material (RM) for dental cavities due to either caries, mechanical injury, or other reasons. For nearly two centuries, DA has been used as a RM (1). This prolonged therapeutic presence has a variety of causes. In contrast to the majority of other RMs used in restorative dentistry, DA is very affordable and simple to produce. DA restorations have a long lifespan (2). DA is simple to manipulate once it has been inserted into the prepped dental cavity. The RM exhibits minimum volumetric variation over time, less creeping, substantial compressive strength, and great durability against wear (3). No other RM is known for having the ability to marginally seal, which develops over time once the restoration is inserted in the mouth and leads to minimal microleakage. This quality is a result of the corrosive reaction products that DA restorations emit. In contrast to most other RMs, the clinical insertion of a DA restoration is less method sensitive to operative environment, like the existence of saliva in the mouth. Yet, due to biocompatibility issues raised by its high mercury concentration, DA is arguably the most contentious dental material. Elements of mercury make up around 50% (wt.) of DA, and a small amount of it is dispersed as mercury vapors which may be breathed in. The dental cavity must be properly prepared before placing DA. Mechanical retention is crucial because DA is unable to attach to the dental tissues.

Methodology

This study is based on a comprehensive literature search conducted on December 20, 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about usage, longevity, and biocompatibility of amalgam restorations. There were no restrictions on date, language, participant age, or type of publication.

Discussion

According to various investigations, the general usage of DA in the United States has dramatically decreased over the past ten years (4). The quantity of resin composite (RC) restorations outnumbered DA restorations in one state in 1999 (5). According to a 2005 survey, DA was the first RM taught in four-fifth of US schools, and three-fifths of the students' posterior fillings utilized DA. According to one assessment, direct posterior restorations are treated similarly at Canadian dental schools (6). In all institutions that responded, DA and RC posterior restorations were covered, with either the same or higher focus being given to DA (6). This shows that DA remains a favorite amongst Canadian academicians. DA is utilized similarly in the United Kingdom and the United States. 35% of the 654 generalists surveyed in Britain in 2001 who treated large load-bearing restorations on molars said they "occasionally" utilized RCs (7). In response to this query, 15% said "oftentimes," and 1% said "always." When RC wasn't used, it is assumed that DA was. In one small study, 30 practitioners in the UK stated that DA made up 87% of class II fillings and 67% of class I fillings (7). Some Nordic nations employ DA less commonly than others. Only 28% of Finnish dentists and 40% of Swedish practitioners, according to Ylinen and Lofroth, utilized DA in 2002 (8). In Finland, where 548 practitioners responded to a study from 2000 with information about all the fillings they installed in a typical working shift, DA use was meager. Only 8% of class I fillings used DA, while only 9% of class II fillings used RC (80% resin composite). For a patient of age 20 presenting with a mandibular second molar occlusal lesion, 52.4% of the 173 Danish practitioners, 19.9% of the 759 Norwegian practitioners, and 2.9% of the 923 Swedish practitioners said they would employ DA to repair it (9). Generally speaking, the European schools were comparable to those in the United States in that DA was still taught for class I and II restorations, and at the number of institutions, DA took up the majority of the instruction hours. Overall, DA is still being taught in universities in Europe. The duration of time spent on DA as a RM in one Dutch dental school's syllabus has been steadily declined (10). It completely discontinued training regarding DA in 2001. According to cross-sectional studies of Australian practitioners, the utilization of DA slowly decreased from 57.8% to 23.3% of all restorative services provided between 1984 and 1999 (11). In a 2002 study of 560 randomly chosen Australian practitioners, 32% indicated using RCs "occasionally" for significant load-bearing restorations on molar teeth; 29% said they did so "frequently," and 12% said they did so "oftentimes (12)." In comparison to a research of a comparable format carried out in the UK (16% "often" or "always"), the first two groups showed that RC was used more frequently in

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Australia (41% "often" or "always") (7). These statistics indicate a more significant shift away from DA in Australia than in Europe or the US. In Japan, the opposition to DA has grown even more. However, there are only two accounts of this phenomenon in the English language, and neither one includes any supporting information (12, 13). According to both papers, DA is rarely used in general dentistry, which may be related to the widespread mercury concern in Japan that developed from the 1950s poisoning of Minamata and Niigata residents (13, 14). Fish contaminated with methyl mercury was swallowed by the individuals. It is noteworthy that many Japanese dental institutions do not consider RC an acceptable RM for large class II fillings considering the discontinuation of DA. Twenty five out of 27 Japanese dental schools surveyed in 1997 taught RC for class I restorations, however fewer than 19% of the schools thought RC was a good three-surface class II RM (15). There are few outside-the-US data points. DA may still be the primary RM used for load-bearing restorations in several regions. For instance, 88.8% of all class I and class II fillings were made with DA, according to a 1997 assessment of 241 Jordanian practitioners (16, 17). The pattern is more prevalent in some nations than it is in North America and Europe. For instance, a 1999 study of 65 Brazilian schools found that 97% of them thought RC was appropriate for class I fillings. Only 33% of Brazilian participants stated RC was appropriate for three-surface class II fillings, similar to the opinion of the instructors from dental institutions in the northern countries (18).

It was clear that median survival durations of DA restorations in molars and premolars differed significantly between investigations when Mjor and others evaluated the lifetime of posterior restorations in 1990 (19). Restoration longevity statistics can still seem disorganized even after decades of studies. As an instance, Manhart and other researchers evaluated clinical trials of different RMs used in posterior dentition in 2004, comprising 41 investigations of DA and 50 investigations of RC (20, 21). They discovered that the yearly rate of failure variations was large, ranging from 0 to 7.4% for DA to 0 to 9.0% for RC. Based on these investigations, they estimated average yearly rates of failure of 2.2% for posterior RC fillings and 3.0% for DA fillings (standard deviation, 1.9%). The failure rates of RC and DA are not substantially distinct, so this does not imply that RCs outperformed. However, it would be incorrect to assume that posterior RC fillings would be at least as effective as DA. Manhart and coworkers acknowledge that it is "challenging to make a direct comparison multiple research from different researchers," but they are vague regarding some of the difficulties that can arise when merging data from several investigations (20). As Mackert and Wahl pointed out, several of the mentioned studies, for instance, had comparatively brief follow-up periods (5 years) (22). Due to the exclusion of failure types that manifest more commonly late in a restoration's lifespan, such studies have a bias (marginal breakdown, secondary decay, bulk restoration fracture, and tooth fracture) (19). Manhard and Hickel's average yearly failure rates integrate information from two distinct types of investigations: (1) controlled longitudinal clinical studies, in which fillings are installed and retained under circumstances that are conducive to longevity; and (2) uncontrolled investigations in general practice, wherein fillings have been inserted and retained under circumstances that are less conducive to longevity. The first demonstrates the potential of an RM to be employed effectively, and the second demonstrates whether that promise is truly being fulfilled (19, 23). The longevity of DA restorations in posterior dentition has been reevaluated thanks to long-term evidence from longitudinal research. The environment in which DA fillings are put determines how long they will last. The median survival periods for posterior DA fillings in research done in primary care ranged from seven to fifteen years. More extensive and elaborate restorations have survival times that are closer to the bottom end of this range. Research done in "optimal circumstances" indicated median survival periods of 55 to 70 years (usually in dental schools, where a small number of experienced practitioners operating under few time limitations place fillings in motivated patients). Similar investigations of posterior RCs put in ideal conditions showed that they had a 20–45-year median survival time. Research published in optimal circumstances indicates that DA and RCs may survive better than previously believed in molars and premolars, and that in these circumstances, DA outperforms composite.

The link between the amount of DA fillings and the mercury levels in blood, serum, urine, hair, and saliva has been the subject of extensive in vivo studies. Only two published randomized, controlled clinical studies on DA (Children's Amalgam Trial) involved more than 500 children each, and they were carried out in New England and Portugal (24, 25). Both investigations failed to detect a variation in neurobehavioral effects between the children’s cohorts with and without DA fillings. Yet, in the DA group for both investigations, there was a statistically significant rise in mercury content in the

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urine. Geier et al. reanalyzed the same information five years after the Portugal Clinical Trial by DeRouen et al., using a modified calculation and data methods (25, 26). Children with underlying neurologic or developmental issues were not included in the collecting data presented in the second investigation, contrary to the parent study, which did not. This new analysis reassessed 462 children in all. In the latest analysis, kidney function, urine mercury concentrations, and urinary porphyrin concentration were also evaluated in conjunction to the neurocognitive and neurologic. Additionally, details regarding the kind, quantity, size, and placement of RM in each child's oral cavity were gathered. Geier et al. found statistically significant variation between urinary mercury concentration and DA exposure in a dose-dependent fashion, in contrast to the parent DeRouen et al. investigation and stressed that a follow-up timeframe of decades would be prudent to precisely assess the long-term pathologic negative impact of DA (25, 26). The advantages of the parent investigation and the shortcomings of their own investigation were likewise emphasized by Geier et al. (26). This team just released another report investigating the correlation between renal integrity biomarkers and mercury toxicity from DA restorations (27). This publication also included a reanalysis of the DeRouen et al. parent investigation (25). Using a different statistical approach, Geier et al. examined the dose-dependent connection between the accumulated exposure to mercury from DA restorations and urinary concentrations of kidney biomarkers (27). This was similar to their earlier work. The association between mercury concentration and urine renal biomarkers was first determined to be statistically significant, but after several statistical changes, it was no longer significant. However, this group concluded that their findings pointed to a dose-dependent effect of mercury from DA restorations to chronic renal injury. According to a national assessment on adverse RM reactions in the United Kingdom (N = 175), dental alloys accounted for the greatest percentage of patient-related adverse reactions, with oral lichenoid reactions accounting for 124 of these. Despite a decline in annual placements, DA restorations continue to be the most popular RM due to their increased longevity (up to 20 years) (28). As a result, it is not unexpected that DA is the RM that patients identify as having an adverse reaction to the most. It is important to consider the ratio between patient complaints and the overall quantity of dental restorations that are currently in place in the patient population's mouth. Spanish adults' urine mercury concentrations were examined and respondents with DA restorations had increased mercury amounts (29). Acute mercury exposure from DA has been studied (30), and the results demonstrate that there is no evidence of inflammation because the concentrations of interleukin 6 (IL-6) and C-reactive protein are not increased by the mercury liberated from DA restorations. When Bárány et al. looked at the impact of fish diet and DA restorations on mercury concentration in the blood and serum of 245 adolescents, they found that DA contributed far less mercury than the consumption of seafood did. The patients' average cumulative daily dose (7.4 g) was substantially lower than the acceptable amount of 30 g (28). Exposure to mercury vapor at elevated amounts is linked to negative consequences on the kidneys and the brain. The mercury consumption from other routes, like seafood, water, and industry, has been proven to be substantially higher than the mercury released by DA restorations. DA can be safely used as a RM for adults and children who are at least six years old, according to the US FDA (28). Mercury concentrations in the blood, plasma, saliva, breast milk, hair, brain, and liver are below those that have a negative impact on health. The US FDA has drawn attention to the scant clinical data that is currently available about the possible impact of DA restorations on fetuses, pregnant women, and young children under the age of six. Despite their rarity, the US FDA notes that some persons are allergic to DA and may experience allergic responses after having their teeth restored with this substance. DA has been extensively studied by the US FDA's Life Sciences Research Office, however there is not enough data to draw any conclusions about its potential health risks.

Conclusion

In spite of the presence of mercury, DA is a desirable RM that has been effectively utilized for over 150 years. The primary application of DA is as a direct RM. As opposed to RCs, insertion of DA restorations is less technique sensitive. As a result, it is simple to work with for practitioners and has a more consistent result. Additionally, its modest capacity to recover after corrosion and attain a respectably high compressive strength helped it function well in clinical settings. Due to its inexpensive cost, it has maintained its appeal in most nations regardless of the risk of mercury exposure.

Disclosure

Conflict of interest

There is no conflict of interest

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Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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