REVIEW ON RESTORATIVE DENTAL TREATMENT: DENTAL AMALGAM

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Abstract:

Background: Dental amalgam has been a cornerstone in restorative dentistry for over 165 years due to its versatility, durability, and cost-effectiveness. Despite the ongoing debate surrounding its safety and health implications, dental amalgam remains widely used for its long-term performance in restoring teeth. **Objective**: This review aims to evaluate the effectiveness of dental amalgam as a restorative material in terms of longevity, durability, and impact on oral health outcomes. The study also seeks to explore the various types of dental amalgam available and their unique properties. **Conclusion**: Recent research indicates that high-copper dental amalgams can provide satisfactory performance for over 12 years, even in large restorations. While concerns exist regarding the potential health risks associated with mercury in dental amalgam, numerous studies have shown minimal release during placement and removal. Various types of dental amalgam, such as resin-coated, fluorinated, and bonded amalgams, offer additional benefits in terms of clinical performance and longevity. Overall, dental amalgam continues to be a valuable option for restoring teeth, contributing to caries prevention, tooth preservation, and maintaining oral health. The decision to use dental amalgam should be based on a thorough assessment of individual patient needs and considerations.

Keywords: Dental amalgam, direct restoration, esthetics and tooth colored material

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Introduction:

Dental amalgam, renowned for its versatility, has been a cornerstone in restorative dentistry for over 165 years, constituting a significant majority (approximately 75%) of the restorative materials utilized by dental professionals [1]. Its enduring popularity stems from a unique combination of attributes, including reliable long-term performance in load-bearing scenarios and cost-effectiveness unparalleled by alternative restorative materials. Notably, its low technique sensitivity, self-sealing properties, and remarkable longevity further enhance its appeal [1].

Despite a global trend showing a decline in its usage, the economic viability, durability, and ease of handling have convinced many dentists to persist in selecting dental amalgam as their primary choice for restoring posterior teeth. However, it is crucial to exercise caution in determining the appropriate type of restoration required. In cases where extensive tooth structure loss necessitates restoration support, a gold inlay may be recommended. Nevertheless, there are instances where even elaborate amalgam restorations remain a viable option [2].

The widespread acceptance of dental amalgam as a preferred restorative material can be attributed to the pioneering work of G.V. Black in the late 19th and early 20th centuries. Through his seminal investigations and innovative approaches to cavity design, extending cavities into "immune" areas, and formulating an alloy comprising 68.5% silver, 25.5% tin, 5% gold, and 1% zinc, Black revolutionized the field of dental amalgams, ushering them into the modern era. The introduction of True Dentalloy by S.S. White in 1900, a commercial silver-rich alloy replacing gold with copper, further propelled the advancement of dental amalgam technology [3].

The advent of a novel atomization process in dental amalgam production marked a significant leap forward in enhancing the quality and manipulability of this material. This process involves the spraying of molten alloy into a chamber containing an inert gas through a patented atomization technique [4]. The molten metal solidifies into droplets, which then undergo a heat treatment process, resulting in the formation of spherical particles [5]. This innovation has streamlined the handling and performance of dental amalgams, underscoring their continued relevance in modern dental practice.

Objectives:

The main objectives of this review are:

1. To evaluate the effectiveness of dental amalgam as a restorative material in terms of longevity and durability.
2. To investigate the types of dental amalgam.
3. To analyze the potential health risks and benefits associated with dental amalgam restorations.
4. To explore the impact of dental amalgam restorations on oral health outcomes, such as caries prevention and tooth preservation.

Durability of amalgam restoration:

Recent studies have indicated that the durability of amalgam restorations surpasses previous expectations. Historically, older low-copper amalgams, predating 1963, had a limited lifespan due to the presence of the gamma-2 phase, which led to gradual weakening of the amalgam through corrosion [6]. Conversely, contemporary high-copper amalgams have exhibited satisfactory performance for over 12 years in various clinical investigations [7]. This resilience extends to larger restorations involving cusp replacement, with high-copper amalgams showing no need for post-placement polishing, a practice recommended for enhancing the longevity of low-copper amalgams [8].

Plasmins et al. [9] conducted a study on the enduring viability of multisurface restorations and discovered that extensive amalgam restorations did not impact the survival rate significantly. This finding aligns with a retrospective analysis by Robins and Summitt, who reported a 50% survival rate over 11.5 years [10]. The longevity of extensive amalgam restorations over time is attributed to thwarting traditional mechanical failures like marginal fracture, bulk fracture, and tooth fracture. Notably, the composition of the alloy, particularly zinc and copper content, plays a pivotal role in determining the survival rates of amalgam restorations by influencing their corrosion resistance. High-copper amalgams exhibit superior survival rates compared to conventional counterparts [11].

Letzel conducted a retrospective study on the survival and failure modes of amalgam restorations. Bulk fracture emerged as the primary mode of failure (4.6%), followed by tooth fracture (1.9%) and marginal ridge fracture (1.3%). Other reasons accounted for 0.8% of restoration failures [12].

Toxicity of dental amalgam:

The ongoing debate regarding the safety and effectiveness of dental amalgam has been a longstanding issue, with recent discussions reaching a fervent intensity that often overshadows rational discourse. Dental professionals have relied on amalgam for over 165 years, and while instances of true mercury allergy are rare, attempts to link its use to conditions like multiple sclerosis and Alzheimer’s disease lack substantial evidence, though a potential connection between amalgam restorations and oral lichenoid lesions has been noted [13].

Numerous research studies have explored the potential health impacts of dental amalgam, yielding conflicting findings. Some research suggests a potential correlation between exposure to dental amalgam and neurological disorders such as Alzheimer's disease, multiple sclerosis, and autism. Marshall, in a comprehensive review of dental amalgam, aptly summarized that if certain reported mercury release rates are extrapolated over the lifespan of a restoration, the entire mercury content could be released relatively quickly. For instance, a 500 mg amalgam restoration with around 200–250 mg of mercury could lose all its mercury in 10,000 days if released at a rate of 25 μg/day, a figure consistent with findings in some studies on mercury vapor release [14].

However, other studies have not established a significant link between dental amalgam and these health conditions. Both the World Health Organization (WHO) and the U.S. Food and Drug Administration (FDA) have affirmed that dental amalgam is a safe and effective dental material when used appropriately. They have stressed the importance of individual risk assessment and informed consent in the decision-making process regarding the use of dental amalgam in patients.

In response to concerns about the potential toxicity of dental amalgam, alternative restorative materials like composite resins, glass ionomers, and ceramics have been developed and are increasingly being adopted in dental practice. These materials, devoid of mercury, are considered biocompatible and aesthetically pleasing. Nevertheless, they may not offer the same level of durability or cost-effectiveness as dental amalgam. Dentists are advised to carefully weigh the advantages and drawbacks of each restorative material when determining treatment plans for their patients.

Moreover, the proper management and disposal of dental amalgam waste are critical to reduce environmental contamination and safeguard public health [15].

Composition of amalgam alloy:

Composition of currently used alloy is silver 40–70%, tin 12–30% and copper 12–24%. It may also include indium 0–4%, palladium 0.5% and zinc up to 1%. Zinc prevents the oxidation of other metals in the alloy during manufacturing process. During the manufacturing process of alloys, the presence of zinc plays a crucial role in preventing the oxidation of other metals and inhibiting corrosion. Some researchers have suggested that if a zinc-containing amalgam is exposed to moisture, it may lead to delayed expansion. In contrast, the inclusion of indium in high-copper amalgam has been observed to decrease creep and enhance strength. Youdelis discovered that the addition of indium to amalgam formulations up to a concentration of 10% can reduce the amount of mercury required for mixing, attributed to the rapid formation of indium oxide and tin oxide films that limit mercury release. Furthermore, the incorporation of palladium in amalgam formulations has been found to reduce tarnish and corrosion [16].

In terms of cavity design, historical practices such as Black's original preparation design emphasized extensive extensions to prevent recurrent caries. However, contemporary knowledge supports a more conservative approach to cavity preparations. Some experts recommend extending preparations into fissures, regardless of their carious status. By utilizing smaller burs, it is possible to selectively remove only diseased and weakened enamel and dentin, preserving sound tooth structure with the application of fissure sealants. Additionally, a small diameter bur can be employed to gently open fissures for sealing, ensuring access to sound enamel for etching and facilitating the flow of a liquid resin for effective sealing [17].

Numerous studies have highlighted the longevity of smaller restorations. Osborne and Gale conducted a study evaluating 196 amalgam restorations after 13-14 years and identified cavity width as the most significant factor impacting clinical survival. Wider restorations exhibited higher rates of marginal fracture and replacement compared to narrower restorations. The success of smaller preparations is also associated with reduced occlusal stress on margins and the preservation of tooth strength [18].

Types of dental amalgam:

Dental amalgam, a mixture of metals including silver, tin, copper, and mercury, is commonly used in dentistry for filling cavities resulting from tooth decay. Various types of dental amalgam are available, each offering unique properties and advantages.

Resin coated amalgam, which addresses the issue of microleakage by applying a resin coating over the restoration margins and adjacent enamel. This coating, although it may wear away over time, helps to delay microleakage until corrosion products fill the interface of the tooth restoration. Studies by Mertz-fairhurst and others have shown that bonded and sealed composite restorations placed directly over cavitated lesions extending into dentin, as well as sealed conservative amalgam restorations, exhibit better clinical performance and longevity compared to unsealed conventional amalgam restorations over a 10-year period [19].

Fluorinated amalgam: Fluoride has been incorporated into amalgam to address recurrent caries issues linked with amalgam restorations, as it possesses cariostatic properties. However, a challenge with this approach is the limited duration of fluoride delivery to achieve optimal benefits. Various investigations have explored the levels of fluoride released from amalgam, with findings suggesting that a fluoride-containing amalgam can continuously release fluoride for weeks post-insertion in the oral cavity [20]. Notably, studies have observed a substantial rise in fluoride levels in whole saliva, with a potential ten to twenty-fold increase during the initial week, indicating significant fluoride release from this type of amalgam. The anticariogenic effects of fluoride in amalgam may be attributed to its capacity to deposit fluoride in the surrounding hard tissues, elevate fluoride levels in plaque and saliva, and subsequently influence the remineralization process. Consequently, fluoride from amalgam could potentially exert a beneficial impact not only on caries around the filling but also on early enamel demineralization, acting as a slow-release mechanism [21].

Bonded amalgam: Conventional amalgam is used as an obturating material to fill the space of a prepared cavity, but it does not restore the tooth's fracture resistance lost during cavity preparations. Additionally, creating adequate resistance and retention form for amalgams may necessitate removing healthy tooth structure. Because amalgam does not bond to tooth structure, microleakage is inevitable immediately after insertion. To address these drawbacks, adhesive systems that bond reliably to enamel and dentin have been introduced [22].

The concept of amalgam bonding is rooted in a dentinal bonding system developed in Japan by Nakabayashi and colleagues. Studies have shown varying bond strengths, typically ranging from 12 to 15 MPa, which can be consistently achieved. In one study using spherical amalgam, Summitt et al. reported a mean bond strength of 27 MPa, attributing this higher strength to refrigerating the bonding material until just before use. Bond strengths with admixed alloys tend to be slightly lower than those with spherical alloys. Comparing post-insertion sensitivity, teeth with bonded amalgams were found to be less sensitive than those with pin-retained amalgams after 6 months. However, this sensitivity difference disappeared after 1 year, possibly due to corrosion products in nonbonded amalgam restorations filling the interface, reducing microleakage and sensitivity [23].

Successful long-term bonding could eliminate the need for mechanical retention, thus reducing the risk of further tooth structure damage associated with pin placement or amalgapins. Without the requirement for mechanical retention, cavity design could preserve more healthy tooth structure [24].

Impact of dental amalgam restorations on oral health outcomes:

Dental amalgam restorations have been a longstanding fixture in dentistry, renowned for their robustness and efficacy in repairing decayed or damaged teeth. These restorations, primarily comprised of a blend of silver, tin, copper, and mercury, have been utilized for over a century to address cavities and uphold oral health. Despite apprehensions surrounding the presence of mercury in dental amalgam, numerous investigations have indicated that the levels released during placement and removal are negligible, posing no substantial health hazards. Notably, esteemed bodies such as the American Dental Association, the U.S. Food and Drug Administration, and the World Health Organization affirm the safety and efficacy of dental amalgam as a restorative material [25].

An inherent advantage of dental amalgam restorations lies in their capacity to thwart further decay and safeguard the natural tooth structure. In instances where a tooth is afflicted by caries, the decayed segment necessitates removal and replacement with a restorative material to impede infection spread and reinstate functionality. Dental amalgam fillings excel in this regard due to their durability and longevity, enduring the rigors of chewing and persisting for numerous years without requiring replacement [26]. By sealing off the cavity and preventing bacterial re-entry into the tooth, dental amalgam restorations serve to shield the underlying tooth structure and uphold oral health. Furthermore, studies have demonstrated the efficacy of dental amalgam fillings in averting recurrent caries that may manifest around the filling margins, where bacteria can accumulate [27]. The amalgam's antimicrobial characteristics, coupled with its ability to form a secure seal with the tooth structure, inhibit bacterial growth and mitigate the risk of further decay. This is especially critical in regions of the mouth that are challenging to clean or prone to plaque buildup, such as the molars and premolars. By fostering a healthy environment within the restored tooth, dental amalgam fillings play a pivotal role in preventing secondary caries and preserving overall dentition integrity.

Beyond their role in caries prevention, dental amalgam restorations also bolster tooth preservation by furnishing structural reinforcement and stability to weakened or damaged teeth. In scenarios where a tooth is compromised by decay or trauma, a dental amalgam filling can fortify the remaining tooth structure and forestall additional damage. This is particularly crucial in cases where a substantial portion of the tooth has been lost, as the filling can reinstate the tooth's form and function while averting fractures or breakage. By conserving the natural tooth structure and obviating the necessity for more invasive treatments like crowns or extractions, dental amalgam restorations aid in upholding dentition integrity and fostering enduring oral health [28].

Conclusion:

In conclusion, dental amalgam remains a versatile and durable restorative material in dentistry, with a long history of successful use in restoring teeth. Recent research has shown that high-copper amalgams can provide satisfactory performance for more than 12 years, even for large restorations. Despite ongoing debates about its safety and potential health risks, dental amalgam has been deemed safe and effective by various dental and health organizations. The impact of dental amalgam restorations on oral health outcomes, such as caries prevention and tooth preservation, is significant. With its ability to prevent further decay, preserve natural tooth structure, and withstand the forces of chewing, dental amalgam continues to be a valuable option for dental restoration. Further advancements in types of dental amalgam, such as resin-coated, fluorinated, and bonded amalgams, offer additional benefits and improvements in clinical performance and longevity. Ultimately, the choice of dental amalgam as a restorative material should be made based on a careful assessment of individual patient needs and considerations.

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