

Banning the Dental Amalgam–A Speculation to Review

Hussain Ali John*, Shweta Sedani

Department of Conservative Dentistry and Endodontics, Sharad Pawar Dental College & Hospital, Datta Meghe Institute of Medical Sciences, Sawangi (M), Wardha, India

ABSTRACT

The most controversial material in dentistry is dental amalgam. Despite all the controversy, it is one of the oldest and the most used restorative material in the world. The unique properties of dental amalgam like the ease of use, durability for several years, high compressive strength and inexpensiveness are second to none. However, in no way is dental amalgam the perfect restorative material. It shows tarnish and corrosion, it is not aesthetically pleasing and it contains mercury which can be a potential health hazard as it can cause toxicity, leading to several severe systemic disorders. This has led to a few countries deciding to ban the material altogether while some are planning to reduce its use and eventually no longer permit its use for dental purposes in the future.

Key words: Amalgam ban, Mercury toxicity, Dental amalgam

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Corresponding author: Hussain Ali John

e-mail ✉: iamalijohn@gmail.com

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INTRODUCTION

According to the Encyclopedia of Biomedical Engineering, amalgam used in dentistry is defined as “Dental amalgam, which is composed of mercury, copper, tin, zinc, and silver, is used as a filler material for cavities after tooth decay” [1] Dental caries is the second most prevalent disease in the world occurring in human beings after the common cold. It is a microbe-mediated disease. The widely accepted theory of aetiology of this disease is a concept which involves 4 factors oral microflora, oral environment, host and time [2,3]. The most common modality in preventing the further spread of caries is a ‘restoration’. Dental amalgam has been used for more than 150 years for restorative purposes, it is considered one of the most universal restorative materials in the world, being a component of more than 75% of filling materials used by dentists [4,5]. From the year 2015-2016, more than 50% of restorations in the United States alone contained amalgam [6].

The properties that make dental amalgam an ideal restorative/dental material are: low cost, longevity, strength and ease of use [5]. Despite all this, one of the major drawbacks is aesthetics and issues with safety

because of its potential of causing mercury toxicity. Amalgam contains a small amount of mercury, if ingested in high amounts then toxicity can occur, potentially leading to severe diseases like multiple sclerosis and Alzheimer’s disease [7,8]. Another problem which is not often discussed is the environmental damage occurring from the use and improper disposal of amalgam [9]. Aesthetic restorative materials like Glass Ionomer Cement (GIC), composite resins, ceramic inlays are being widely used as minimally invasive procedures and aesthetic treatments get more popular. This has led to the use of amalgam being lessened to an extent [5,10,11].

Properties: Pros and cons

The ANSI/ADA (American National Standards Institute/American Dental Association) number of Dental Amalgam is ‘1’ [12]. Mechanical Properties: Dental amalgam has high compressive strength but low tensile and shear strength. Compressive strength for low-copper amalgam is 380MPa (megapascals), while it is 414MPa for high copper amalgam. It also has the property of creep which causes the unsupported edges of the material to be quite weak. Amalgam shows low dimensional change but it does tarnish and corrode. High-copper amalgams do have higher strength and can survive for more than 12 years [13,14]. Chemical Properties: Amalgams that are currently used contain silver (40-70%), tin (12-30%), copper (12-24%), indium (0-4%), palladium (About 0.5%) and zinc (1%). Amalgam can be classified based on its percentage of copper as high-copper and low-copper. Based on the presence or absence of zinc, it can be classified as zinc-containing alloy and zinc-free alloys respectively [5,14]. Galvanic shock is a property

of amalgam which is electrochemical corrosion, it occurs when amalgam comes in contact with another dissimilar metallic restoration like gold in the oral cavity [15].

Applications of dental amalgam

Dental amalgam has been routinely employed as a restorative material for carious or fractured teeth in the posterior region for Class I and Class II restorations, it is also employed as a foundation restoration and for failed restorations in the posterior teeth and for restoring large defects in areas where aesthetic is not a concern and proper isolation cannot be maintained [14].

Mercury toxicity

Amalgam alloy is mixed with mercury in the ratio of 1:1 as per the technique given by Eames, the mercury content of a finished amalgam restoration is about 50% [16,17]. Mercury exposure can be through vapour, ingestion, corrosion of dental amalgam or direct absorption through the mucosa present in the oral cavity while absorption through the skin or gastrointestinal tract is very poor. Corrosion is one of the properties of amalgam, this can lead to the release of corrosion products like mercury which can be potentially damaging to systemic health [4,16]. Exposure to mercury from dental amalgam is maximum during removal or placement of the restoration but even if mercury has entered the body, it has a half-life of about 55 days, meaning it won't stay in the body forever. [18] According to the 2007-09 Canadian Health Measure Survey, no adverse effects are observed in individuals with concentrations of mercury below 5 ug Hg/g of creatinine or 7 ug Hg/L of urine. The mean concentration of mercury in urine was between 0.12 and 0.31 ug Hg/L [19].

Symptoms of toxicity vary and depend on route and amount of absorption. Metallic taste, cough, fever, nausea, vomiting, gastrointestinal disturbances, respiratory and visual disturbances are some of the symptoms. Mercury toxicity is difficult to diagnose as its signs and symptoms are common to several diseases and are difficult to differentiate from several other maladies. The differential diagnosis for mercury toxicity might include Alzheimer's disease, Parkinson's disease, dementia, carbon monoxide poisoning etc. [20].

Alternatives for amalgam

Tooth-coloured aesthetic restorative materials have become popular due to the rise in aesthetic concern amongst patients and the popularity of minimally invasive procedures. Some of these materials are direct composite resins, GIC, ceramic and composite inlays. The cost of these materials is higher than amalgam, the highest being that of ceramic inlays followed by composite inlays and direct composite resins. These materials cannot be used in patients with large defects as they do not have strength comparable to amalgam. Another drawback of certain restorative materials like composite resins and GIC is that they cannot be used in mentally challenged and hyper salivating patients. Furthermore, these are technique-sensitive materials

which cannot bear high occlusal stresses as much as amalgam can [10,14]. Composite resins are specifically contraindicated in patients with high caries index because of the potential of secondary caries due to polymerization shrinkage [21].

Recent Advances in amalgam

Because of the controversy surrounding the use of mercury in amalgam several new advances have been introduced, these include gallium-based alloys and direct filling silver.

Gallium alloys

The use of gallium alloys for use in restorative dentistry was first suggested in the year 1928. These have been frequently marketed as mercury-free dental amalgam as they replace mercury. When comparing the properties of gallium-containing alloys and mercury-containing amalgam, gallium alloys have higher compressive strength, higher rate of corrosion and lower hardness. [22]. When compared in primary teeth, gallium-based alloys showed better marginal adaptation while no difference was observed for the degree of microleakage [23]. Gallium is also difficult to manipulate and shows higher setting expansion (Table 1) [24].

Direct filling silver

The following values are available in the literature about the comparison of physical properties between silver amalgam and direct filling silver (Table 2) [25].

Ban on amalgam

Despite all the drawbacks, dental amalgam remains the most popular restorative material. However, considering the potential health hazards, it has been banned in some Scandinavian countries like Sweden, which banned it in 2009, Norway did it in 2008 and Denmark has put significant restrictions on its use. Ireland, Slovakia, Czech Republic and Finland have announced a phase-wise plan

Table 1: Comparison of gallium alloys and silver amalgam based on their properties.

Property	Gallium Alloys	Dental Amalgam
Compressive Strength	Higher	Lower
Rate of Corrosion	Higher	Lower
Hardness	Lower	Higher
Marginal Adaptation	Better	Lower
Rate of Microleakage	No Difference	No Difference
Ease of Manipulation	Difficult	Easier
Setting Expansion	More	Less

Table 2: Comparing dental amalgam and direct filling silver based on flexural test results.

Property	Dental Amalgam	Polished Silver	Burnished Silver
Flexural Strength (MPa) (n=10)	86+/-20 MPa	180 ± 21 MPa	209 ± 19 MPa
Modulus of Elasticity (GPa) (n=10)	27.3 ± 3.40D	15.8 ± 2.5E	19.0 ± 1.7E
Work of Fracture (kJ/m ²) (n=10)	0.15 ± 0.06F	1.72 ± 0.30G	2.43 ± 0.67G

to eradicate the use of amalgam in dental practice in their countries [26]. One of the primary reasons why the ban is being held back in other countries might be the economic impact it might have on the healthcare system [27].

CONCLUSION

Dental amalgam is one of the most widely used restorative materials in the world. The reason for its popularity is its high durability, high compressive strength and its low cost. Mercury toxicity is a real health hazard but such cases are few and not enough to conclusively prove a direct correlation. Other materials like composite and G.I.C (Glass Ionomer Cement) have become popular in recent times as the desire for better aesthetics among patients has risen. However, they have not matched the properties of amalgam. For any material to beat dental amalgam's prevalence of use it should not just match its properties or be marginally better, the new material should overpower the cons in such a magnitude that the use of dental amalgam becomes obsolete. Until then, it would be very difficult to ban dental amalgam. Even though some countries have banned the material, there will be an economic impact which would result in increasing the funding for dental care. All factors considered, unless a powerful alternative comes, dental amalgam shall remain the most popular restorative material in the world.

CONFLICT OF INTEREST

None.

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