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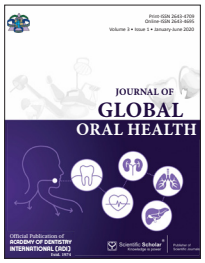

Review Article

Roadmap to mercury free dentistry: Toxic past to a healthier future

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ABSTRACT

Ever since its introduction, mercury has been widely used in dental practice because of its durability, ease of handling and placement, low cost, lower technical sensitivity compared to other restorative materials, antibacterial effect, etc. When esthetics are not an issue, it can be used in people of all ages, in stressed areas and with poor oral hygiene. However, concerns have been raised that amalgam causes mercury toxicity. At present, there is much controversy about the safety of dental amalgam and it has been shown to pose an occupational risk to patients, dentists, and their assistants. This review has attempted to summarize the past controversies and the current status of this restorative material in routine dental practice. It also discusses various alternatives to its use in terms of safety and esthetics.

Keywords: Dental amalgam mercury, Amalgam wars, Mercury toxicity, Newer restorative materials, Glass ionomer cement

INTRODUCTION

For the past two centuries, mercury has been used in dental silver amalgam as a dental restorative filling material. The presence of this metal provides the restoration a plastic mass that can be inserted and burnished in teeth, further hardening to a structure that resists the tension of the oral cavity extremely well. However, it is also the presence of this same element in the oral environment that has been raising concerns regarding safety for more than 170 years. Injudicious handling of amalgam consequently leads to human health risk, particularly associated with occupational exposure and environmental damage from mercury emission.[1] It still remains as one of the most popular restorative materials despite the introduction of alternative fillings largely due to its low cost, durability, strength, bacteriostatic effects, and ease in handling and placement.[2] The recurrent concerns have been referred to as the "amalgam wars," reflecting the arguments between the proponents and opponents of its use. At present, we are in the third amalgam war, which started in the early 1980s and continues till present, unabated.[3]

THE AMALGAM WARS

Invented in 1819 by the English chemist, Bell, the dental amalgam mercury filling was first used in England and France in 1826. 1830's marked the advent of amalgam fillings to the United States, however, numerous harmful effects were soon widely reported.[4]

The *"First Amalgam War"* started soon after its introduction. Dementia and loss of motor control were some common toxic effects of mercury in those times and many dentists objected to the obvious disadvantage of using such a dangerous material in people's mouths. In 1845, the American Society of Dental Surgeons asked its members to sign a pledge only to never use it.

However, the world economies were crippling. The only other feasible restorative material in those times was gold which was out of question for the mass public, and hence, amalgam looked to be the only solution. Furthermore, patients did not show signs of acute poisoning as soon as they left the dentist's office, so it did not appear to be an immediate concern. As the use of amalgam grew, the American Society of Dental Surgeons fell apart, and in 1859, the pro-amalgam faction formed the American Dental Association (ADA).

The *"Second Amalgam War"* was provoked in the 1926 by Professor Alfred E. Stock, a leading chemist at the Kaiser Wilhelm Institute in Germany. As he himself faced some adverse effects due to the use of amalgam, he blatantly questioned its safety. His research concluded that there were adverse health effects and were published in leading scholarly journals of the day. It started off a debate that raged through the 1930's without a clear resolution, only to fade away in the storm of World War II.

Introduction of modern methods of detecting the presence of trace amounts of mercury including mass spectrophotometry and the Jerome mercury vapor detector reopened the amalgam argument in the late 1970's and early 1980's which gave birth to the *"Third Amalgam War."* The chain of toxic events that lead to this war were as follows:

- Amalgam releases significant amounts of mercury
- The mercury distributes to tissues around the body and is the biggest source of mercury body burden
- The mercury from amalgam crosses the placenta and into breast milk, resulting in significant pre- and post-partum exposures for infants
- Adverse physiological changes occur from that exposure on the immune, renal, reproductive and central nervous systems, as well as the oral and intestinal flora.[5]

The most likely physiologic side effects to dental amalgam include *Contact dermatitis* or *Coombs' Type IV hypersensitivity reactions*. These are, however, experienced by <1% of the treated population. When such a reaction is documented, alternative material (e.g., a composite or ceramic) must be given unless the reaction is self-limiting (usually with 2 weeks).[1]

Elemental mercury vapors (HgO) are considered a major form of exposure and are released during manipulation of dental amalgam in several routine tasks, including preparation, restoration, and removal of dental amalgam. Approximately, 80% of the inhaled mercury vapors are captivated in the blood stream, circulate throughout the body, and can pass through both the placental and the blood–brain barriers.[6] Although metallic mercury can be absorbed through skin or by ingestion, the primary risk to dental personnel is from inhalation.

The maximum level of occupational exposure that is considered safe is 50 μg of hg/m^3. The ADA has estimated that 1/10 dental office exceed the maximum safe exposure level for mercury.[1] Furthermore, dental personnel are also exposed to inorganic mercury (mercuric salts and mercurous compounds) and organomercurials from contaminated diet intake and mercury stemming from their own dental amalgam fillings.[2] However, only a few cases of serious mercury intoxication caused by dental exposure have ever been reported. Mercury blood levels that were measured in one study indicated that the average level in patients with amalgam is 0.7 ng/mL compared to a value of 0.3 ng/mL for subjects with no amalgam. Furthermore, according to Berglund, studies have also reported that the use of mercury in dentistry is consequently associated with 10–70% of the total daily mercury load in the wastewater collection system.[7]

THE DENTAL AMALGAM CONTROVERSY

The ADA and many practicing dentists believe amalgams to be safe. However, a growing number of researchers and dentists believe that amalgams are an unrecognized serious health risk.[8]

The "amalgam is safe" viewpoint

The 1988 report from the ADA's Council on Scientific Affairs concluded that based on available scientific information, amalgam continues to be a safe and effective restorative material. It was also stated that there currently appears to be no justification for discontinuing the use of dental amalgam.[9]

This ideology promotes the idea that when mercury is mixed with the other components that make up the amalgam filling, stable compounds are formed and only trace amounts of metallic mercury remain. More significant sources of mercury exposure are from food, water, and air. Amalgam is a cost effective and quick way to restore teeth and hundreds of thousands of amalgams are placed each year. Therefore, the unjustified removal of amalgams is an unnecessary risk which increases the potential for other complications.

Mercury toxicity experts all over the world claim that mercury fillings should not be used.[10] Experts believe that removing existing amalgams should be accomplished using specific protocols and the removal of mercury fillings without adjunctive therapies is not recommended. The adjunctive protocols may include but are not limited to body chemistry analysis (blood, urine, hair, etc.), electrodermal screening, applied kinesiology, homeopathy, biocompatibility testing,

and chelation therapy. Many of these protocols are empirical, but the concept is that there must be regard for physiologic issues. It is necessary to understand that dental treatment to remove the possible source of toxicity is a separate issue from medical treatment to detoxify the body.

DENTAL MERCURY HYGIENE RECOMMENDATIONS

In 1999, the ADA Council on Scientific Affairs adopted mercury hygiene recommendations to provide guidance to dentists and their staff members for safe handling of mercury and dental amalgam.[11,12]

- Proper training of all personnel involved in the handling of mercury or dental amalgam
- Personnel should be well aware of potential sources of mercury vapor in the operatory and know about the proper handling of amalgam waste and be aware of environmental issues
- Work in well-ventilated spaces, with fresh air exchanges and outside exhaust. If the spaces are air-conditioned, air-conditioning filters should be replaced periodically
- Work area design should be such to facilitate spill contamination and clean-up. Flooring covering should be non-absorbent, seamless, and easy to clean
- Strict use of capsulated alloys only. The use of bulk mercury and alloy should be discontinued
- An amalgamator with a completely enclosed arm should be preferred for use in the operatory
- Skin contact with mercury or freshly mixed amalgam must be avoided at all costs
- High-volume evacuation when finishing or removing amalgam should be done. Evacuation systems should have traps or filters
- Proper disposal of mercury-contaminated items in sealed bags according to applicable regulations should be done
- All professional clothing must always be removed before leaving the workplace.

In 2013, the *Minamata Convention on Mercury* (a global treaty to protect human health and the environment from the adverse effects of mercury) was agreed as a gradual phase down in the use of dental amalgam in restorative treatment. The convention was ratified in 2017 making it necessary to strategically plan and act to reduce the need for restorative treatment using dental amalgam. Emphasis was also given to strengthening dental students' curriculum toward prevention and teaching alternative restorative materials and techniques, including the minimum intervention approach, where appropriate.[13]

Increased focus on caries prevention and ongoing research and development of new dental restorative materials with improved quality, safety, longevity, and adhesive properties favors a phased reduction in the use of dental amalgam.

In the recent year's composites, glass ionomer cements (GICs) and a variety of hybrid structures have been used due to increased demand for safe as well as esthetic restorations.[14]

Glass ionomers

Resin-modified glass ionomer cement (RMGIC) is a hybrid of glass ionomer and resin composites. A dimethyl methacrylate monomer, HEMA is grafted in polyacrylic acid. With the exposure of light, polymerization is initiated along the methacrylate groups, after that the acid-base reaction is carried out.[15] Improved working time, early resistance to water attack, chemical as well as micromechanical bonding to tooth, better esthetics, bond easily to composite, improved mechanical and physical properties, and minimal or no post-operative sensitivity.

Compomer is a polyacid-modified resin composite which contains dimethacrylate monomer and two carboxylic groups along with ion-leachable glass and absence of water in the composition. The glass particles are fillers and are partially silanated to ensure bonding with the matrix.[16] Fluoride is released for more than 1 year and at the same rate, but it does not act as a fluoride reservoir like RMGIC. Compressive and tensile strength equal to that of hybrid resin composite but exceed that of RMGIC.

Resin based and contain surface pre-reacted glass ionomer particles which provides excellent esthetics, polishability, and biocompatibility. While Giomer release fluoride, they do not have the initial "burst" type of fluoride release and overall long-term release (i.e., 28 days) is considerably lower than GIC, RMGIC, and compomer.[16,17]

Mainly used for atraumatic restorative treatment, these are purely chemically activated resin-modified GICs with no light activation at all. Also commonly used in pediatric dentistry for cementation of stainless steel crowns, space maintainers, bands, and brackets. It has high viscosity due to addition of polyacrylic acid to the powder and fine grain size distribution.[16,17] Packable/condensable, easy placement, non-sticky, reduced early moisture sensitivity, rapid finishing, improved wear resistance, and low solubility in oral fluids.

Composites

Packable composite

Developed in a direct effort to produce a composite with handling characteristics similar to amalgam. Distinguishing characteristics include less stickiness and higher viscosity.[14-16]

Flowable composite

Essentially "thinned down" composite with reduced filler content which decreases the viscosity of the mixture as the

amount of resin increased. Mechanical properties are inferior to those of standard hybrid composites but are popular due to their ease of use, favorable wettability, and good handling properties.[17,18]

Ceromers

Combine the advantages of ceramics and composites. Durable esthetic quality, abrasion resistance, high stability, ease of final adjustment, excellent polishability, low degree of brittleness, susceptibility to fracture, conserve tooth structure.[18,19]

Nanosized silica particles are used in nanocomposites because of which they show high translucency, high polish, better wear resistance, and polish retention similar to that of micro filled composite while maintaining physical properties and resistance equivalent to those of several hybrid composites.[20]

Restorative material which utilizes alkaline filler capable of releasing acid-neutralizing ions such as fluoride, calcium and hydroxide, and an isofiller which reduces polymerization shrinkage. It is a self-curing filling material with optional light curing, thereby making it a cost efficient substitute of amalgam for posterior load bearing restorations.[21]

CONCLUSION

Majority of dentists, particularly those in developing nations, lack adequate knowledge about the Minamata Convention and the phase-out of amalgam. Due to increased costs, time constraints, and technical sensitivity of the process, the effort to use safer alternatives to amalgam still remains a challenge. Amalgam-free procedures require additional staff and material investments. Therefore, while developed countries have already started their ascension toward a future free of mercury, developing countries still have a long way to go.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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