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REVIEW ARTICLE

Roadmap To Mercury Free Dentistry… Are We Prepared?

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Abstract

Dental amalgam has been phased-down throughout the world. 2020 is the year of eradication of use of amalgam in dentistry. Alternative restorative materials with improved properties are the need for future. Restorative dentistry must strongly promote the prevention of dental caries to reduce the need for restorative materials and emphasize the best management practices for all materials in use. Use of dental amalgam for restoration during the past 10 years or so, the awareness and recognition of the environmental implications of mercury have increased and dentistry has gained further attention as being a source of contamination of the environment. In addition, within the dental profession and the oral health research community the interest of serving patients through the use of alternative dental restoration materials has grown markedly.

Keywords: Amalgam alternatives, mercury free dentistry.

Introduction

As early as 160 years dentistry has used silver amalgam, which contains approximately 50% Hg metal, as the preferred material of choice for tooth restorations due to its ease of application, strength, and low cost. In recent years, the risk of mercury toxicity has been widely discussed and elaborated and the risk benefits of the use of amalgam are criticized. The dental amalgam has been seen as hazardous to society. World Health Organization (WHO) stated that even the small amount of mercury might be capable of causing severe health and environment problems which leads to the developmental defects of child in-utero and early stages of life. United Nations Environment Program (UNEP), global mercury Assessment 2013 revealed that dental amalgam uses 21%of global mercury consumption. The fact that mercury is highly toxic element, which is considered by WHO as one of the top ten chemical of major public health concern, because of its non-degradable nature; so, more amount of dental amalgam use results in more accumulation of mercury in environment.

Various Laboratories in early 1980's suggested that Vapor Mercury Exposure from Amalgam Fillings is continuously released from the tooth fillings and the rate of release into month air is increased immediately after chewing. A single amalgam restoration of size 0.4cm.sq. is estimated to release about 15ug Hg/day.

Effect of Amalgam Mercury on Organs

Various studies have shown that the mercury immediately after exposure is seen in significantly higher concentrations in the Brain, Kidneys and Lungs. The continuous release of mercury from amalgam restorations results in neurodegenerative diseases like Alzheimer's disease and can lead to impaired renal function. It has been seen that occupational exposure to mercury has led to infertility in female dental assistants because of the long-term exposure to mercury ions. So, it's very essential to restrict the use of dental amalgam.

Phase Down of Dental Amalgam

The complete ban on amalgam mercury was the need of the hour which leads to the Minamata Convention Treaty in 2013. The treaty that aimed to protect environment and the human health from the anthropogenic emission and release of mercury and mercury compounds.

The treaty proposed nine measures to phase down the use of dental amalgam:

1. Setting of national programs aiming at dental caries prevention and health promotion, thereby reducing the need for dental restorations.
2. Setting national objectives at minimizing use of mercury.
3. Promoting the use of cost-effective and clinically effective mercury free alternatives for dental restorations.
4. Promoting research and development of quality mercury –free materials for dental restorations.
5. Encouraging dental professional organizations and dental schools to educate

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and train dental professionals and students on the use of mercury free dental restorations alternatives and on promoting best management practice.

6. Discouraging insurance policies and programs that favor dental amalgam use over mercury –free dental restorations.
7. Encouraging the insurance policies and programs that favor the use of quality alternatives to dental amalgam restorations.
8. Restricting the use of dental amalgam to its encapsulating form.
9. Promoting the use of best environmental practices in dental facilities to reduce releases of mercury and its compounds to water and land.

• Strategic intervention aligned with the nine measures of the Minamata Convention was the Implementation of strategies.

• Waste Management,
• Knowledge Management
• Health System Strengthening.

Waste Management

It includes best practice management, one that combines infection-control measures, chemicals management, environmentally sound lifecycle management of dental amalgam waste and quality mercury-free dental materials waste. Making the use of dental amalgam in encapsulated form and amalgam separators mandatory.

Knowledge Management

Raising public awareness and supporting country- level communication strategies and programs based on the results of the situations assessment and documentation of voluntary implementation.

Health System Strengthening

Integrating strategies to phase down the dental amalgam as part of the policy of prevention and control of non-communicable disease and addressing the social determination of health.

Improving the afford ability of mercury –free materials for dental restorations in the essential list of medicine products and medical devices and equipment managed by the national and regional authority.

Researching and developing qualities, affordable and safe alternatives to dental amalgam whose waste can be controlled in an efficient and effective manner in all health care settings.

Reorientation of the oral health work force; education agenda towards greater social accountability and of educational curricula to meet local community's needs; increasing national capacity of oral health professionals towards preventive and non-operative minimally invasive dental care by developing training materials and resources.

Encouraging and support insurance companies to examine policy and program options that favor a shift to quality mercury–free materials for dental restorations, including materials that re-mineralize tooth substance and inhibit dentine demineralization.

Technical Advantages of Mercury – free Dentistry

• Mercury –free fillings are more minimally invasive than amalgam: It is a fact that amalgam damages health tooth tissue weakens tooth structure as cavities has to be prepared more intensively for mechanical retention, due to its non- adhesive nature. So, mercury free materials like composite offer the more benefits of preserving the sound tooth tissues.

• Mercury – free fillings can last as long or longer than amalgam: With the recent advances in the dentine adhesive agent, the quality and longevity has improved. Composite have progressed so far over the past decade that it has reached at par with the strength of amalgam restoration.

• Mercury- free fillings can be placed as fast as amalgam: The ease of application for composite has improved and does not take any more time to place than it does with amalgam. Glass Inomer can be placed faster than amalgam.

• The factors effecting the time taken for restoration with composite and amalgam are: First, time may vary depending on whether the tooth structure has already been damaged by amalgam. Composite used to replace amalgam restoration may take more time than replacing a composite filling. The times vary depending on the training of the dentist. Dentist, who has more experience in using composite, can place composite as fast as amalgam. The range of time may vary ease of cavity preparation, as composite requires most of the time, conservative cavity preparation.

• Mercury–free fillings can help prevent caries, unlike amalgam: Materials like Glass Ionomer releases Fluoride over a period of time, which can help prevent dental caries. Flowable composite restorations are used in the pit and fissure sealing which again prevents caries.

• Mercury–free fillings can be repaired more easily than amalgam: Composite not only save tooth tissue during cavity preparation, but it permits us to do localized repairs instead of total restoration replacement, which in turn saves both tooth structure and costs.

• Mercury–free fillings are safer than amalgam: Seeing the public health implication of amalgam, composite restorations and GIC are safer. So, the Bis-gamma level in saliva returns to baseline within few hours, it's agreed with so many researches that composite are safer for humans and environment. World Health Organization & Food and Agriculture Organization of the United Nations Expert Meetings stated, "BPA (Bis–Glycidyl methacrylate) levels in saliva from dental materials were low. The Expert Meeting determined that there was no need to collect additional Data on BPA level from dental materials, as exposure is short term and unlikely to contribute substantially to Chronic exposure."

• Mercury-free fillings are safer for the environment: There is potentially no evidence of significant personal or environmental toxicity from the mercury-free restorative materials.

Human Safety of Current Dental Restorative Materials

Human safety evaluation must consider the release/exposure of substances from a dental material into the oral cavity of the patient, to dental personnel, and into the environment.

It is generally accepted that mercury in different oxidation states is released from amalgam fillings. Uptake for metallic mercury (Hg0) occurs mainly through the lungs, with only minor parts as Hg2+ through the intestines. Ingested mercury in amalgam particles is virtually unabsorbed. Exposure is considered to be very hazardous to the life and indeed to the environment.

For Resin-Based Composites, many different substances have been identified to be released to the liquid interface (saliva, dentin/pulp) (Schmalz and Arenholt-Bindslev, 2009), to ambient air in the dental setting (Marquardt et al., 2009). Mainly, monomers like HEMA, TEGDMA, or UDMA are released, but also Bis-GMA and Bis-DMA. In this context, epoxy-intermediate 2, 3-epoxymethacrylic acid is formed, which is considered to be minimally releases in the saliva.

Available evidence shows that BPA is, under clinical conditions, not released from pure Bis-GMA. However, Bis-DMA is converted to BPA, e.g., by salivary esterase. Furthermore, BPA may be detected as residues/impurities in Bis-GMA because it may be used during the fabrication of Bis-GMA. After placement of Bis-DMA containing fissure sealants, BPA could be detected immediately or shortly after placement in saliva and urine, and salivary samples were estrogenic in vitro.) Calculations of exposure levels showed that even after exposure to Bis-DMA-containing materials (fissure sealants), the amounts of BPA were much below limit/reference values of classic toxicology. However, these levels are currently under discussion. The clinical relevance and the possible environmental impact are unknown.

Glass-ionomer cements release fluorides and aluminum ions. No systemic reactions and very few, if any, allergic reactions have been reported when these are used as dental filling materials. Biological properties of various combinations of glass ionomer cements and resin-based composites are determined mainly by their resin components.

A gross overview of data from the literature has been reported for the different endpoints and for the different material groups (SCENIHR, 2008) possible to generally rank them from the most to the least toxicmaterial. Fewer allergic reactions occur with glass-ionomercements, but their mechanical properties are insufficient formore than one surface cavity (Frencken et al., 2012).“Clinical risk evaluation” of dental materials is based on theconcept that 'safety' is freedom from unacceptable risks and 'risk'is the combination of probability (frequency) and severity of harm (in general). Epidemiological data on the frequency of adverse effects caused by dental materials are sparse, but estimated to be very low.

The EU report states: “All the materials are considered safe to use and they are all associated with very low rates of local adverse effects (… allergic reactions and an association with clinical features characteristic of lichen planus …) with no evidence of systemic disease”.

The longevity of a restoration is a relevant parameter as a benefit of dental restorative materials. In this respect, Modified Resin-based composites are replacements for the amalgam in the near future.

Environmental Safety of Current Restorative Materials

There are ever-increasing concerns for protecting the environment from effects of manufacture, use, and disposal of Amalgam. A strong emphasis in developed countries during the past decade has been the collection and recycling of amalgam waste materials.

The American Dental Association (ADA) has done considerable investigation and planning over the past two decades, not only for dental amalgam management but also for similar issues for other restorative materials. Technical issues regarding restorative materials affect much more than just simply those associated with restoration placement and service.

Waste management includes concern for residual materials from use, disposal of packaging, chair-side traps, vacuum pump filters, separators, plumbing, sewer systems, crematoria, and cemeteries, to mention just a few examples.

ADA's mission statement clearly emphasizes its roles as a trusted source for oral health information and for improving public health outcomes. During the past 10 years, the ADA has promoted the use of “best management practices” (BMPs) for all dental materials (ADA, 2003, 2007).Efforts to recapture Hg and derivatives within the dental office have included a range of chair-side filters and separators on waste water lines which reclaim greater than 99% of those materials.

Decreasing use of dental amalgam in most developed regions has been driven mostly by preferences for adhesive dentistry and aesthetic restorations. Thus far, those options do not provide the amalgam alternative that would also offer improved performance and longevity. That is why the current discussion of potential options is so important.

Alternatives For Dental Amalgam

Dental amalgam should be phased-down throughout the world. Alternative restorative materials with improved properties are needed for the future. A coordinated world-wide approach to research and funding for those materials is needed. Foremost, restorative dentistry must strongly promote the prevention of dental caries to reduce the need for restorative materials and emphasize the best management practices for all materials in use.

*** Recent Advances in Amalgam to Over Come Mercury Exposure**

Bonded Amalgam: The advantages of adhesive amalgam restoration over non-adhesive treatment alternatives are:

It is a treatment option for extensively carious posterior teeth, with a lower cost than either cast metal restoration or metal-ceramic crowns.

It allows use of amalgam in teeth with low gingivo-occlusal height which is not possible in conventional amalgam, amalgam with pins, inlays, onlays, complete cast crown restoration.

It permits more conservative cavity preparations, as it does not require additional retention in form of groove, pins etc.

Silver-based mercury-free restorative alloys: Mercury free metallic restorative materials proposed as substitute for mercury containing amalgam are gallium containing materials and pure silver and/or silver-based amalgam.

Advantages of Gallium Based Alloys

- Rapid solidification.
- Good marginal seal by expanding on solidification.
- Heat resistant.
- The compressive and tensile strength increases with time comparable with silver amalgam
- Creep value are as low as 0.09%
- It sets early so polishing can be carried out the same day
- They expand after setting therefore provides better marginal seal.

Nanocrystalline Melt spun Ag-Sn-Cu Alloy Ribbons

A new non-gamma-two dental powder has been developed from nanocrystalline melt-spun Ag-Sn-Cu alloy ribbons.The amalgam made from this powder exhibits excellent properties for dental filling. The nanocrystalline microstructure was found for the first time in as-spun and heat-treated Ag, Sn, Cu alloy ribbons, using X-ray diffraction, scanning electron microscopy and energy-dispersive spectroscopy.

Powder Coated Technology

A technology has been developed recently at the National Institute of Technology (Gaithersburg, Maryland, USA) that allows the formation of two types of condensable metallic composites.

One approach consists of cold-welding silver that is based on a powder technology and transforming it from an extremely plastic mixture to a solid within the prepared tooth at oral temperature.

The second approach is to condense a mixture of two inter-metallic compounds, Ag_4Sn (beta phase) and Ag_3Sn (gamma phase), or similar alloy particles that have been silver coated and which have undergone an appropriate treatment in a surface-activating solution

Advantages:

- Flexure strength as that of amalgam
- Smooth surface and hardening were obtained
- More resistant to wear because of work hardening

Glass Ionomer Cements

Glass ionomer is the generic name of a group of materials that use silicate glass powder and an aqueous solution of polyacrylic acid.

Though, glass-ionomer was originally aimed to be restorative material, soon it was modified as luting cement also. The early cement was a slow setting and highly technique sensitive. But since its introduction, it has undergone many changes.

Metal Modified Glass Ionomer Cement

Metal modified cements are two types:

Silver alloy admix - amalgam alloys are interpreted into the glass powder.

Cermet ionomer cement - precious metals like silver, gold, titanium, palladium etc. incorporate in glass powder. Silver is commonly used

Glass is generally brittle and addition of silver was expected to improve the toughness of the cement as silver acts as stress absorber and also improves the abrasive resistance of cement.

Glass Cermets

This was introduced by Mclean and Gasser in 1985. Glass and metal powders were sintered at high temperature. This was attempted to improve the wear resistance, flexural strength and at the same time maintains the aesthetics.The main disadvantages of conventional glass ionomers are brittleness, poor surface polish, porosity and surface wear. Improvements in these areas are essential if the clinical use of glass ionomer cements is extended to high stress bearing areas. Cermet's was introduced in 1984 under the trade name Ketac-silver. Due to its higher strength than conventional Glass Ionomer, it has replaced amalgam to some extent.

Silver-Alloy Powder & Glass Ionomer Cement (Miracle Mix)

Adding silver alloy powder to a type II restorative glass cement powder and mixing this powder admixture with polyacrylic acid liquid was intended to make this first metal reinforced glass ionomer cement radio opaque and harder. Addition of this spherical silver alloy powder to the pure hydrous restorative type II glass ionomer cement is termed "Miracle Mix". It was one of the materials which replaced amalgam.

Resin Modified Glass Ionomers

They were introduced to overcome the problems associated with the conventional glass ionomers and at the same time preserving the clinical advantages of the conventional materials. These combined the technologies of resin composites and conventional glass ionomers. In general, the resin modified glass ionomer materials are the hybrid of a glass ionomer and resin composites.

Advantages of resin modified glass ionomer cements

- Sufficiently long working time controlled in command to a snap set by photocuring.
- Improved setting characteristics.
- Protects the acid base reaction from problems of water balance.
- Rapid development of early strength.
- Can be finished and polished immediately after set.
- Repairs can be easily carried out, as the bond between old and new material is very strong.

Compomer (Polyacid Modified Composite Resins)

Compomers are the combination of composites ('comp') and glass ionomers ('omer'). Compomers contain dimethacrylate monomer and two carboxylic groups along with ion leachable glass. There is no water in the composition of these materials and the glass particles are partially silanated to ensure some bonding with the matrix.

Advantages

- Superior working characteristics to resin modified glass ionomer cement
- Ease of use
- Easily adapts to the tooth
- Good esthetics
- Good fluoride release

Giomer (pre-reacted glass-ionomer)

Giomers are a relatively new type of restorative material. The name 'giomer' is a hybrid of the words 'glass ionomers' and 'composite'. They have the properties of both glass ionomers (fluoride release, fluoride recharge) and resin composites with excellent esthetics, easy polishability, and biocompatibility.

Ketac™ N100 Light Curing Nano-Ionomer Restorative

A nano-ionomer is an aesthetic, fluoride-releasing restorative solution. Easy to create a high initial gloss and achieve a smooth final surface. Saving time in difficult to polish situations such as Class V's. Reduces waste, quick delivery of the material and the right mix every time.

NVP modified glass-ionomer cements

Modification of conventional glass-ionomer cements with N-vinylpyrrolidone containing polyacids, nano-hydroxy and fluorapatite to improve mechanical properties. After 24h setting, the NVP modified glass-ionomer cements exhibited higher compressive strength (163–167MPa), higher diametral tensile strength (DTS) (13–17MPa) and much higher biaxial

More Recent Advances in GIC

- Zirconia–Glass Ionomer Cement—A Potential Substitute for Miracle Mix
- Reactive fibre reinforced glass ionomer cements
- Chlorhexidine containing GICs
- Bioactive glass containing GIC

Composites

Bowen resin, was made up from the combination of bisphenol –A and glycidyl methacrylate. Developed by Bowen, a polymer based on dimethacry late chemistry. This polymer was generally known as Bis-Glycidyl Methacrylate. Composite are finely ground amorphous silica or quartz with wide distribution in particle size Average size 8-12 microns; up to100microns can also be present. Problems of surface roughening and low translucency associated with traditional and small particle composites is overcome by the use of micro filled composites.

A modification of Small Particle Filler and hybrid composites results in flowable composites Adapts intimately to a cavity. Used as a cavity base or liner; where access is difficult. There are condensable composites, to enable clinicians to apply techniques similar to those used for amalgam restorations. Have higher strength.

Micro filled composite is greater than that of unfilled acrylics because of transfer of stress from matrix to filler particles. Tensile strength and elastic modulus and hardness is also increased. Increase in hardness is due to filler reinforcement and cross-linked resin structure

Ceromers

Ceramic Optimized Polymer was introduced by Ivoclar Composition: It is Composed of specially developed & conditioned fine particle ceramic fillers of submicron size (0.04 & 1.0 µm), which are closely packed (75 – 85 weight %) & embedded in an advanced temperable organic polymer matrix.

Properties of ceromers = composites & they exhibit fluoride release lower than conventional glass-ionomers or compomers.

Ormocers:

Dr. Herbert Wolters from Fraunhofer Institute for Silicate Research introduced this class of material in 1994.Ceromers combine the advantages of ceramics and composites. These are Durable estheticswith High abrasion resistance and stability. Have Excellent polishing abilityand are Effective bond with luting composite. Acronym of Organically Modified Ceramic Represents a novel inorganic-organic copolymer in the formulation -allows for modification of its mechanical parameters.

E.g.; Definite Inorganic condensing molecule segment is used to build inorganic network. An inorganic Si-O-Si network is developed through targeted hydrolysis and inorganic polycondensation in a sol-gel process. ORMOCER has a biocompatible polysiloxane net with low shrinkage

Composite Inserts

Preformed shapes & sizes of glass ceramic whose surfaces have been silane treated. Available in different shapes: L, T, round, conical, cylindrical size 0.5-2mm (mega fillers).

Application: Used to minimize the marginal contraction gaps in composite fillings.

Properties: they have Low coefficient of thermal expansion and Wear resistant.

Fiber reinforced composites

First described in 1960s by Smith, when glass fibers were used to reinforce polymethyl methacrylate. Contain fibers aimed at enhancing the physical properties. This group of materials is very heterogeneous; depending on the nature of the fibergeometrical arrangement of fibers overlying resin used. Fibers within the composite matrix are bonded to the resin via an adhesive interface. Fibers increase the structural properties by acting as crack stoppers. The resin matrix acts to protect the fibers and fix their geometrical arrangement, holding them at predetermined positions to provide optimal reinforcement

Nanocomposites

Nanotechnology refers to the deliberate placement, manipulation and measurement of sub-100 nanometer scale matter. The first nanocomposite introduced was Filtek Supreme (3M ESPE). With its nanosized particles and another few technologies called "clustering"; it provided more polishibility without sacrificing strengthClustering is a process by which numerous nanoparticles are combined to form larger particles. They are available in 30 different shades in 4 opacities (dentin, body, enamel and translucent).

Advantages

- Superior translucency and esthetic appeal, excellent color, high polish and polish retention.
- Superior hardness, flexural strength and modulus of elasticity.
- About fifty percent reduction in polymerization shrinkage.
- Excellent handling properties.

Smart Composites

Introduced as the product Ariston in 1998.Smart Composites are active dental polymers that contain bioactive amorphous calcium phosphate (ACP) filler capable of responding to environmental pH changes by releasing calcium and phosphate ions and thus become adaptable to the surroundings. These are also called as intelligent composites.

It is the Barium, Aluminum Fluoride, silicate glass filler (1m) with Ytterbium trifluoride, silicon dioxide and alkaline glass (1.6 m) in dimethacrylate monomers.

This phenomenon is based on a newly developed alkaline glass filler and is expected to reduce the formation of secondary caries at the margins of the restorations due to an inhibition of bacterial growth, a reduced demineralization and a buffering of acids produced by cariogenic micro-organisms It releases functional ions- fluoride, hydroxyl, and calcium ions as the pH drops in the area immediately adjacent to the restorative materials, as a result of active plaque.

Conclusions

Dental amalgam should be phased-down throughout the world. Alternative restorative materials with improved properties are need for the future. A coordinated world-wide approach to research and funding for those materials is needed. Foremost, restorative dentistry must strongly promote the prevention of dental caries to reduce the need for restorative materials and emphasize the best management practices for all materials in use.

The need of the hour is to completely ban the use of Amalgam to prevent the exposure of mercury on the human health and the environment. Until we achieve the complete success in eliminating the use of amalgam, it is necessary that knowledge regarding the detrimental effect of amalgam to the environment and human health should be spread to the dental professionals and to the dental schools. With, the more emphasis put on the use of mercury –free dentistry.

The recent advancements which have introduced a true revolution in the field of restorative dentistry have enabled the dental clinicians to perform better and to present high quality service for their patients.

"The world hates change, yet it is the only thing that has brought progress." --Charles Kettering

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