

AMALGAM RESTORATIONS - AN OVERVIEW

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ABSTRACT

A filling is the repair of a damaged or decayed tooth, restoring it back to its normal shape, appearance and function. Amalgam Restoration is an example of the material giving its name to the process. Amalgam fillings are made up of mercury, powdered silver and tin. They are mixed and packed into cavities in teeth where it hardens slowly and replaces the missing tooth substance. This article throws light on properties of amalgam, its advantages, disadvantages and contraindications. A review of some patents on amalgam is also provided that summarizes the recent technical advancements taken place in this area.

KEY WORDS: Amalgam; Uses; Advantages; Patents

1. INTRODUCTION

A dental restoration is also called a filling. It is the repair of a damaged or decayed tooth, restoring it back to its normal shape, appearance and function. The name of the material that is used to repair a tooth is often the name given to the repair process. "Amalgam Restoration" is an example of the material giving its name to the process. Dental amalgam is a combination of mercury with other metals and has been used for over 150 years for the treatment of tooth cavities because it is very strong and durable. It is also soft to adapt to the size and shape of the tooth cavity, yet hardens sufficiently fast to make it practical. It is still considered a material of choice for some fillings in the back teeth, the use of amalgams has been decreasing in recent years, because it is not tooth-colored and does not adhere to the surface of the tooth^{1,2}.

Alternative tooth-colored filling materials have become increasingly popular. Not only do these materials look better, but

they require the dentist to remove less tooth material and they do not contain mercury also. Amalgam fillings (silver fillings) are made up of mercury, powdered silver and tin. They are mixed and packed into cavities in teeth. It hardens slowly, and replaces the missing tooth substance. Amalgam fillings are held in place by the shape of the prepared cavity^{3,4}.

The cavity has to have an undercut to prevent the filling from falling out. The amalgam is then slotted into the cavity. It is still commonly used, despite an ongoing debate about mercury toxicity⁵.

2. CLASSIFICATION OF AMALGAM ALLOYS⁶⁻¹³

2.1 According to content

- **Silver Amalgam:** Silver more than 65%.
- **Copper Amalgam:** 70% Hg and 30% Cu.

- **Preamalgamated alloys:** Contain less than 3% of Hg.
- **Noble metal amalgam alloys:** Contain Au and/or Pd.

2.2 According to presence or absence of Zinc

- **Zinc-containing alloys:** More than 0.01% Zn.
- **Zinc-free alloys:** Less than 0.01% Zn.

2.3 According to Copper content

- Low Copper alloys (2-4% Cu)
- High copper alloys (13-30% Cu)
 - Admixed alloy (1/3rd Low Cu + 2/3rd Ag-Cu eutectic)
 - Unicompositional or Single compositional alloy

2.4 According to number of metals in the alloy

- **Binary alloy:** Ag; Sn
- **Ternary alloy:** Ag; Sn; Cu
- **Quaternary alloys:** Ag; Sn; Cu; In.

2.5 According to the shape of alloy particles

- **Spherical** (Smooth shaped spheres)
- **Spheroidal** (Irregular shaped spheres)
- **Lathe-cut** (Irregular shavings or filings). It is of three types: Micro-cut, Fine-cut and Coarse cut.

2.6 According to development of Amalgam alloys

- **1st generation amalgam alloys:** G.V.Black's formulation of 3parts Ag and 1 part Sn
- **2nd generation amalgam alloys:** Addition of 4% Cu and upto 1% Zn
- **3rd generation amalgam alloys:** Admixed alloys.
- **4th generation amalgam alloys:** Ternary alloys - Addition of Cu to Ag and Sn to form Ag_2CuSn .

- **5th generation amalgam alloys:** Quaternary alloys - Ag, Sn, Cu, and Indium.

- **6th generation amalgam alloys:** Ag-Cu-Pd eutectic alloy (62%, 28%, and 10% respectively) is added in a ratio of 1:2 to low Cu alloy.

3.PHASES OF DENTAL AMALGAM¹⁴⁻¹⁶

- Gamma: AgSn
- Gamma 1: AgHg
- Gamma 2: SnHg
- Epsilon: CuSn
- Eta: CuSn
- Beta: AgSn
- Beta 1: AgHg
- Beta (Galloy): GaCu + Sn

4.COMPONENTS¹⁷⁻²¹

4.1. Silver: Increases strength, expansion and reactivity. Decreases creep.

Corrosion products are AgCl and AgS.

4.2. Tin: Increases reactivity and corrosion. Decreases strength and hardness.

Corrosion products are SnO, SnCl, and SnS.

4.3. Copper: Increases strength, expansion and hardness. Decreases creep. Corrosion products are CuO and CuS.

4.4. Zinc: Increases plasticity, strength and the Hg: alloy ratio.

Decreases creep. Causes secondary expansion. Corrosion products are ZnCl and ZnO.

4.5. Mercury: Wets the alloy particles. Decreases strength if in excess amounts. Implicated in toxic and allergic reactions.

5.PROPERTIES OF DENTAL AMALGAM²²⁻²⁶

- **Dimensional Change:** Expansion that occurs due to reaction of Hg with alloy components is termed primary expansion or mercuroscopic expansion. Expansion

that occurs after 1 to 7 days due to moisture contamination during trituration or condensation before the amalgam mass is set, is termed secondary expansion or delayed expansion. Release of mercury from γ_2 phase during corrosion results in additional crystallization of phases on reaction with unreacted γ phase, causing further expansion. This is also termed mercuroscopic expansion.

- **Particle size:** If size decreases, there is contraction initially (due to increased surface area/ unit volume and increased dissolution of Hg) but later expansion (due to outward thrust of forming crystals). Decreased size also results in increased strength (due to increased surface area / unit volume)

- **Particle shape:** Smoother shape (as in spherical type) there is better wetting with Hg causing in faster amalgamation resulting in contraction. Regular uniform shape result increased strength (due to more wettability, more coherent mass, less interrupted coherent interphases)

- **Trituration:** Rapid trituration and longer trituration within limits results in contraction because of faster amalgamation decrease in particle size, pushing of Hg between particles and prevention of outward growth of crystals. Increased trituration within limits increases strength (due to increased coherence of matrix crystals) but beyond decreases it.

- **Condensation:** Increased condensation pressure causes closer contact of Hg with alloy particles and squeezing of excess Hg from the mix resulting in contraction.

- **Creep:** Creep occurs because of grain boundary sliding. η crystals on γ_1 grains prevent grain boundary sliding and therefore are responsible for decreased creep values of high copper alloys. Higher creep is associated with flow of amalgam over cavity margins which is thin and easily fractures under occlusal stress

("ditched amalgam"). Over trituration increases creep. Decreased creep is seen in lathe-cut type of amalgam. Increased Condensation pressure, decreased creep (due to less residual Hg)

- **Modulus of elasticity:** At low rates of loading, the elastic modulus of amalgam is $11-20 \times 10^3 \text{ MN/m}^2$. At high rates of loading, the elastic modulus is $62 \times 10^3 \text{ MN/m}^2$

- **Resistance to corrosion:** Passive layer of chlorides, sulphides, and/or oxides seen on amalgam surface in unhygienic mouths. Electrolytic corrosion of dissimilar portions of the filling. Corrosion products that form at the margins over a period serve to seal the marginal gaps. Therefore marginal integrity of amalgam restorations improves with time.

6. ADVANTAGES OF DENTAL AMALGAM²⁷⁻³⁰

- Durable
- Least technique sensitive of all restorative materials.
- Applicable to a broad range of clinical situations.
- Newer formulations have greater long-term resistance to surface corrosion.
- Good long-term clinical performance
- Ease of manipulation by dentist.
- Minimal placement time compared to other materials.
- Initially, corrosion products seal the tooth-restoration interface and prevent bacterial leakage.
- One appointment placement (direct material)
- Long lasting if placed under ideal conditions
- Often can be repaired
- Economical
- Relatively inexpensive.
- Easy to manipulate.

- Restoration is completed within one sitting without requiring much chair time.
- Well-condensed and triturated amalgams have good compressive strengths.
- Sealing ability improves with age by formation of corrosion products at tooth-amalgam interface.
- Relatively not technique sensitive.

7.DISADVANTAGES OF DENTAL AMALGAM³¹⁻³⁴

- Some destruction of sound tooth tissue
- Poor esthetic qualities
- Long-term corrosion at tooth-restoration interface may result in "ditching" leading to replacement.
- Galvanic response potential exists
- Local allergic potential
- Concern about possible mercury toxicity
- Marginal breakdown
- Marginal breakdown and fracture.
- Tarnish and corrosion.
- Unnatural appearance (not aesthetic).
- Metallic taste and Galvanic shock.
- Marginal leakage.
- Discoloration of the tooth structure.
- Lack of chemical or mechanical adhesion to the tooth structure.
- Mercury toxicity.
- High rate of secondary caries.
- Thermal conductivity.
- Promotes plaque adhesion.
- Delayed expansion.

8.USE OF DENTAL AMALGAM³³⁻³⁵

- In individuals of all ages,
- In stress-bearing areas and in small-to-moderate sized cavities in the posterior teeth,
- When there is severe destruction of tooth structure and cost is an overriding consideration,

- As a foundation for cast-metal, metal-ceramic, and ceramic restorations,
- When patient commitment to personal oral hygiene is poor,
- When moisture control is problematic with patients, and
- When cost is an overriding patient concern.
- As a filling material for Class I and Class II cavities.
- Can be used for Class V cavities of posterior teeth.
- Sometimes can be used for cuspal restorations (with pins usually).
- As a core build-up material prior to cast restoration.
- As a retrograde filling material.
- In combination with Composite resin for cavities in posterior teeth. Resin veneer over amalgam.
- As a die material.
- In persons of all ages.
- In areas where most chewing is done, mainly in the rear teeth.
- When there is severe damage of tooth structure and cost is a big factor.
- As a foundation for metal, metal-ceramic, and ceramic crowns or caps.
- When patient commitment to personal oral hygiene is poor.
- When moisture control is a problem when placing the filling.
- When cost is a large patient concern.

9.CONTRAINDICATIONS OF DENTAL AMALGAM^{36,37}

- Where esthetics are important, such as in the anterior teeth and in lingual endodontic-access (root canal) restorations of the anterior teeth,
- Patients having a history of allergy to mercury or other amalgam components.
- A large restoration is needed and the cost of other restorative materials is not a significant factor in the treatment decision.

- A large filling is needed and the cost of other restorative materials is not a major factor in the treatment decision.

10. AMALGAM FAILURES – CAUSES³⁸

- Inadequate retention
- Insufficient bulk for strength
- Failure to remove unsupported enamel
- Caries not removed
- Inadequate condensation
- Recurrent caries

11. MERCURY TOXICITY

Dental workers are more exposed to mercury toxicity than the general population.

People are mainly exposed to elemental mercury by breathing in its vapour, since contact with the skin or ingestion leads to very little absorption into the body. Mercury vapour is absorbed in the lungs, spreads to the entire body and is then slowly excreted. Breathing in extremely high concentrations of mercury may produce bronchitis and pneumonia and affect the central system, for instance leading to muscle tremors. Long-term exposure to high levels may affect the kidneys and the inside of the mouth and gums³⁹.

However, the amount released by dental amalgams is much lower than the limits allowed for exposure at work. Dental amalgam fillings occasionally cause local effects in the mouth, such as allergic reactions of the gums and of the skin inside the mouth, but this happens only rarely and is normally easy to manage. Mercury toxicity may cause signs like Tremor Headache, Ataxia Irritability, Personality change Slowed nerve conduction, Loss of memory, Weight loss, Insomnia Appetite loss, Fatigue

Gingivitis, Depression Psychological distress, etc⁴⁰.

12. SOME PATENTS ON AMALGAM RESTORATIONS

12.1 Low silver containing dental amalgam alloys: Charles F, Edward J. reported a conventional or non-conventional dental amalgam alloys in the form of lathe-cut, spherical or irregular shaped. They used particles of silver, tin, copper and zinc to improve the efficiency of alloy. The resulting dental alloy mixture was corrosion resistant, and was used as a filling for dental cavities after amalgamation with mercury⁴¹.

12.2 New dental amalgam alloy composition: De L adapted two new composition for amalgamation with mercury to form better dental amalgam from the currently used alloy, it consists essentially of a uniform mixture of:(a) A first alloy composed of at least 65 weight percent silver, up to 29 weight percent tin, up to 6 weight percent copper, and up to 2 weight percent zinc; and(b) A second alloy composed of from 46 to 51 weight percent silver, from 4 to 6 weight percent tin, and from 45 to 48 weight percent copper⁴².

12.3 Amalgamatable dental alloy powder having an effect of reducing initial mercury vapor release rate: The present invention of Lin, Chern J provides an amalgamatable dental alloy powder for making an amalgam having a low initial mercury vapor release rate having a composition comprising 50-80 wt % Ag; 10-30 wt % Cu, and 10-35 wt % Sn, and optionally less than 7 wt % of Pd, which is prepared by subjecting a single-alloy powder having a particle size ranging from 1 to 55 microns with a majority thereof having a particle size less than 20 microns to a heat treatment, or separately subjecting a Ag--Cu--Sn powder having a particle size ranging from 1 to 70 microns

with a majority thereof having a particle size less than 30 microns and a Ag--Cu--Pd powder having a particle size ranging from 1 to 100 microns with a majority thereof having a particle size less than 45 microns to heat treatments, and subjecting the heat treated powders to a pickling treatment⁴³.

12.4 Method of producing alloyed powders for dental amalgams: Werner G invented an economical alloyed powder for dental amalgams exhibiting good working properties. The formed body is produced by mixing and pressing powders of elemental silver, copper and tin with a subsequent sintering between 150°C and the solidus temperature of the alloy being formed. The sintering is performed until a homogeneous distribution of the tin has been achieved in the silver and copper particles⁴⁴.

12.5 Adhesive amalgam system: David J. invented a modified amalgam composition forming an adhesive bond with tooth structure treated with a dental adhesive. The modified amalgam can be prepared by admixing particulate additives into conventional amalgam alloy powder to form a modified alloy powder and then triturating the modified alloy powder with mercury. The modified amalgam when applied to a prepared tooth cavity that has been precoated with an acrylate- or methacrylate-functional dental adhesive results in an adhesive bond between the modified amalgam and coated tooth structure. Preferred particulate additives for the amalgam alloy powder are acrylate- or methacrylate-functional polymers, metal salts of acrylates or methacrylates, nonmetallic fillers, oxidizing agents and reducing agents⁴⁵.

CONCLUSION

Dental amalgam not only corrects the damaged tooth but also restores the esthetics, phonetics and function of the tooth. Proper treatment should be done to avoid any complications and to make tooth appear more natural. Amalgam's main advantage is that it is durable, easy to manipulate by dentist and economical. Amalgam is not recommended in cases where esthetics is important like in anterior teeth. Every treatment should be done according to the particular patient's condition and work should be done in such a way that most portion of natural tooth is protected from damage. Hope this review will be helpful in providing some useful information related to dental amalgam to dental students.

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