USES OF HIGH COPPER AMALGAM ALLOYS IN DENTISTRY

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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 high copper alloys 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.

Keywords: Amalgam, High Copper, 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. High copper amalgams contain more than 6 % copper, in fact there are 2 main groups, one containing around 12-13 % copper, and the other containing up to 30 % copper. The additional copper helps to increase the formation of gamma 1 (silver-tin) and prevent the formation of a weak phase of dental amalgams, named gamma-2 (tin-mercury) and thus the strength of the final product is higher. Therefore, the high copper amalgams have a higher compressive strength and in general, better mechanical properties. 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. 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.

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 toxicity[1-5].

2. Classification of amalgam alloys

2.1 According to content[6, 7]

- **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[8, 9]

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

2.3 According to Copper content[10]

- 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[11]

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

2.5 According to the shape of alloy particles[12]

• **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[13]

• **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 Ag2CuSn.
• **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 amalgam[14 – 16]

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

4.Components[17 – 21]

4.1. Silver: Increases strength, expansion and reactivity and it also decreases creep.
Corrosion products due to silver are AgCl and AgS.

4.2 Tin: Increases reactivity and corrosion but decreases strength and hardness.
Corrosion products due to tin are SnO, SnCl, and SnS.

4.3 Copper: Increases strength, expansion and hardness but decreases creep.
Corrosion products due to copper are CuO and CuS.

4.4. Zinc: Increases plasticity, strength and the Hg: alloy ratio. It also decreases creep and causes secondary expansion. Corrosion products due to zinc are ZnCl and ZnO.

4.5. Mercury: It wets the alloy particles and decreases strength if present in excess amount. It is implicated in toxic and allergic reactions.

4.6. Indium: It increases strength, expansion and flow but makes amalgamation more difficult. It also increases setting time.

5. Composition of High Copper Alloys[22]

• Silver: 40% min.
• Tin: 32% max.
• Copper: 30% max.
• Mercury: 3% max.
• Zinc: 2% max.

6.Setting Reaction of High Copper Alloys[23]

This is a process by which liquid Hg reacts with dental amalgam alloy particles to produce a matrix of intermetallic compounds of Hg with metals of the alloy.

• **Reaction 1:**

$Ag_3Sn + Ag_3Cu_2 + Hg \rightarrow Ag_2Hg_3 + Sn_7Hg_8 + Ag_3Sn + Ag_3Cu_2$

• **Reaction 2:**

$Ag_3Cu_2 + Sn_7Hg_8 \rightarrow Ag_2Hg_3 + Cu_6Sn_5$

7.Advantages of Dental Amalgam[24, 25]

• 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.

8. Disadvantages of Dental Amalgam[26, 27]

- Galvanic response potential exists
- Local allergic potential
- Concern about possible mercury toxicity
- Marginal breakdown
- Some destruction of sound tooth tissue
- Poor esthetic qualities
- Long-term corrosion at tooth-restoration interface may result in "ditching" leading to replacement.
- Marginal breakdown and fracture.
- Tarnish and corrosion.
- Mercury toxicity.
- High rate of secondary caries.
- Thermal conductivity.
- Promotes plaque adhesion.
- 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.
- Delayed expansion.

9. Can be used in[28 – 30]

- 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.
- In patients with poor oral hygiene
- When moisture control is a problem
- In low economic status patients
- In patients of all ages
- Stress bearing areas
- In small to moderate size cavities
- As a foundation to metal ceramic, cast metal restorations
- As a filling material for Class I and Class II cavities.

10. How to Avoid Failures of Restoration[31 – 33]

- avoid bulk placement of material
- avoid contact with fingers or gloved hands
- keep cavity as small as possible complete removal of dental caries
- complete and proper base application
- proper isolation while placement of the restoration
- avoid sharp internal line angles
- use small increments
- Restoration at bevelled areas should be polished properly

11. Contraindications of Dental Amalgam[34 – 36]

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

12. Mercury toxicity[37 – 40]

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 gums. 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 likeTremor Headache, Ataxia Irritability, Personality change Slowed nerve conduction, Loss of memory, Weight loss, Insomnia Appetite loss, Fatigue Gingivitis, Depression Psychological distress, etc. 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.

13. Some patents on amalgam restorations

13.1 Method of producing alloyed powders for dental amalgams: An economical alloyed powder for dental amalgams exhibiting good working properties is obtained from pressed and sintered molded bodies by mechanical comminution. The formed body is produced by mixing and pressing powders of elemental silver, copper and tin with a subsequent sintering between 150.degree. 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 particles[41].

13.2 Adhesive amalgam system: 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 agents[42].

13.3 Amalgamatable dental alloy powder having an effect of reducing initial mercury vapor release rate: The present invention 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 treatment[43].

13.4 Dental amalgam alloy: The present invention relates to low in silver particulate dental amalgam alloys comprising by weight from about 46 to 48% silver, about 23 to 33% tin, about 20 to 28% copper and about 0.5 to 5% indium. The dental amalgam alloys of the present invention have been found to be particularly efficacious when incorporated in blends with high silver particulate dental amalgam alloys, said high silver alloys being used in amounts between about 30% and 70% of the total alloy blend[44].

13.5 Anti-tarnish silver alloy: An anti-tarnish silver alloy is provided including at least about 85% silver, with the balance including zinc, copper, indium, and tin. Also provided are articles made from the alloy and methods of making the articles[45].

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. 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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