Lec. 9 **Dr. Sahar**

Dental Materials

Glass ionomer cements: There are two main types of glass ionomers:

1.Conventional glass ionomer
2.Resin-modified glass ionomer which is subdivided into:
- **True light cure Glass Ionomer System**
- **Tri-Cure Glass Ionomer System**
- **Nano ionomer**

Uses of Glass Ionomers: both conventional and resin-modified glass ionomers are used for a variety of restorative applications, especially in:

1. High caries activity or where caries are likely to recur.
2. small caries lesions in non-stress-bearing restorations in permanent teeth
3. interim restoration in permanent teeth.
4. They make an excellent liner or base in all deep lesions.
5. Resin-modified glass ionomers are often the material of choice for pediatric restorations and preventive applications.

Properties of Glass Ionomers:

1. The physical and mechanical properties of GIs are lower than that of composite resins .
2. The coefficient of thermal expansion has been shown to be closer to tooth structure (dentin) than are resin composites. (Serve as good insulation against thermal shock, particularly when used as liners and bases).
3. Fluoride ion release and uptake these materials act as a **reservoir of fluoride ions**.
4. Good adhesion to tooth structure. Unlike composite materials (etching of the enamel or dentin surface is not needed). Hence these materials are sometimes referred to as being **self-adhesive**.
5. is radiopaque

Compomers: Compomers or poly acid–modified composites have fluoride-releasing silicate glasses. They are used for restorations in low stress–bearing areas, Compomers are recommended for patients at medium risk of developing caries.

Amalgam Restoration

Dental amalgam is an alloy produced by mixing liquid mercury with solid particles of silver, tin, copper and zinc. In dentistry, the amalgam has been successfully used for more than a century as a restoration material for tooth decay mainly in posterior teeth.



Supplied as:

1- Bulk powder and mercury.
2- Alloy and mercury in disposable capsule mixed amalgamator machine.

Classification of amalgam alloys:

1. Based on copper content:

* Low copper alloys: Contain less than 6% copper (conventional alloys).

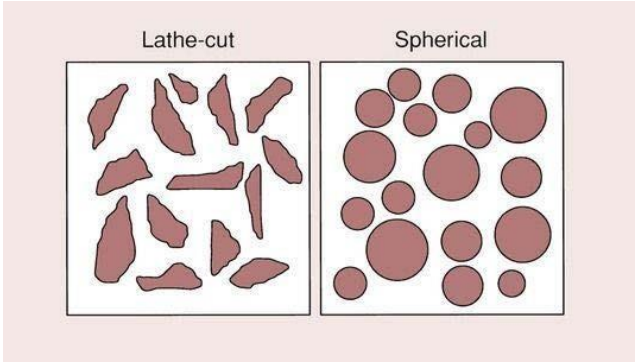
* High copper alloys: Contain more 13-30% copper.

2. Based on zinc content:

* Zinc-containing alloys: Contain more than 0.01% zinc.

* Zinc-free alloys: Contain less than 0.01% zinc.

3. Based on the shape of alloy particle:



* Lathe cut alloys: irregular shape.

* Spherical alloys.

* Mixture of Lathe cut and spherical alloys.

4. Based on number of alloyed metals:

* Binary alloys: e.g. silver-tin.

* Tertiary alloys: e.g. silver-tin-copper.

* Quaternary alloys: e.g. silver-tin-copper-indium.

Composition:

Amalgam alloy consist essentially of sliver and tin, in lesser amount cooper, zinc and a trace of gold, palladium, indium and selenium.

Setting reaction:

1- Low copper alloys: (Traditional, Conventional)

* Composed of silver 63-7o%, tin 25-27%.

* Available as: lathe-cut alloys, spherical alloys, blend of lathe-cut and spherical particles.

- when alloy powder and mercury are triturated, mercury diffuses into the alloy particles and starts reacting with the silver and tin present in it, forming silver-mercury, tin-mercury compounds and unreacted silver-tin compound.

Ag3Sn + Hg ========== Ag3Sn+ Ag2Hg3 + Sn8Hg

(Ag3Sn) gamma (Y) phase a silver-tin compound that forms a substantial part of the amalgam alloy (form the strongest phase).

(Ag2Hg3) gamma 1 (Y1) phase A silver-mercury compound that is a reaction product in dental amalgam (noble phase, the main constituent of set amalgam).

(Sn8Hg) gamma 2 (Y2) phase A tin-mercury compound (the weakest compound and cause tarnish and corrosion)

Note: These are called as phases of setting reaction. Properties of hardened amalgam depend upon proportion of reaction phases. The (Y2) phase is weakest compound and is least stable to corrosion process. If more (Y) phase is present the stronger the amalgam. The alloy particles do not react completely with mercury. About 27% of the original Ag3Sn remains as unreacted particles. Set amalgam consist of unreacted particles (Y) surrounded by matrix of the reaction

products (Y1) and (Y2).

2- High copper alloy:

They are preferred because of their improved mechanical properties, resistance to corrosion and better marginal integrity (because the weakest Y2 phase is eliminated in high copper amalgam).

High copper alloy is further classified as:

A- Admixed Alloy

- Made by mixing one-part 1/3 of high copper spherical particles (eutectic alloy) silver-copper with 2 part 2/3 of (low-copper, lathe-cut particles) silver-tin.

The main role of adding copper is to avoid Sn to react with Hg and react with Cu itself, to avoid formation of Y2.

B- Single-composition alloys:

Made from particle has the same composition silver (40-60%), copper (13-30%), tin (22-30)

AgSnCu + Hg ------- Cu6Sn5 + Ag2Hg3 + AgSnCu

Properties of amalgam:

1- **Dimensional change**: In general, most amalgams expand or contract only slightly during setting. Expansion may result in post placement sensitivity or protrusion from the cavity. Whereas contraction would leave gaps between the restoration and the tooth prone to leakage and recurrent decay. The initial contraction after short time (the first 20 minutes after tirturation) is believed to be associated with the solution of mercury in the alloy particles. After this period an expansion occurs which is believed to be result of reaction of the mercury with silver and tin.

Factors favoring contraction are:

1. Low mercury/alloy ratio.

2. Higher condensation pressure (squeezes out mercury).

3. Smaller particle size (accelerate mercury consumption).

4. Longer trituration times (accelerate setting).

*The dimension becomes **nearly constant after 6-8 hours,** and thus the values after 24 hours are final values.

*Modern amalgams show a net contraction, whereas older amalgams always showed expansion.

Two reasons for this difference:

A. Older amalgams contained larger alloy particles and were mixed with higher mercury/alloy ratios.

B. Hand trituration was used before; modern amalgams are mixed with high-speed amalgamators.

The effect of moisture contamination (delay expansion): If zinc containing amalgam contaminated with water during trituration or condensation, a large expansion can take place. It is usually starting after 3-5 days and may continue for months. This is known as delayed or secondary expansion.

$H_2O + Zn$ ------ $ZnO + H_2$ (gas)

The hydrogen gas does not combine with the amalgam, but collects within restoration, creating internal pressure and expansion of the mass. It may reach 4% and cause pressure on the dental pulp and post-operative sensitivity; this is known as delay or secondary expansion.

Amalgam without zinc tends to be less plastic and less workable; used only for cases where it is difficult to control moisture, e.g.: patients having excessive

salivation, subgingival lesions, etc.

2.Strength

Hardened amalgam has good compressive strength but low tensile or bending strength. Therefore, the cavity design should be such that the restoration will receive compression forces and minimize tension or shear forces in service.

Factors affecting strength:

1. **Trituration affect:** either under or over trituration will decrease the strength for amalgam.

2. **Mercury content affect:** sufficient mercury should be mixed with the alloy to wet each particle of the alloy. Otherwise, a dry, granular mix results which has rough and pitted surface that invites corrosion. Excess mercury in the mix can produce a marked reduction in strength because high mercury amalgam has more y2 content (which is weakest phase).

3. **Condensation affect:** higher condensation pressure results in higher compressive strength. Good condensation technique will minimize porosity, improves adaptation and remove excess mercury from lathe-cut amalgam. While the spherical amalgam condense with lighter pressures produce adequate strength (If heavy pressure is used the condenser will punch through).

4. **Porosity affect:** voids and porosity reduce strength. **Porosity is caused by:**

A. low and high Hg/alloy ratio & over and under trituration.





B. Inadequate condensation pressure.

C. Irregularly shaped particles of alloy powder.

D. Insertion of too large increments.

5. **Rate of hardening affect**: strength increase with time. Amalgam do not gain strength as rapidly as might be desired. Patient should be cautioned not to bite too hard for least 8 hours after placement. The time at which at least 70%

of its strength is gained.

6. Cavity design affect: the cavity should be designed to reduce tensile stresses. Amalgam has strength in bulk; therefore increase thikness will increase strength, the cavity should has adequate depth.

3.Creep: Creep is defined as a time dependent plastic deformation. Creep of dental amalgam is a slow progressive permanent deformation of set amalgam which occurs under constant stress (static creep) or intermittent stress (dynamic creep).

It is related to marginal breakdown of low copper amalgam. The higher the creep, the greater is the degree of marginal deterioration (ditching). Creep causes the amalgam to flow over time such that unsupported amalgam protrudes at the margin of the restoration.



* Low copper amalgam creep= 0.8-8.0%.

* High copper amalgam creep= 0.4-0.1%.

* Creep should be below 3%.

* The Y2 phase is associated with higher creep rates.

* Increase in zinc content gives less creep.

Effect of manipulative variables (for increase strength & low creep):

- Hg/alloy ratio should be minimum.
- Condensation pressure should be maximum for lathe-cut or admixed alloys.
- Careful attention should be paid to timing of trituration and condensation. Either under or over trituration or delayed condensation tend to increase the creep rate.

4.Tarnish: Tarnish: means loss of luster from the surface of metal or alloy due to the formation of a surface coating.

- Cause no change in the mechanical properties of the alloy.
- Amalgam is usually tarnish due to the formation of sulphide layer on the surface.
- Tarnish increase in patients on a high sulfur diet.
- Rough surface and moisture contamination during condensation increase tarnish.

5.Corrosion: Corrosion is the progressive destruction of a metal by chemical or electrochemical reaction with its environment that penetrate the body of the amalgam and cause the failure of the restoration



- Excessive corrosion can lead to increased porosity, reduced marginal integrity, loss of strength, and the release of metallic product into oral environment.

Factors related to excess tarnish and corrosion:

1. High residual mercury increase corrosion.
2. Contact of dissimilar metals, e.g gold, and amalgam increase **galvanic** corrosion.
3. High copper amalgam is cathodic in respect to a low copper amalgam so mixed high copper and low copper restoration increase **galvanic** corrosion (should be avoided).
4. Rough surface texture, small scratches and exposed voids increase corrosion.
5. Moisture contamination during condensation.
6. Patients on a high sulfur diet.
7. Type of alloy-low copper amalgam is more susceptible to corrosion (due to greater y2 content) than high copper.

Corrosion of amalgam can be reduced by:

1. Smoothing and polishing the restoration.
2. Correct Hg/alloy ratio and proper manipulation.
3. Avoid dissimilar metal including mixing of high and low copper amalgams.

Corrosion has one advantage that corrosion products gathered at the restoration-tooth interface (seal the gap) to prevent or decrease micro leakage.

6.Thermal properties*:* Amalgam has a relatively high value of *thermal diffusivity*. In large cavities it is necessary to line the base of the cavity with an insulating, cavity lining material prior to condensing the amalgam. The *coefficient of thermal expansion* value for amalgam is about three times greater than that for dentine.

7.Biological properties

Certain mercury compounds are known to have a harmful effect on the central nervous system. The patient is briefly subjected to relatively high doses of mercury during placement, contouring and removal of amalgam fillings. A lower, but continuing, dose results from ingestion of corrosion products. Properly handled dental amalgam should be regarded as safe for general use as a direct restorative material.

Mercury toxicity: Mercury is toxic, Free mercury should not be sprayed or exposed to the atmosphere. This hazard can arise during triturating, condensation, and finishing of restoration, and also during the removal of old restoration at high speed. Mercury vapors can be inhaled; skin contact with mercury should be avoided as it can be absorbed. It also reacts with gold.

Mercury has a cumulative toxic effect. Dentists and dental assistant are at high risk. Though it can be absorbed by skin or by ingestion, the primary risk is from inhalation. The clinic should be well ventilated. All excess mercury and amalgam waste should be stored in well-sealed containers.

Precautions:

1. The clinic should be well ventilated.
2. Mercury should be stored in well-sealed container.
3. Skin contact with mercury should be washed with soap and water.
4. During removing old filling, water spray and high suction should be used.
5. The use of ultrasonic amalgam condenser is not recommended as a spray of small mercury droplets is observed.

6. If gold jewelry come in contact with mercury will ruin the jewelry. Boiling it with coconut oil will fix it.