CHAPTER 1

Amalgam Restorations

Chapter outline

- Definition of amalgam
- Advantages and disadvantages of amalgam restorations
- Indications and contraindications of amalgam restorations
- Classification of amalgam alloys
- Cavity preparation for amalgam restorations
- Manipulation of amalgam
  ✓ Selection of the alloy
  ✓ Proportioning
  ✓ Trituration
  ✓ Condensation
  ✓ Carving
  ✓ Finishing and polishing
Objectives of Chapter (1)

In the end of this chapter, the student will be able to recognize:

(1) Definition of Amalgam.

(2) Advantages and disadvantages of amalgam restorations.

(3) Indications and contraindications of amalgam restorations.

(4) Classifications of amalgam.

(5) Cavity preparation for amalgam restorations.

(6) Manipulation of amalgam.
Definition of Amalgam:

It is an alloy in which one of its constituents is mercury.

Advantages of amalgam

1. Superior adaptation to cavity walls: It improves with time. This inhibits microleakage and subsequently inhibits postoperative hypersensitivity, pulp affection and caries recurrence.

2. High compressive strength: It enables the restoration to sustain occlusal forces without fracture.

3. Good form stability: which enables the restoration to maintain surface polish, occlusal anatomy and inter-proximal contact due to insolubility, high wear resistance and low creep tendency of high copper amalgam.

4. Ease of manipulation: this helps in obtaining a successful and lasting restoration due to easy technique of manipulation.

5. Relative low cost.

Disadvantages of amalgam:

1. Low tensile and shear strength: (about 25 % of its compressive strength) Clinical significance of low tensile strength is the tendency to marginal ditching and isthmus fracture.

2. Creep: it is a time-dependent plastic deformation of a set material. This results in marginal breakdown, flattening of contacts, saucering of occlusal anatomy and formation of gingival overhang.

3. High thermal conductivity: which may cause pulp irritation unless is adequately protected.

4. Metallic color: and hence cannot be used in esthetic areas in
addition to their affection by tarnish and corrosion.

5. **Lack of adhesion to tooth structure**: which dictates the use of macromechanical means of retention like undercuts and grooves.

6. **Galvanic shock**: it can occur if another metallic restoration was placed a close proximity.

7. **Potential health hazards** due to its mercury content.

**Indications:**
1. Small and medium sized class I & II cavities.
2. Class V in posterior areas of the mouth.
3. Previously, it was used for restoration of class III in distal surface of upper canine to resist the anterior components of forces and hence the mesial drifting of the upper first premolar.
4. Core build-up under full coverage restorations.

**Contra-indications:**
1. Extensive lesions especially those including undermined cusps where cast gold is the material of choice.
2. Appeared areas of the mouth in the anterior and posterior teeth where composite resin is more favorable.
3. Presence of opposing gold bridge to avoid galvanic shock.
4. Rampant caries where glass ionomer can act as a control restoration.

**Classification of amalgam alloys**

I. **According to the shape of the powder particles:**
   - Lathe-cut
   - Spherical
   - Admixed
II. According to the size the powder particles:

- Micro-cut
- Fine-cut
- Coarse-cut

III. According to the copper content:

1. **Low copper amalgam (conventional):** copper content is 4% or less.
2. **High copper amalgam:** copper content is more than 4%.

**N.B:** the total copper content of this amalgam is 13-30 wt. %, the most corrodesible γ2 phase is eliminated, but if excess Hg is present γ2 phase will be formed.

IV. According to the zinc content:

1. Zinc containing type.
2. Zinc free type: that is used in areas where moisture contamination is impossible as: partially erupted teeth, and sub-gingival cavities.

*Cavity preparation for amalgam restorations:*

Based on the inherent properties of amalgam (brittle), cavity preparation for amalgam must be: conservative and provides adequate bulk.
Specific features:

1. 90° CSA. e.g. reverse curve in the bucco-proximal wall of class II.
2. The walls must be parallel or perpendicular to occlusal loads.
3. A definite gingival seat of 1.5-2 mm. in depth for compound cavities.
4. Rounded internal line angles.
5. Sufficient bulk at the isthmus area through:
   a. Saucerizing the pulpal floor at the isthmus.
   b. Inclining the axial wall towards the isthmus.
   c. Rounding the axio-pulpal line angles.
6. Each portion must have its own independent retention and resistance.

![Fig. 2: A figure showing cavity design for amalgam restorations](image)

Manipulation of amalgam

1. Selection of the alloy.
2. Proportioning
3. Trituration.
4. Condensation.
5. Carving.
6. Finishing and polishing.
I. Selection of the alloy

- **Spherical powder particles** provide the following advantages:
  1. Very soft consistency that requires light condensation forces and so it can be easily condensed and adapted around pins in pin-retained restorations and recommended in pulp capped teeth.
  2. Require less Hg content.
  3. Provide smooth surface.

**N.B.** Spherical alloys are not recommended for extensive restorations because it cannot establish better contour and contact areas.

- **High copper amalgam** has the following advantages:
  1. High strength properties.
  2. Greater corrosion resistance.
  3. Low creep values therefore, it is indicated in extensive preparations involving centric holding areas.

- **Zinc containing amalgam**

  If zinc containing amalgam used in area of moisture contamination, this will lead to: Delayed expansion of amalgam.

  **Mechanism:**
  1. Zinc + moisture (H2O) \( \rightarrow \) ZnO + H (Reaction takes place in 24-72 hours after amalgam insertion).
  2. H+ accumulates in considerable amounts and exerts pressure (400 micron/ cm.) \( \rightarrow \) Pain
  3. Then, they migrate to the surface \( \rightarrow \) Corrosion.

Therefore, Zinc free amalgam is preferred when moisture contamination is impossible to control.
**Presentation of amalgam:**

Amalgam can be presented in different forms as powder and mercury, tablets which will mixed with mercury or a pre-proportioned capsules. Capsule form is preferred than other forms as it provides a standardized pre-weighted amalgam alloy.

**II. Proportioning of alloy and Hg**

The amount of alloy and Hg to be used depends on:

1. The amount required to slightly over fill the cavity.
2. The amount which can be condensed within a period of 3-5 min (working time).

The amount of mercury should completely wet every alloy powder particle without affecting the final properties of the amalgam restoration.

**N.B:** The alloy / Hg ratio must be based on weight not volume due to variation in particles size and shape.

**If amount of mercury is more than needed**

The final restoration will be characterized by the following due to formation of more gamma 2 phase:

1. Decreased strength properties.
2. Decreased hardness.
3. Increased flow and creep.
4. Increased expansion.
**If the amount of mercury is less than needed**

The final restoration will be characterized by the following because some of the powder particles uncoated with mercury and not bound to the rest of the structure.

1. Non-coherent, friable mix which is difficult to condense.
2. Weak and corrodible.

**Proportioning techniques:**

1- Wet mix technique:

It is termed *(Jorgenson technique)* at which alloy/Hg ratio is 5:8 ratio by weight. It is the technique of the beginners as it provides a plastic mass for a considerable working time, while excess Hg will remain in the mix, with the deleterious effect of decreased strength and hardness, increased expansion, creep, tarnish and corrosion.

**N.B.** Excess Hg can be eliminated by squeezing.

2- Low Hg technique:

It is termed *(EAM's technique)* at which alloy/Hg ratio is 5:5 or 1:1 ratio by weight. It minimizes the deleterious effects of excess Hg in the final restoration.

**N.B.** Spherical alloys require only 40 wt %, high copper alloys needs 45 wt% and Lathe-cut conventional alloys require 50 - 54 wt%.
*Methods for proportioning:*

1. **Manual:** using volume dispenser.

2. **Mechanical:** using amalgamizer (Fig. 3) or pre-weighted capsule. Pre-weighted capsule are more accurate because the ratio is formerly determined by the manufacturer.

![Fig. 3: Amalgamizer used for proportioning and trituration of amalgam](image)

**III. Trituration**

**Definition:** It refers to the process of mixing Hg and alloy particles to produce a coherent plastic and homogenous mass of condensable amalgam.

**Objectives:**
1. Removal of surface oxide film off the alloy particle.
2. Coating of each alloy powder particle with Hg.
3. Allow the amalgamation reaction to start.

**The outcome of the amalgamation reaction are:**

1. Decrease in the size of remaining unconsumed \( \gamma \) phase (strongest and hardest phase).
2. Production of non-corrodible \( \gamma_1 \) phase.
3. Production of corrodible \( \gamma_2 \) phase in conventional alloy.
4. Progressive consumption of Hg and hence, decrease in plasticity.

**Factors affecting trituration:**

1. Time (minutes)
2. Speed (rpm)
3. Pressure (F/A)

1. *Under trituration will results in:*
   a. Some alloy powder particles will remain covered with oxide film.
   b. Presence of excess Hg.
   c. The production of dull, non-coherent and friable mix.
   d. The restoration will be weak, corrodiible and exhibits excessive expansion.

2. *Proper trituration:*
   The mix appears homogenous, coherent, shiny, plastic, and climbs at the sides of the mortar (curl off).

3. *Over trituration will results in:*
   1) Fast setting as a result of rapid Hg consumption and crystallization.
   2) The mix appears homogenous, but less plastic and hence improperly condensed and adapted to cavity walls.
   3) Over triturated amalgam exhibits less setting expansion or insignificant contraction.

**Methods of trituration**

1. *Manual trituration:*
   It involves the use of mortar and pestle (Fig.4). They must be conforming in shape, surface roughness, and material. Movement must be in one direction with palm- and thumb grasp and maximum force.
II. Mechanical trituration:
It ensures optimum results due to standardization of manipulation variables.
There are two different techniques:

1. **Amalgamators**: for trituration of pre-weighted amalgam capsules (fig. 5).
2. **Amalgamizers**: for proportioning and trituration of powder and Hg.

![Amalgamator](image1.png)

**Fig. 5: Amalgamator used for amalgam trituration**

✔ **Squeezing and mulling:**

**Squeezing**: It is the process of squeezing the triturated amalgam mix in a piece of gauze to remove excess mercury without affecting its plasticity.
**Mulling:** It is the process of rubbing the triturated amalgam mix for few seconds in between thumb and index fingers using rubber material as a piece of rubber dam to improve its homogeneity and plasticity.

**N.B.:** Mulling can be performed mechanically by increasing the time of trituration for 1 – 2 sec.

 ✓ **Matricing and wedging:**

For compound and complex cavities, matrix should be used. Matrix is a piece of metal or any other material acts as a temporary wall during insertion of amalgam till hardening of the restoration.

**Requirements:**
1. Thin but rigid.
2. Easily applied and removed.
3. Easily contoured.
4. Compatible with the restorative material.
5. Wedged: In proximal cavities.

![ Fig.6: A tofflemire matrix holder and bands of different shapes to suit different clinical situations ](image)
Wedge placement instructions:

1. Wedges are available in a variety of shapes and sizes.
2. Wooden wedges may be placed from either the buccal or the lingual aspect.
3. Should usually be inserted from the side with the widest embrasure.
4. Should be tightly inserted to enable development of an adequate contact (the thickness of the band).

Function of wedge:

1- Prevent proximal overhangs.
2- Teeth separation.
3- Matrix stabilization.

Fig. 7: A wooden wedge placed interproximally

IV. Condensation

Definition: It is the process of forcible packing of the fresh amalgam mix into the details of the cavity walls and margins.

Objectives:

1. Elimination of excess Hg.
2. Decreased porosity.
3. Increased strength and density.
4. Increased adaptation.

**How to obtain successful condensation?**

1) Proper matricing and wedging.
2) Only fresh mix should be condensed (maximum time 3 min.)
3) The force of the condensation should be towards the cavity details not towards the matrix band.
4) Incremental placement and condensation.
5) Amalgam is carried into the cavity using amalgam carrier.
6) Use of suitable sized condensers (slightly smaller than cavity width).
7) The initial condenser should be small enough to condense into line and point angles but large enough to avoid formation of holes in amalgam mass.
8) The size of the condenser must be increased in succeeding layers.
9) Slight overfilling: 1 mm to ensure that CSA are completely covered.

**Techniques of condensation:**

1. *Hand condensation:* utilizing hand condensers (smooth or serrated)
2. *Mechanical condensation:* either by vibration or compaction. Mechanical condensation is better than hand condensation because of the standardization of manipulative variables.

**Pre-carving burnishing:**

It is the use of a large ball burnisher to increase adaptation of the condensed amalgam to cavity margins as well facilitating carving. However,
it may be disagreed with by some clinicians because it may carry excess Hg into the critical CSA.

V. Carving

**Definition:** It is the process at which the anatomical and functional relationship of the restored tooth is achieved.

- **Timing of carving:** It starts after initial setting which detected when there is a slight resistance to carver.
- **Direction of carving:** Any direction except from the restoration to the tooth because it leads to creation of sub margins.
- **Carver:** Must be sharp because dull carver leads to stress induction, crack formation and disturbances in Hg distribution within the restoration.

![Fig. 8: A figure showing direction of carving from tooth to restoration](image)

**Steps of carving of compound restoration:**

a. Initial carving: a carving explorer is used to reproduce occlusal embrasures (from the buccal aspect to the center then from lingual to the center).

b. Final carving: after initial setting using sharp carver parallel to the cusp inclined plane using discoid, cleoid, diamond shaped or Hollenback carvers.

c. Final reproduction of anatomical features.
d. Removal of cervical overhangs using fine explorer.

e. **Post carve burnishing:** using a small ball burnisher at very light strokes to allow for smooth margins of the restoration, (satin or velveteen appearance).

f. Checking of inter proximal contact for tightness.

g. Checking of occlusion using articulating paper and removal of premature contact.

h. A bite-wing x-ray is taken to confirm freedom from proximal overhangs and for record purpose.

i. Instructions: the patient is instructed not to use the operated side for the next 24 hours to avoid cracking or fracture of amalgam till complete setting.

### VI. Finishing and polishing

**Finishing:** It is the process of achieving a smooth surfaced amalgam and elimination of marginal flashes and minor overhangs.

**Polishing:** It is the process by which a lustrous homogenous polished surface amalgam is obtained.

**Clinical significance:**

1. Increases corrosion resistance.
2. Decreases plaque retention and hence decreases possibility of caries recurrence and gingival irritation.
3. Decreases stress concentration and possible ditching or fracture due to premature contact.
Manipulation of amalgam:

1. Selection of the alloy.
2. Propertioning
3. Trituration.
4. Condensation.
5. Carving.
6. Finishing and polishing.
I. Selection of the alloy.

*Spherical alloys provides the following advantages:

1. Very soft consistency that requires only light condensation forces.

2. Requires less Hg.

3. Provides smooth surface.

Therefore it is indicated in:

1. Pulp capped teeth.

2. Around pins in pin-retained restorations.
*N.B.: spherical alloys are not recommended for extensive restorations because it cannot establish better contour and contact areas.

* High copper amalgam has the following advantages:

1. High strength.
2. Greater corrosion resistance.
3. Low creep value.

Therefore it is indicated in extensive preparations involving centric holding areas.
The alloy may be supplied in the form of:

* powder
* tablets
* capsules.

** capsules form is preferred than other forms as it provides a standardized pre-weighted amalgam alloy.
• Zinc containing amalgam when used in areas of moisture contamination, this will lead to:

**DELAYED AMALGAM EXPANSION**

**Mechanism:**

1. Zinc + moisture (H2O) → ZO + H⁺

   The reaction takes place in 24-72 hours after amalgam insertion.

2. H⁺ accumulate in considerable amounts and exert pressure (400 micron/cm.) → PAIN

3. Then, they migrate to the surface → CORROSION
Therefore, Zinc free amalgam is preferred when moisture contamination is impossible to control

1. In partially erupted teeth.

2. Deciduous teeth

3. Subgingival cavities.
II. Proportioning of alloy and Hg: The amount of alloy and Hg to be used depends on:

1. The size of the cavity (slight overfill)
2. The time required for condensation (3 minutes average time)

The alloy / Hg ratio must be based on weight not volume WHY?

Because of variation in particles size.
Hg is essential to wet every alloy particle.

Less Hg:

1. Non-coherent, friable mix which is difficult to condense.
2. Weak and corrodbile restoration.

Excess Hg:

1. Increased Y2 phase which may lead to,
3. Increased expansion.
4. Increased flow & creep.
Techniques of proportioning

1. Wet mix technique: *(5:8 alloy /Hg ratio)*

**JORGENSON TECHNIQUE**

**Advantage:**

* It is the technique of the beginners as it provides a plastic mass for a considerable working time.

**Disadvantage:**

1. More residual Hg. With the deleterious effects of:

* decreased strength, increased expansion, flow and creep, and tarnish and corrosion.
2. Low Hg technique: *(5:5 or 1:1 ratio By weight)*

**EAM’S TECHNIQUE**

**Advantage:**

it minimizes the deleterious effects of the residual Hg in the final restoration.

**N.B:** What ever the efforts to express excess Hg by squeezing, residual Hg would remain in the final restoration.
Alloy / Hg ratio depends mainly on:

1. The type of amalgam alloy.

2. The particles size and shape.


N.B: Spherical alloys require only 40 wt %, high copper alloys needs 45 wt % and Lathe-cut conventional alloys require 50 - 54 wt %
Methods for proportioning:

1. Volume dispenser: they must be kept upright for accurate proportioning

2. Pre-weighted capsule: more accurate because the ratio is formerly determined by the manufacturer.

N.B: Regardless of the method of proportioning, the addition of Hg after trituration is contraindicated.
III. Trituration:

Definition: refers to the process of mixing together Hg and alloy particles to produce a coherent plastic and homogenous mass of condensable amalgam.

Objectives:

1. Removing of surface oxide film off the alloy particle
2. Coating of each alloy particle with Hg.
3. Supplying energy for the amalgamation reaction
The outcomes of the amalgamation reaction are:

1. Decrease in the size of remaining unconsumed Y phase (strongest and hardest phase).

2. Production of non-corrodible Y1 phase.

3. Production of corrodbile Y2 phase in conventional alloy.

4. Progressive consumption of Hg and hence, decrease in plasticity.
Factors affecting trituration:

1. Time (minutes)

2. Speed (rpm)

3. Pressure (F/A)

Failure to standardize the over mentioned factors will lead to either:

1. Under trituration, or

2. Over trituration.
Under trituration:

*Some alloy particles will remain covered with oxide film.

*Excess of residual Hg.

*The mix appears dull, non-coherent, friable.

*The restoration will be weak, corrodirble, and exhibits excessive expansion.
Proper trituration:

*The mix appears homogenous, coherent, shiny, plastic, and climbs at the sides of the mortar (curl off).

Over trituration:

*It sets fast as a result of rapid Hg consumption and crystallization.

*The mix appears homogenous, but less plastic and sticks to the sides of the mortar.
*over triturated amalgam exhibits less setting expansion or insignificant contraction.

N.B: amalgam should never be under triturated and too plastic or non plastic mix must be discarded.

*Trituration time is determined by the manufacturer for the capsule form.
Methods of trituration

I. Manual trituration:

*involves the use of mortar and pestle.

*they must be conforming in shape, surface roughness, and material.

*movement must be in one direction with palm and thumb grasp and maximum force.
II. Mechanical trituration:

*It ensures optimum results due to standardization of manipulative variables.

There are two different techniques:

1. Amalgamators: for trituration of preweighted amalgam capsules.

2. Amalgamizers: for accurate proportioning and trituration of powder and Hg.
Mulling:

*it is the process of rubbing the triturated amalgam mix in a rubber cloth or a piece of rubber dam material for few seconds in between thumb and index fingers.

Functions:

1. To improve homogeneity, and plasticity.

2. To remove surface oxides.

N.B.: mulling is a continuation of trituration.
Matricing: For compound and complex cavities e.g., O.M., O.D., MOD., OB or OL

Dental matrix: is a piece of metal or any other material that is used as a temporary wall(s) for compound or complex cavities during insertion till hardening of the restorative material.

Requirements:

1. Thin but rigid.
2. Easily applied and removed.
3. Easily contoured.
4. Compatible with the restorative material.
5. Wedged: In proximal cavities.
1. Ivory matrix No. 1
2. Ivory Matrix No. 8
# Tofflemire matrix retainer
Tofflemire matrix retainer
Fixation of the matrix band to Tofflemire matrix retainer
Application of the matrix: the retainer is applied in the buccal sulcus
The wedge should be applied from the side of the widest embrasure:

Functions:

1. Make use of all condensation forces.
2. Prevents overhanging.
3. It induces slight separation to compensate for thickness of matrix band.