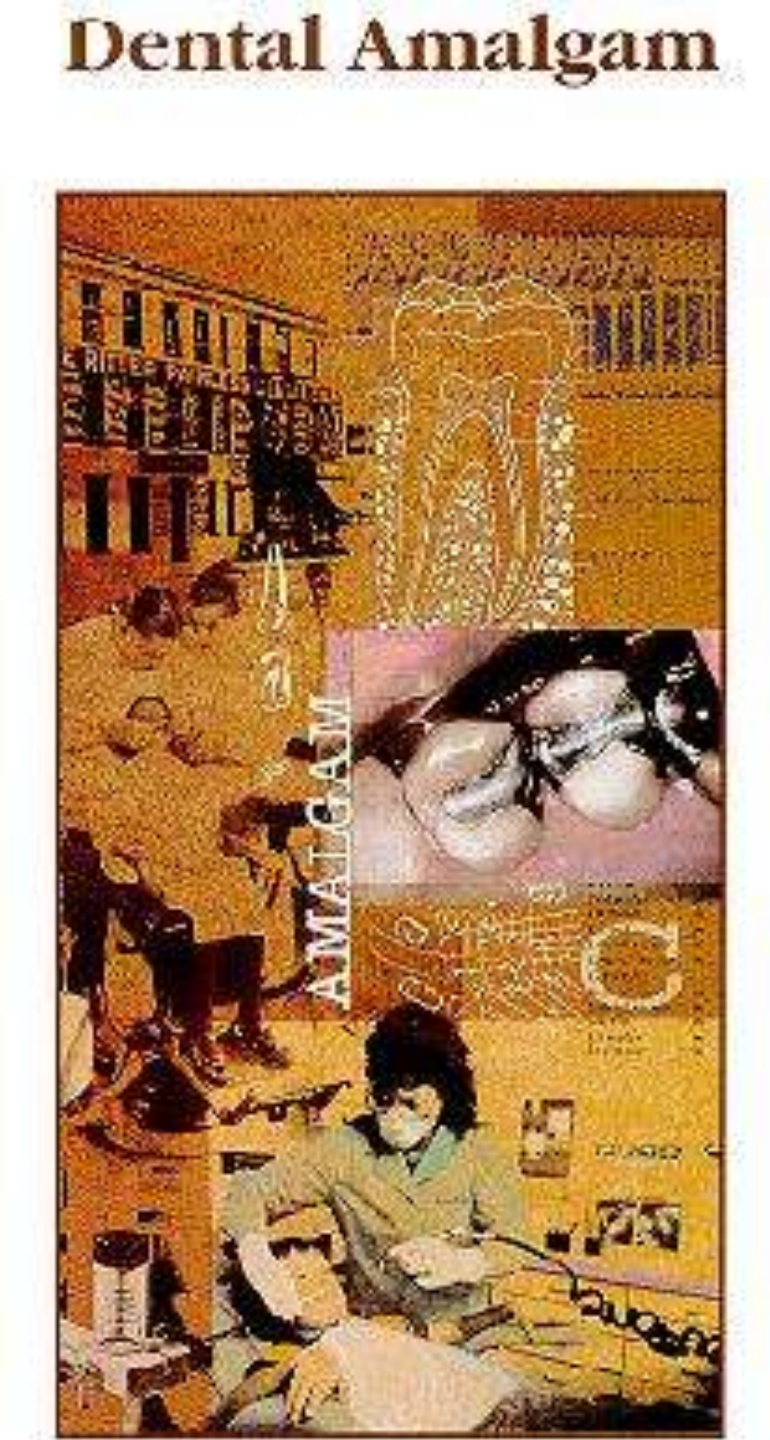
DENTAL AMALGAM



Dental amalgam has been extensively used as a tooth filling material for more than 150 years and has beyond doubt saved millions of teeth that otherwise would have needed to be extracted.

DEFINITIONS

Amalgam is an alloy which has mercury as one of its components. Amalgam is a powder and liquid. The liquid is mercury, the powder is a silver-based alloy with variant types and combinations. (M.A.Marzouk)

An alloy of mercury, silver, copper and tin, which may also contain palladium, zinc, and other elements to improve handling characteristics and clinical performance. (Phillips’ 11th edition.)

HISTORY & EVOLUTION

The Chinese developed a silver Amalgam for fillings more than 1000 years before dentists in west. ”Silver Paste” was used in 659 A.D in China.

The first dental silver Amalgam was introduced- Bell of England in 1819 and was known as Bell’s putty.

Later used by Traveau in France in 1826.

In 1833, two Frenchmen- the Crawcour brothers- brought it to the United States- “Royal Mineral Succedaneum”. *(silver shavings cut from coins + mercury)*

In 1843 a resoultion was passed by ASDS in USA- use of amalgam a ‘malpractice’.

Thus the ‘*Amalgam War*’ began.

JADA,Vol.129,Nov.1998

In 1844 Westcott reported that 50 percent of all restorations placed in upstate New York were made of amalgam.

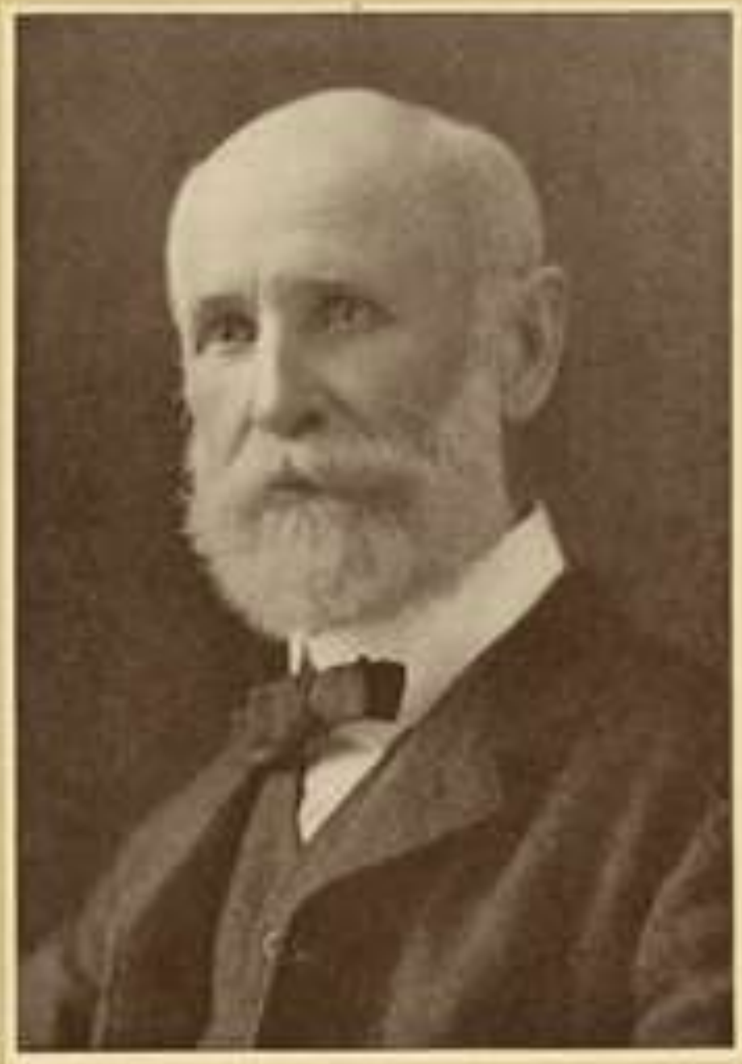
In 1845 ‘Amalgam Pledge’ was adopted by ASDS

(American society of dental surgeons) not to use amalgam.

In 1895, G.V.Black published a formulation for dental amalgam that proved to provide acceptable clinical performance.

In 1959, Dr. Wilmer Eames recommended a 1:1 ratio of mercury to alloy, thus lowering the 8:5 ratio.

JADA,Vol.129,Nov.1998



Greene Vardiman Black

CONSTITUENTS IN AMALGAM

- **Basic**
  - Silver
  - Tin
  - Copper
  - Mercury
- **Other**
  - Zinc
  - Indium
  - Palladium

ADA specification No.1 requires that amalgam alloys be predominantly composed of Ag & Sn.

BASIC CONSTITUENTS

Silver (Ag)

- increases strength
- increases expansion

Tin (Sn)

- decreases expansion
- decreased strength
- increases setting time

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BASIC CONSTITUENTS

Copper (Cu)

- ties up tin
  - reducing gamma-2 formation
- increases strength
- reduces tarnish and corrosion
- reduces creep
  - reduces marginal deterioration

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BASIC CONSTITUENTS

- Mercury (Hg)
    - activates reaction
    - only pure metal that is liquid at room temperature
    - spherical alloys
        - require less mercury
            - smaller surface area easier to wet
                - 40 to 45% Hg
    - admixed alloys
        - require more mercury
            - lathe-cut particles more difficult to wet
                - 45 to 50% Hg

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OTHER CONSTITUENTS

Zinc (Zn)

- used in manufacturing
  - decreases oxidation of other elements
    - sacrificial anode
- provides better clinical performance
  - less marginal breakdown
    - Osborne JW Am J Dent 1992
- causes delayed expansion with low Cu alloys
  - if contaminated with moisture during condensation
    - Phillips RW JADA 1954

$$H_2O + Zn \Rightarrow ZnO + H_2$$

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OTHER CONSTITUENTS

Indium (In)

- decreases surface tension
  - reduces amount of mercury necessary
  - reduces emitted mercury vapor
- reduces creep and marginal breakdown
- increases strength
- must be used in admixed alloys
- example
  - Indisperse (Indisperse Distributing Company)
    - 5% indium

J Dent Res 1989

OTHER CONSTITUENTS

Palladium (Pd)

- reduced corrosion
- greater luster
- example
  - Valiant PhD (Ivoclar Vivadent)
    - 0.5% palladium

Mahler J Dent Res 1990

CLASSIFICATION. (M.A.MARZOUK)

ACCORDING TO NUMBER OF ALLOYED METALS :

1. Binary alloys (eg. Silver–tin)
2. Ternary alloys (eg. Silver –tin –copper).
3. Quaternary alloys (eg. Silver –tin –copper –indium).

Based on copper content :

- 1. Low copper alloys : contain < 6% copper (conventional alloys)
- 2. High copper alloys : contain > 6% copper
- The high copper alloys are further classified as:
- i) Admixed or dispersion or blended alloys.
- ii) Single composition or uni-composition alloys.

Based on the powders particle size

microcut

fine cut

coarse cut

Based on zinc content

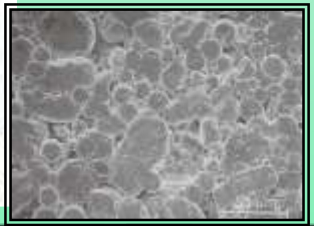
1. Zinc – containing alloys – contain more than 0.01% zinc.
2. Zinc –free alloys - contain less than 0.01% zinc

BASED ON SHAPE OF THE ALLOY PARTICLES

1. Lathe cut alloys

Dentalloy

2. Spherical   alloys



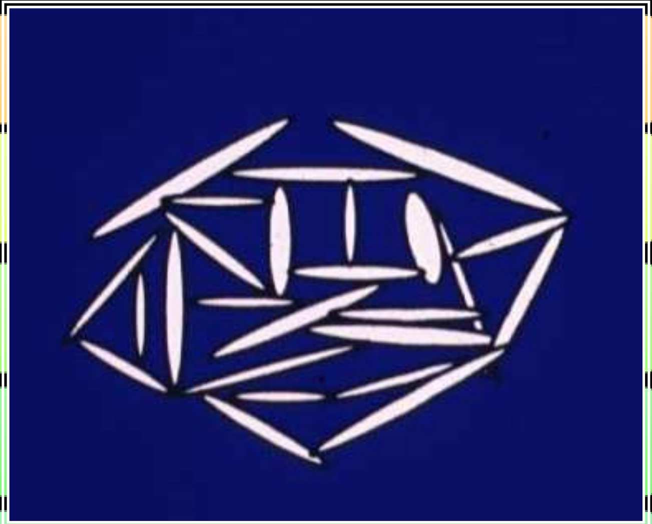
3. Admixed alloys - contains both lathe cut & spherical alloys.

Approximate composition: (Craig)

Alloy	Particle Shape	Ag	Sn	Cu	Zn	In	Pd
Low Copper	Irregular/ Spherical	63-70	26-28	2-5	0-2	0	0
High Copper Admixed regular	Irregular	40-70	26-30	2-30	0-2	0	0
	Spherical	40-65	0-30	20-40	0-1	0	0-1
Admixed Uni-Composition	Irregular	52-53	17-18	29-30	0	0	0.3
	Spherical	52-53	17-18	29-30	0	0	0.3
Uni-compositional	Spherical	40-60	22-30	13-30	0	0-5	0-1

PRODUCTION OF ALLOY PARTICLES

LATHE CUT / IRREGULAR PARTICLES:



metal ingredients are heated

poured into a mold – ingot

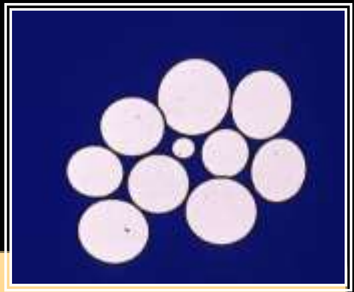
cooled relatively slowly

heated for 6-8 hrs at 400ºc → HOMOGENIZATION

cut on a lathe or ball milled

passed thro a sieve for even particle size

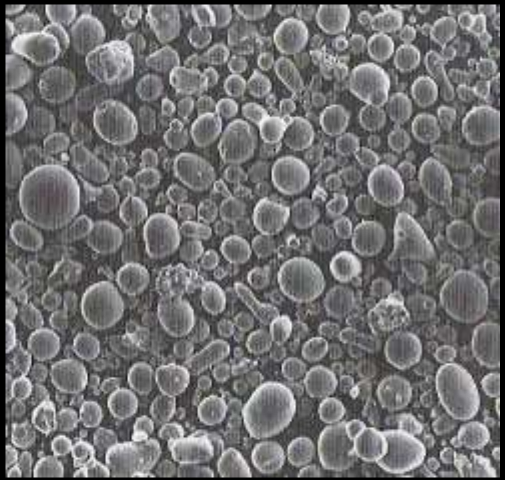
ANNEALING



Spherical / atomized particles:

metal ingredients are mixed

liquid metal is atomised into fine spherical droplets



Lathe-cut Alloys	Spherical Alloys
➢Particles are irregular	➢Particle are spherical
➢Manufactured by milling an annealed ingot of alloy	➢Manufactured by atomization of molten alloy
➢More Hg required hence has inferior properties	➢Requires less Hg hence has better properties
➢Less plastic and resists condensation pressure	➢More plastic, hence a contoured & wedged matrix is essential to establish proximal contour

Admixed High Copper	Spherical High Copper
Advantages	Advantages
➢Longer working time ➢Less dimensional change ➢Displacement of matrix ➢Adapt better to cavity walls and adjacent teeth	➢Faster set ➢Less Hg in mix ➢Higher early strength ➢Lower creep ➢Easy finish ➢Low condensation force
Disadvantages	Disadvantages
➢Slower set ➢More mercury in mix ➢Less early strength ➢High creep during condensation ➢Difficult to finish	➢Less working time ➢Greater dimensional change ➢Do not displace matrix

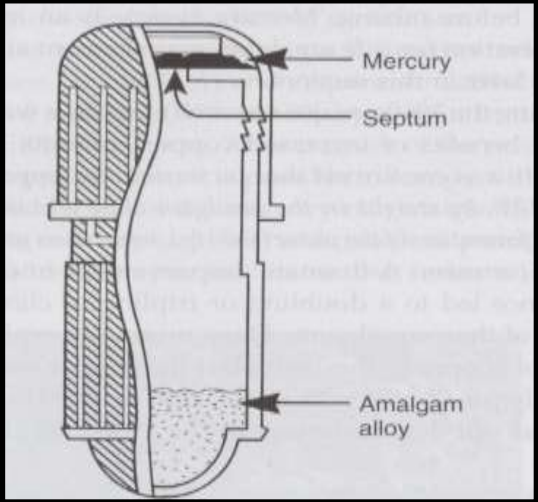
MODE OF SUPPLY

All types of alloy are supplied as :

Bulk powder

Alloy & mercury in disposable capsule

Pre weighed alloy as tablet/ pellet & mercury in sachets.



Mercury and alloy separated by septum that must be perforated before mixing

METALLURGIC PHASES IN DENTAL AMALGAM

The 2 main types of amalgam alloy compositions are Ag-Sn alloys with & without significant amounts of Cu.

In high Cu alloys, silver is replaced by Cu resulting in formation ofCu-Sn compound (Cu_3Sn).

Greek Symbols and formulas of metallurgic phases of amalgam setting reactions are:

Phases in Amalgam alloys & set dental amalgams	Formula
Gamma(γ)	Ag_3Sn
Gamma 1 (γ1)	Ag_2Hg_3
Gamma 2 (γ2)	$Sn_{7-8}Hg$
Epsilon (ε)	Cu_3Sn
Eta (ή)	Cu_6Sn_5
Silver Copper eutectic	Ag-Cu

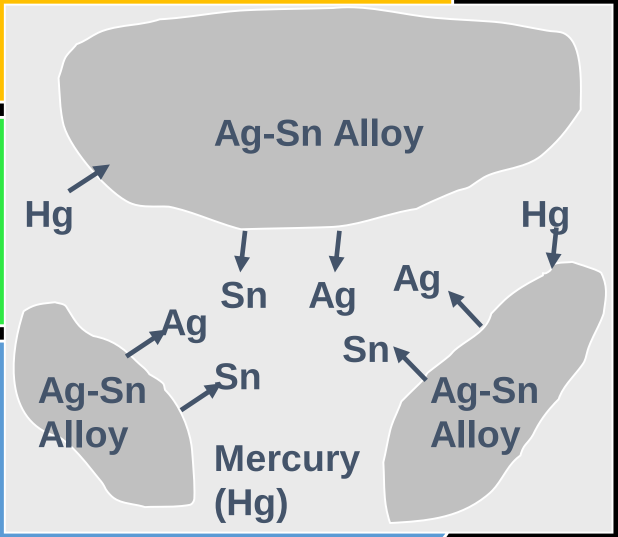
AMALGAMATION PROCESS

Conventional Low-Copper Alloys

Dissolution and precipitation

Hg dissolves Ag and Sn from alloy

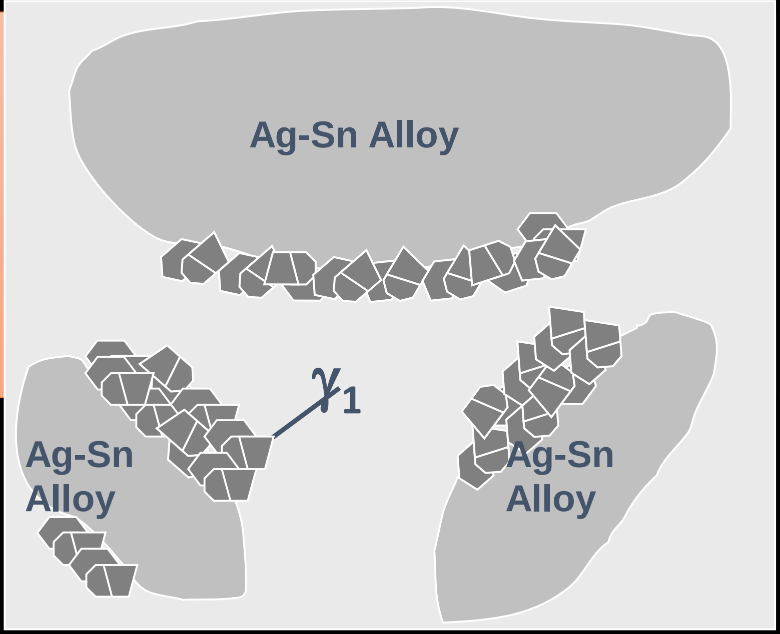
Intermetallic compounds formed



$$\underset{\gamma}{Ag_3Sn} + Hg \Rightarrow \underset{\gamma}{Ag_3Sn} + \underset{\gamma 1}{Ag_2Hg_3} + \underset{\gamma 2}{Sn_8Hg}$$

Conventional Low-Copper Alloys

- Gamma 1 (γ_1) = Ag_2Hg_3
  - matrix for unreacted alloy and 2nd strongest phase
  - 60% of volume



$$\underset{\gamma}{Ag_3Sn} + Hg \Rightarrow \underset{\gamma}{Ag_3Sn} + \underset{\gamma_1}{Ag_2Hg_3} + \underset{\gamma_2}{Sn_8Hg}$$

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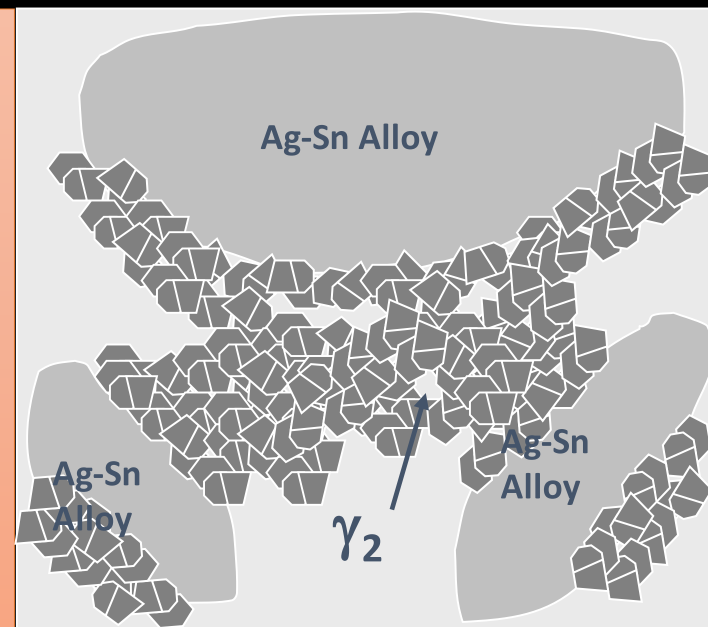
Conventional Low-Copper Alloys

- Gamma 2 (γ_2) = Sn_8Hg
  - weakest and softest phase
  - corrodes fast, voids form
  - corrosion yields Hg which reacts with more gamma (γ)
  - 10% of volume
  - volume decreases with time due to corrosion



$$\underset{\gamma}{Ag_3Sn} + Hg \Rightarrow \underset{\gamma}{Ag_3Sn} + \underset{\gamma_1}{Ag_2Hg_3} + \underset{\gamma_2}{Sn_8Hg}$$

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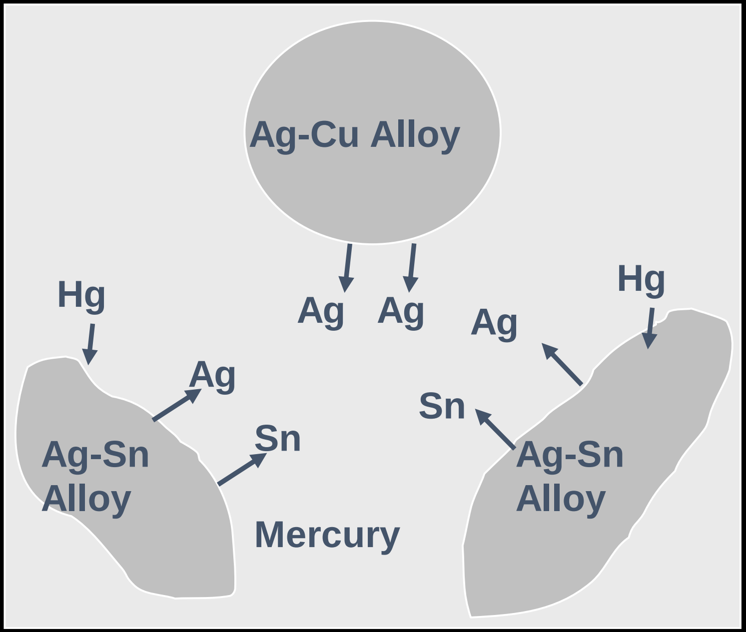
ADMIXED HIGH-COPPER ALLOYS

- Ag enters Hg from Ag-Cu spherical eutectic particles
  - eutectic
    - an alloy in which the elements are completely soluble in liquid solution but separate into distinct areas upon solidification
- Both Ag and Sn enter Hg from Ag_3Sn particles



Ag3Sn + Ag-Cu + Hg = Ag3Sn + Ag-Cu + Ag2Hg3 + Cu6Sn5

γ γ γ_1 η

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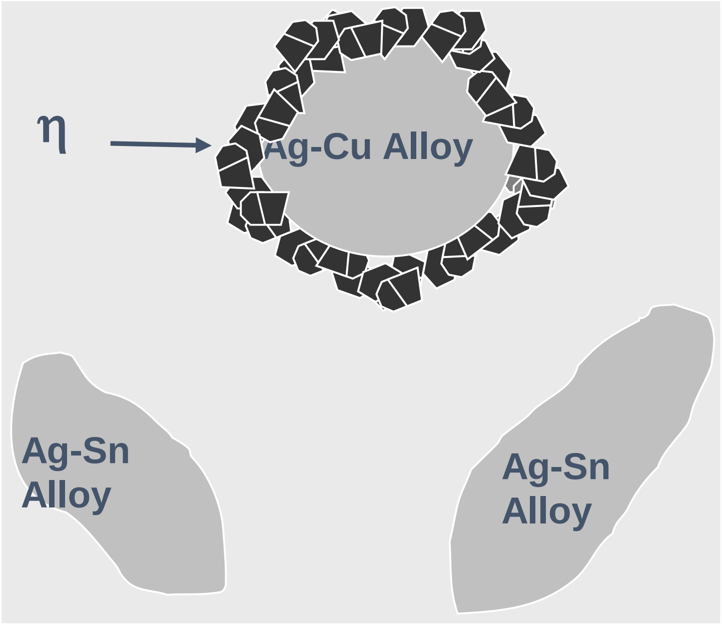
ADMIXED HIGH-COPPER ALLOYS

- Sn diffuses to surface of Ag-Cu particles
  - reacts with Cu to form (eta) Cu_6Sn_5 (η)
    - around unconsumed Ag-Cu particles



Ag3Sn + Ag-Cu + Hg = Ag3Sn + Ag-Cu + Ag2Hg3 + Cu6Sn5

γ γ γ1 η

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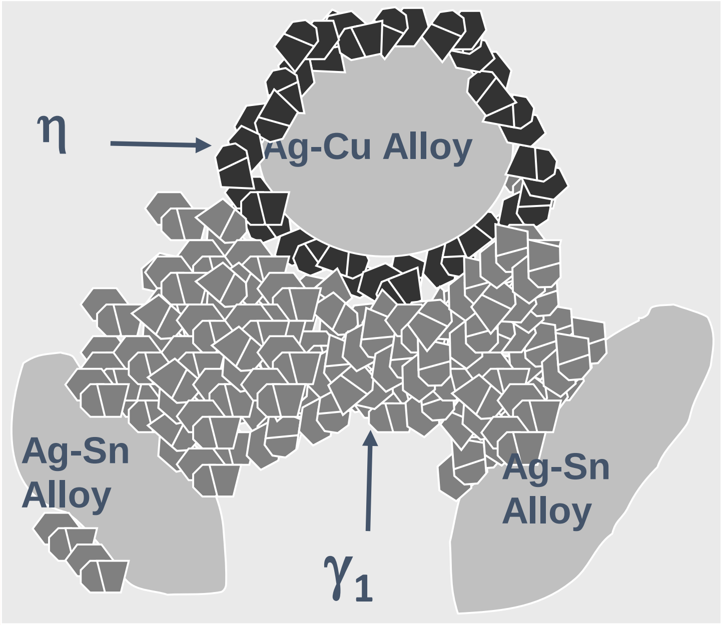
ADMIXED HIGH-COPPER ALLOYS

- Gamma 1 (γ_1) (Ag_2Hg_3) surrounds (η) eta phase (Cu_6Sn_5) and gamma (γ) alloy particles (Ag_3Sn)



$$\underset{\gamma}{Ag3Sn} + Ag\text{-}Cu + Hg = \underset{\gamma}{Ag3Sn} + Ag\text{-}Cu + \underset{\gamma_1}{Ag2Hg3} + \underset{\eta}{Cu6Sn5}$$

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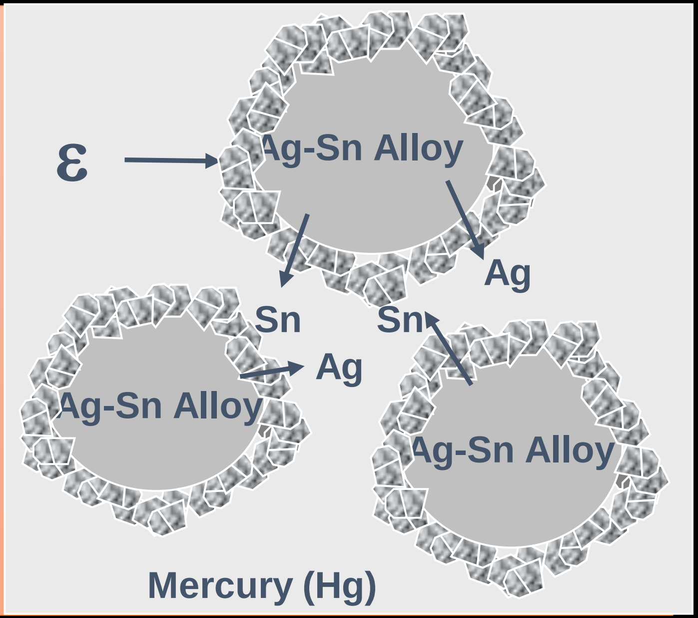
SINGLE COMPOSITION HIGH-COPPER ALLOYS

- Gamma sphere (γ) (Ag_3Sn) with epsilon coating (ε) (Cu_3Sn)
- Ag and Sn dissolve in Hg



$$\underset{\gamma}{Ag_3Sn} + \underset{\varepsilon}{Cu_3Sn} + Hg = \underset{\gamma}{Ag_3Sn} + \underset{\varepsilon}{Cu_3Sn} + \underset{\gamma_1}{Ag_2Hg_3} + \underset{\eta}{Cu_6Sn_5}$$

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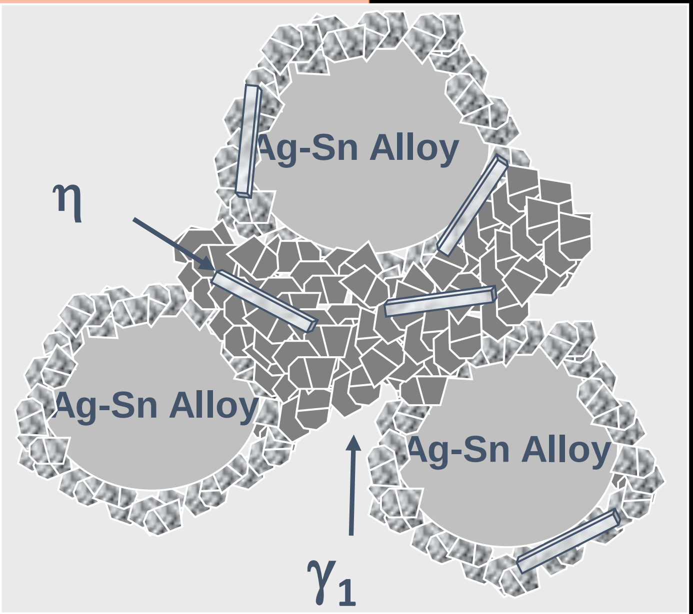
SINGLE COMPOSITION HIGH-COPPER ALLOYS

- Gamma 1 (γ_1) (Ag_2Hg_3) crystals grow
- binding together partially-dissolved
- gamma (γ) alloy particles (Ag_3Sn)
- Epsilon (ε) (Cu_3Sn) develops crystals on
- surface of gamma particle (Ag_3Sn) in the
- form of eta (η) (Cu_6Sn_5)
  - reduces creep
  - prevents gamma-2 formation



Ag3Sn + Cu3Sn + Hg Þ Ag3Sn + Cu3Sn + Ag2Hg3 + Cu6Sn5

γ ε γ ε γ_1 η

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MANIPULATION OF AMALGAM

SELECTION OF ALLOY

- Type of the alloy

*Spherical particle alloys: if quick attainment of strength necessary.

-Require fast operator to use

* Non zinc alloys-

Chosen when clinically impossible to eliminate moisture from field of operation.

HIGH CU AMALGAM

Material of choice- improved physical properties & elimination of Y2 phase, better corrosion resistance- leading to superior clinical performance. (Phillips)

Admixed used more often than spherical.

Low creep, corrosion resistance, & resistance to marginal fracture. (Craig)

Anatomic position of the restoration

Operator’s skill and armamentarium

Early disposal of patient

Extent of cavity

PROPORTIONING

Mercury concentration techniques:

(a) High Hg technique

- contains more mercury than needed for the powder(52-53%) producing a very plastic mix.

(b) or Eames technique, Minimum Hg or 1:1 Technique.

- Proportioning to be done by weight not by volume.

- original Hg:alloy ratio is reduced

- with this technique 50% or less Hg will be there in final restoration

TRITURATION

The process of mixing an alloy with mercury is called trituration.

Trituration can be carried out by hand or by mechanical amalgamators.

Hand trituration is performed in glass mortar and pestle.

The mortar has its inner surface roughened to increase friction b/w amalgam and glass surface.

MECHANICAL TRITURATION

Mechanical mixing is done in semi automatic or fully automatic amalgamator.

With this the mixing time is reduced and the procedure is more standardized.

They have automatic timer and speed control device .

Basic Principle: (Skinner’s)

Alloy and mercury are dispensed into capsule which serves as mortar and metal or plastic piston inserted into capsule serves as pestle.

When the capsule has been secured in the machine & the machine has been turned on, the arms holding the capsule oscillate at high speed thus trituration accomplished


M1
M2
M3
L3
H1
H2
H3
SPEED
Caulk
Vari-Mix®
II-M
MULL

Reusable capsules are available with friction fit and screw cap lids with either type it is important that the lid on capsule fit tightly.

Newer amalgamators have hoods that cover the reciprocating arms holding the capsule , which confine mercury that might get sprayed into the room if the capsule lid is not fitted properly.

Acc. To speed - Low – 3200 to 3400 cycles /minute

Medium – 3700 to 3800 cycles/minute

High – 4000 – 4400 cycles/minute

OBJECTIVES OF TRITURATION

1 Achieve workable mass within a minimum time and wet all the alloy particles with mercury

2 Remove oxides from powder particles

3 Decrease particle size & increase surface area of alloy particles.

4 Dissolve particles of powder in Hg

5 To keep Y1 or Y1-Y2 matrix crystals as minimal as possible.

Factors that control the quality of Trituration :

a) Time : vary from 25 – 45 sec.

varies corresponding to

→ type of alloy : higher for spherical low copper

lower for spherical high copper

→ types of amalgamation

→ pestles of diff weight and size

Speed : depends on manufacturer

with time and use the accuracy varies.

low copper – low speed

high copper – high speed

Force : applied during mechanical amalgamation is a function of --

→ weight of the pestle (more weight more force)

→ size of capsule

→ design of pestle

UNDERTRITURATED AMALGAM:

- Looks somewhat **grainy and dull**.

- Crumbles when handled because all the alloy particles are not wetted by mercury.

- Rough surface after carving.

- Results in a weak and porous restoration, which also corrodes faster.

OVERTRITURATED AMALGAM

Shiny and hard.

The mixed amalgam is also rather warm (hot) and difficult to remove from the capsule.

Sets too fast and results in higher contraction

PROPERLY TRITURATED AMALGAM

Can be warm (not hot) when it is removed from the capsule.

Looks **shiny and is plastic**.

Setting time in accordance with the instructions from the manufacturer.

MULLING (Marzouk)

It is a process by which the mix is given a cohesive form.

Continuation of trituration although it is a remnant of old mortar and pestle trituration technique the step can still be used following mechanical trituration

METHODS

After hand trituration mulling is done by taking the mix in hand and rubbing between fingers.

After mechanical trituration , mulling is done by rotating the mix in a pestle free capsule.

By placing in a rubber dam sheet and pressing against the sheet

After mulling the mass is taken in a muslin cloth or guaze and squeezed to remove the excess mercury especially in hand trituration. This squeezing should not be done in open environment of clinic as it can lead to increased mercury vapor content in the atmosphere.

A clean chamois skin or linen cloth can also be used .

OBJECTIVE

-Homogenity of mix-

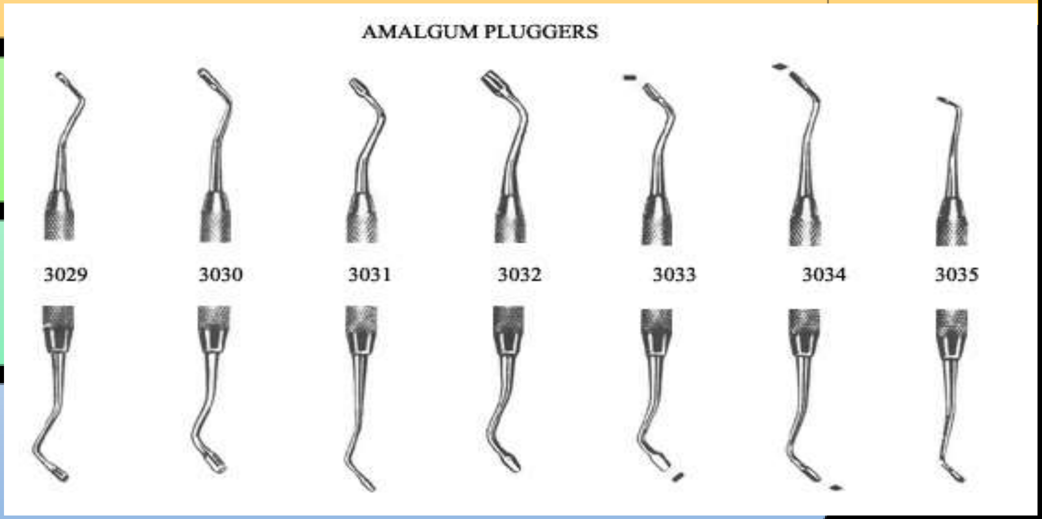
- Will also assure cleaning of the capsule walls of remnants of amalgam mix thereby delivering the mix in one single coherent and consistent mass.

CONDENSATION OF AMALGAM

Condensation is a process by which the mix is compacted into the prepared cavity to attain a dense mass.

Types of condensation:

- Hand condensation
- Mechanical condensation
- Ultrasonic condensation



AIM OF CONDENSATION

To compact the amalgam into the prepared cavity so the greatest possible density is attained, with sufficient mercury present

To ensure complete continuity of the matrix phase between the remaining alloy particles.

To optimize the adaptation between the amalgam and the cavity walls

Better adaptation between the incremental layers of amalgam

The creep is decreased, strength of the amalgam is increased and excess mercury is removed from the increments

Different amalgam alloys particle pack differently. For example, spheres pack more efficiently than irregular particles. By improving the packing. the density increases and the quality of the amalgam improves.

In order to improve the packing density of the lathe-cut particles, they have to be displaced in relationship to each others. In order to achieve such a displacement, one must overcome an "internal friction" that exists between the different particles. That friction is lower for spheres than for lathe-cut particles.

In fact. a spherical amalgam cannot be condensed with a small condenser under high pressure, because such a condenser will just penetrate the extremely plastic spherical amalgam.

Condensation of non-spherical amalgam: forces should be applied about 45º to walls and floors

Each portion of amalgam should be condensed from its centre to its periphery

Use large increments enough to fill the entire cavity(spherical amalgam)

Use the larger condenser that will fit the cavity or part of it. This will prevent lateral escape of spherical particles during condensation pressure.-(Marzouk)

Serrated condensers are not used for spherical amalgam because they exert high pressure compared to smooth condensers.

Due to pressure being increased , the mass of amalgam under condenser goes along with the packing instrument rather than being adequately condensed.

Condensation time : 3-4min.

CONDENSING INSTRUMENTS

Round condensers : 3 instruments

Diameters : 15 ,25 , 35 tenths millimeters ;
All are at 10 centigrade to the shaft
Nib length is :7mm
15 and 25 –used for small pieces
35– used to make the final heavy pressure in cavities in occlusal surfaces of molars

Parallelogram condensers: 2 pairs

smaller pair – for proximo- occlusal in bicuspids and molars
larger pair – for proximo-occlusal in molars.
blade in hoe form – proximal portion ; hatchet form – occlusal

Sweeney Instruments : with sharp angles to condense in angles of cavity.

Serrated and nonserrated.

MECHANICAL CONDENSATION

Use an impact or vibratory type of force
Less energy is required than hand condensation
Apply a consistent condensing force – prevent lamination of amalgam .

ULTRASONIC CONDENSATION

Usually not recommended because these produce local heating of amalgam leading to release of mercury.

PRECARVE BURNISHING

- Large rounded burnisher is used in light strokes proceeding from amalgam surface to tooth surface on occlusal and other portions of the restoration.

Objectives

Further reduce the size of voids on critical surface and marginal areas of amalgam

Brings any excess Hg to the surface

Adapt the amalgam further to cavorsurface anatomy

Conditions the surface amalgam to carving step.

Produces denser amalgam at the margins of occlusal preparation restored with high Cu amalgam alloys and initiates carving.

To ensure marginal amalgam is well condensed before carving the overpacked amalgam should be burnished immediately with large burnisher using heavy strokes mesiodistally & faciolingually. (Sturdevant).

CARVING

Started when metallic cry or ringing sound heard.

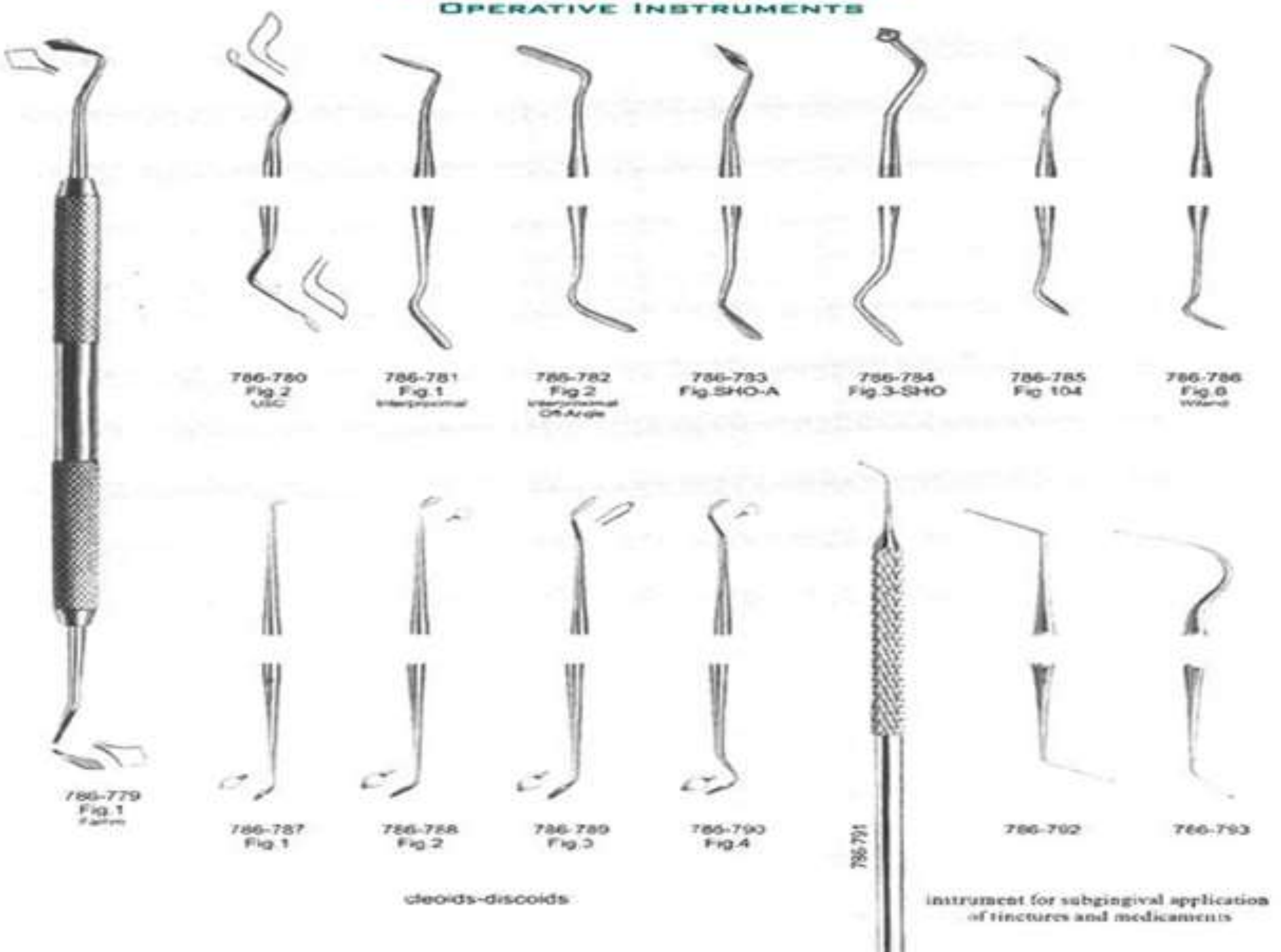
Carving should be carried out by placing half of the blade edge of carver on the tooth structure and half on restoration following the incline plane of each cusp.

Carving should proceed in a direction parallel to or slightly towards the margin of the prepared tooth whenever possible.

Best accomplished with a bladed instrument such as Hollenback carver.

It is also beneficial to maintain contact with the tooth surface to minimize the risk of ditching or hypomargination

AMALGAM CARVERS
OPERATIVE INSTRUMENTS



cleoids-discoids

instrument for subgingival application of tinctures and medicaments

OBJECTIVES

To produce restoration with no overhang.

Restoration with proper physiological contours.

Restoration with minimal flash

With functional, non-interfering anatomy.

With adequate compatible marginal ridges.

With physiological, compatible embrasures.

Non-interfering with integrity of periodontium.

POST CARVE BURNISHING

Rough surface produced by carving is smoothened by final burnishing.

At this stage, the mass is hard/set enough to prevent any disturbance of anatomy formed by carving.

Produces denser amalgam at the margins of occlusal preparation restored with low copper amalgams,

FINISHING AND POLISHING

Finishing amalgam restorations involves removing marginal irregularities, defining anatomical contours, and smoothing the surface roughness of the restoration.

Polishing is performed to obtain a smooth, shiny luster on the surface of the amalgam.

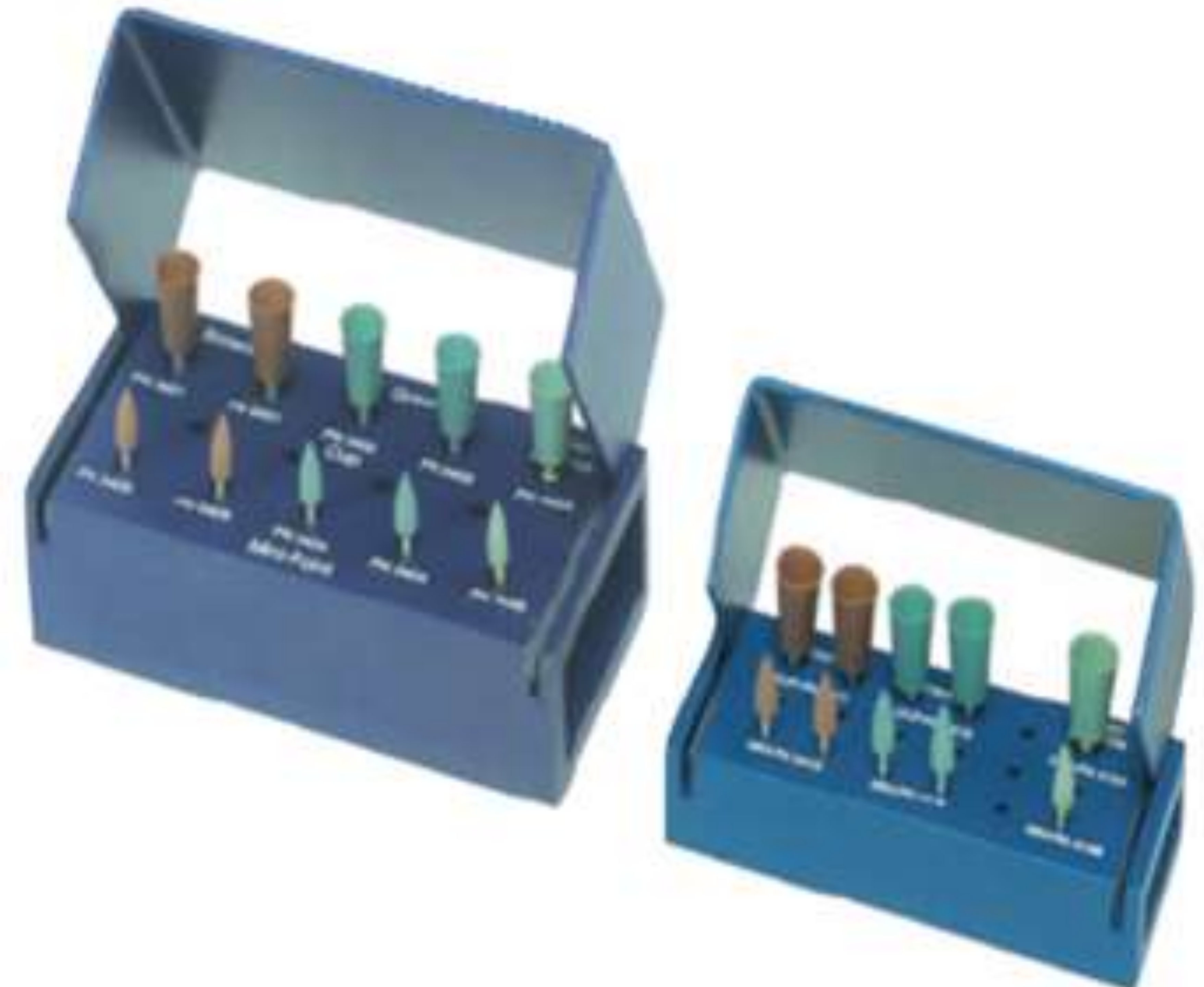
Why amalgam restorations should be finished & polished

- To complete carving
- Refine the anatomy contours and marginal integrity
- Enhance surface texture of restoration
- Prevention of recurrent decay
- Prevention of deterioration of the amalgam surface
- Maintenance of periodontal health
- Prevention of occlusal problems

The finishing and polishing procedures should not be initiated on an amalgam restoration until the amalgam has reached its final set, at least 24 hours after it has been placed and carved so as to allow the setting reaction to complete. (Skinner's)

Polishing of high Cu amalgam is less important than with conventional amalgam because high copper amalgam are less susceptible to tarnish and corrosion and marginal breakdown

Operative dent 1992 ;17(4):129



Begin the finishing procedure by marking occlusion with articulating paper and evaluating margins with explorer.

If occlusion can be improved- green carborundum stone followed by pointed white fused alumina stone are used to correct the discrepancy

green stone more abrasive than white stone

During surfacing of the amalgam, the stone's long axis is held at right angles to the margins.

After the stone is used the margins are evaluated with an explorer tine.

FINISHING BURS

Differ from cutting burs in that their blades are finer, their sizes smaller, and their number of blades greater.

Finishing burs should be operated in the burnishing direction rather than cutting direction. If it grabs or catches it is in the cutting direction.

FINISHING DISKS

Disks are used primarily on the proximal, buccal, or lingual surfaces.

Available in a variety of sizes and grits.

Use of a medium grit disk is always followed by the application of a finer grit disk which cuts less.

POLISHING

Initiated with coarse rubber abrasive point at low speed, to produce surface with smooth appearance.

- Pumice and tin oxide are two commonly used polishing agents.
- Other polishing agents are available in the form of abrasive-impregnated rubber points and cups.

The creation of heat during the polishing procedure is potentially dangerous

1. Heat can cause thermal damage to the pulp (and pain to the patient!).
2. Temperature rise above 60 ^{0}C brings the mercury to the surface of the restoration which results in a dull, cloudy surface, and a surface that is more susceptible to corrosion

PRECAUTIONS

Use abrasive agents that are wet rather than dry. Some abrasive materials (pumice and tin oxide) can be mixed with water or alcohol to help lubricate and cool the agents.

Use compressed air directed at the amalgam surface during polishing.

Use light, intermittent pressure with rotary instruments lifting the instrument off the restoration frequently. Heavy or prolonged pressure generates heat.

Use slow to moderate speed with rotary instruments. High speeds increase friction and thus generate more heat. Increase speed only to produce the final high shine.

PROPERTIES OF AMALGAM

Dental amalgam is unique in some of its characteristic properties, and differs in this respect from many other alloys.

The characteristics of an amalgam depends on its properties, which in turn depend on the alloy selected & how it is manipulated.

After placement in a cavity, amalgam continue to undergo changes as result of moisture contamination, corrosion, slow solid-state phase changes & mechanical forces.

MICROLEAKAGE

There is small amount of leakage under amalgam restorations even if properly inserted, leakage decreases as the restoration ages in the mouth.

This decreased marginal leakage may be due to the corrosion products that forms in the interface between the tooth & the restoration which seals the interface & thereby prevents leakage.

The presence of calcium & phosphorus & the demineralization of tooth structures adjacent to the amalgam restoration suggest a possible biological interaction in this corrosion process.

Both low & high copper amalgams are capable of sealing against microleakage, but the accumulation of corrosion products is slow with the high-copper alloys.

DIMENSIONAL CHANGE

Dental amalgam may expand or contract, depending on its manipulation.

Ideally, the dimensional change should be small.

Excessive contraction can lead to microleakage , secondary caries & plaque accumulation.

Excessive expansion can produce pressure on the pulp & postoperative sensitivity.

Protrusion of a restoration can also result from excessive expansion.

MEASUREMENT OF DIMENSIONAL CHANGE

A.D.A.specification No. 1 requires that amalgam should not expand or contract more than 20um/cm at 37°c,between 5 minutes & 24hrs after the beginning of trituration.

THEORY OF DIMENSIONAL CHANGE

When the alloy & mercury are mixed contraction results as the particles dissolve & the Y1 grows.

The final volume of Y1 is less than the total of the initial volumes of dissolved silver & liquid mercury that are used to produce the Y1.

Therefore, contraction will continue as long as growth of Y1 continues.

The Y1 crystals as they grow , impinge against one another , & produce an outward pressure tending to oppose contraction.

If there is sufficient mercury present to provide a plastic matrix, an expansion will occur when Y1 crystals impinge upon one another.

After a rigid Y1 matrix has formed, growth of Y1 crystals cannot force the matrix to expand.

Instead Y1 crystals will grow into interstices containing mercury, & producing continued reaction.

Therefore, manipulation that results in less mercury in the mix will favour contraction, such as lower mercury : alloy ratios & higher condensation pressures.

Higher condensation pressures will squeeze mercury out of the amalgam producing a lower mercury: alloy ratio & favouring contraction.

In addition, manipulative procedures that accelerate setting & consumption of mercury also causes contraction, like longer trituration times & use of smaller particle size alloys.

Smaller particle sizes accelerate the consumption of mercury, because small particles have a larger surface area per unit mass than larger particles.

Many modern amalgams show a net contraction, whereas the older amalgams always indicated an expansion. Two reasons for this difference are :

i. Older amalgams contained larger alloy particles & were mixed at higher mercury : alloy ratios.

ii. Hand trituration was used previously. The current amalgams are mixed with high-speed mechanical amalgamators

EFFECT OF MOISTURE CONTAMINATION

If is a zinc-containing low-copper or high-copper amalgam is contaminated by moisture during trituration or condensation, a large expansion can take place.

This expansion usually starts after 3to5 days & may continue for months, reaching values greater than 400 um (4%).

This type of expansion is known as delayed expansion or secondary expansion.

The delayed expansion is associated with the zinc in the amalgam .

If a zinc containing alloy is contaminated with moisture during trituration or condensation, hydrogen gas is produced by electrolytic action.

H_2o + Zn ---------ZnO + H_2 (gas)

This hydrogen gas does not combine with the amalgam, but collects within the restoration, creating extreme internal pressure within the mass, & results in expansion of the amalgam .

Class V restoration failed because of excessive expansion

This causes protrusion of the restoration out of the cavity , increased creep, increased microleakage, pitted surfaces & corrosion.

Dental pain, recurrence of caries, & fracture of the restoration are also seen with these poorly inserted restorations.

It should be noted that the contamination must occur during trituration or condensation.

After the amalgam is condensed , the external surface may come in contact with saliva without the occurrence of delayed expansion.

Non zinc alloys do not show this type of expansion when contaminated with water .

Amalgam without zinc tend to be less plastic & less workable. So non zinc alloys are used only for cases where it is clinically impossible to control moisture like in patients having excessive salivation, retrograde root canal filling etc.

STRENGTH

A prime requisite for any restorative material is to have sufficient strength to resist fracture.

Fracture of a restoration may lead to corrosion, secondary caries & hence it is a clinical failure.

The compressive strength of a satisfactory amalgam should be at least 310 MPa (45,000 Psi).

When amalgams are manipulated properly, they will show a compressive strength, which is more than this value.

Type of amalgam alloy	Compressive (1hr)	Strength (7 days)	Tensile strength	
Low copper amalgam	145	300	60	
High copper admix	137	430	48	
High copper unicompositional	262	500	62	

COMPRESSIVE AND TENSILE STRENGTH

Weaker in tension than in compression.

Both low-copper & high –copper amalgams have tensile strengths that range between 48 to 70 mpa.

Amalgam cannot withstand high tensile or bending stresses .

FACTORS AFFECTING STRENGTH

- Triturition
- Hg/alloy ratio
- Condensation
- Porosity
- Rate of Hardening

Effect of Trituration

Depends on the type of amalgam alloy, the trituration time & the speed of the amalgamator

Either under trituration or over trituration will decrease the strength for both low-copper & high–copper amalgam.

EFFECT OF MERCURY CONTENT

Sufficient Hg should be mixed with the alloy to wet each particle of the alloy. Otherwise a dry, granular mix forms which has rough & pitted surface causing corrosion.

Any excess of Hg left in the restoration can produce a marked reduction in strength.

The strength of an amalgam is related to amount of unconsumed alloy particles (strong in nature) & Hg containing phases (weak in nature) present in it.

EFFECT OF CONDENSATION

Condensation pressure, technique, & alloy particle shape effect amalgam properties.

For lathe –cut alloys the greater the condensation pressure, the higher is the compressive strength.

Higher condensation pressure, with good condensation technique will minimize porosity & express Hg from lathe –cut amalgams & result in a less volume fraction of matrix phases.

If heavy pressures are used in spherical amalgams, the condenser will punch through the amalgam.

However, spherical amalgams condensed with lighter pressures produce adequate strength.

EFFECT OF POROSITY

Voids & porosities reduces the strength of hardened amalgam.

Porosity is related to the plasticity of the mix. Plasticity of amalgam mixes ↓with under trituration or delayed condensation.

Decreased plasticity would lead to greater porosities & these pores facilitate stress concentration & propogation of cracks & corrosion & hence lower strength of the amalgam.

Porosities are also increased by under condensation, under trituration, irregularly shaped particles of the alloy powder & insertion of too large increments into the cavity prepared.

Increased condensation pressure improves adaptation at the margins & decreases the number of voids.

Fortunately, voids are not a problem with spherical alloys. Thus, lighter pressure can be used to produce adequate strength.

EFFECT OF RATE OF HARDENING

Since a patient may be dismissed from the dental chair within 20 min, the rate of hardening of the amalgam is of considerable interest to the dentist.

Amalgam do not gain strength as rapidly as might be desired.

At the end of 20 min, compressive strength may be only 6% of the 1 week strength.

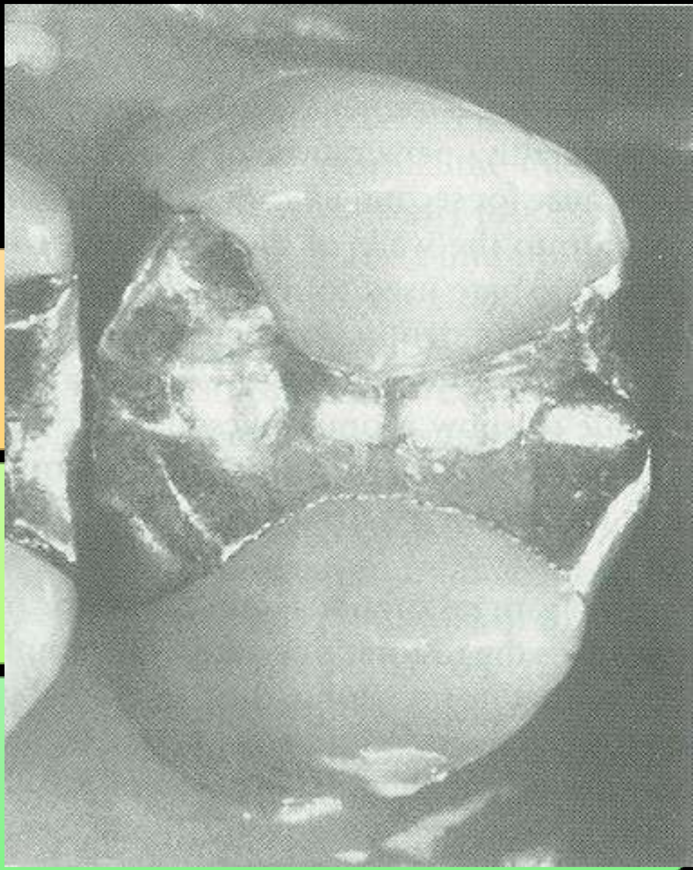
TENSILE STRENGTH

It is the fraction of Compressive strength.

Tensile strength at 15 min for high copper Uni-compositional alloys are 75%-175 % higher than others.

The high early tensile strengths of high copper uni-compositional alloys are important, as they resist fracture by premature biting stresses better than other amalgams.

CREEP



Defined as a time dependent plastic deformation.

Significance of creep to amalgam performance

Found to correlate with marginal breakdown of traditional low-copper amalgams i.E. The higher the creep, the greater is the degree of marginal deterioration.

The margins of high creep amalgam are severely ditched & the marginal breakdown is greater.

According to A.D.A. specification No. 1

Amalgam alloys should be selected, such that their creep rate is <3%.

The creep values for high copper amalgam is 0.4 or less, so marginal fracture in such restorations is not usually due to creep.

CREEP VALUES

Low - copper amalgam	- 0.8 to 8.0%
High – copper amalgam	- 0.1 to 1%

THE INFLUENCE OF MICROSTRUCTURE ON CREEP:

The (Y1) Ag –Hg phase exerts a primary influence on low-copper amalgam creep rates.

↑d creep rate is shown by larger Y1 volume fractions.

↓d creep rate is shown by larger Y1 grain sizes.

Y2 phase is associated with higher creep rates.

The single-composition high –copper amalgams have very low creep rates, due to the

absence of Y2 phase &
presence of (n) Cu6 Sn5 rods,

which acts as barrier to deformation of the Y1 phase

MANIPULATIVE VARIABLES

- Minimum Hg/alloy ratio
- Proper timing of Triturition
- Delayed condensation
- Improper condensation

TARNISH AND CORROSION

Tarnish : is a surface discolouration on a metal or even a slight loss or alteration of the surface finish or luster.

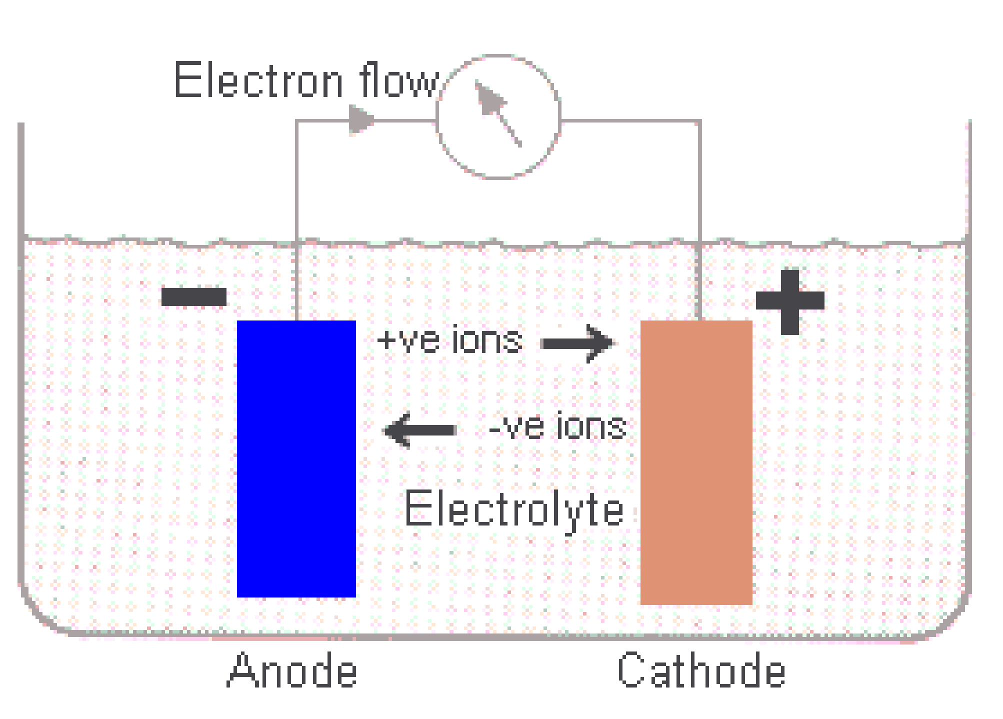
Corrosion: is an actual deterioration of a metal by reaction with its environment.

Amalgam restorations often tarnish & corrode in the oral environment .

The degree of tarnish depends on

i. The oral environment

ii The type of alloy used



Active corrosion of a newly placed restoration occurs in the interface between the tooth & the restoration.

The space between the alloy & the tooth allows the microleakage of electrolyte to take place & hence crevice corrosion occurs.

But, later the build up of corrosion products gradually seals this space, making dental amalgam a self-sealing restoration.

In both low-copper & high-copper amalgams, the corrosion products found are oxides & chlorides of tin (tin oxide & tin chloride).

These are found at the tooth-amalgam interface and within the bulk of older amalgam restorations.

Corrosion products containing Cu are found in high copper amalgams.

But, the corrosion process is more limited , since the (n) Cu6 Sn5 phase is less susceptible to corrosion than Y2 of low-copper amalgams.

However, the surface on a restoration should be made homogenous & smooth to minimize tarnish & corrosion , regardless of the alloy system used.

The role of corrosion in the process of marginal breakdown has not been established.

There is indirect evidence that the Y2 phase is involved in both marginal failure & active corrosion in low-copper amalgams.

Such a correlation is not possible for high-copper alloys.

When a Au restoration is placed in contact with an amalgam restoration, corrosion of the amalgam can take place due to large difference in EMF of the two materials.

The free Hg liberated due to corrosion can contaminate & weaken the Au restn.

Biological effects like galvanism can also occur. So this should be avoided.

A high-copper amalgam is cathodic in relation to a low-Cu amalgam.

So, the low Cu amalgam restns are placed in the same mouth with existing low-Cu amalgam.

But, the clinical observations do not indicate such accelerated corrosion & the laboratory models showed the current flow path in such a way that electrochemical interaction between the restorations is minimal.

Since the high-copper amalgams eliminate Y2 phase (more anodic), they show improved laboratory corrosion behaviour than low copper amalgam.

But , high mercury : alloy ratios can lead to the formation of Y2, even with the high copper alloys, thus promoting corrosion.

ADVANTAGES

1. Cost effective
2. Time effective
3. Ease of placement
4. Wear resistance
5. Prevent marginal leakage after a period of time.
6. Adequate resistance to fracture
7. Maintain anatomical form
8. Not overly technique sensitive.
9. Favourable long term clinical research results.

DISADVANTAGES

- Aesthetics
- Toxicity
- Corrosion and galvanic action
- Difficult tooth preparation
- Initial marginal leakage.
- Technique sensitive if bonded.
- Brittle
- Marginal breakdown
- Do not help retain weakened tooth structure

- **Amalgam Failures:**

  Clinical failure is defined as a point at which the restoration is no longer serviceable or at which time the restoration causes other severe risks if it is not replaced.

- Usually amalgams lasts for about 10 -12 years

- Failures in amalgam restoration are not usually because of poor material

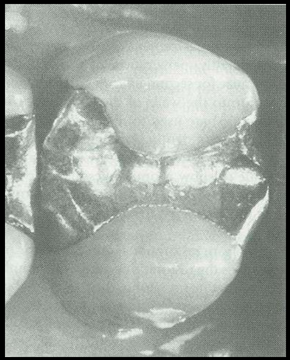
- Everything done from time of cavity preparation until restoration is polished have a definite effect on the restoration

Types of Amalgam failures

- **At visual level**
  →Secondary caries
  →Marginal fracture
  →bulk fracture
  →tooth fracture
  →Dimensional change

- **At the microstrutural level**
  →Corrosion and tarnish
  →Stresses associated with masticatory forces
- **Pain following amalgam restoration**
- **Pulp and/or periodontal involvement**

- FRACTURE
  a. Marginal fracture
  b. Isthmus fracture
  c. Bulk fracture
  d. Tooth fracture.



- Letzel et al investigated survival and modes of failure of amalgam restorations retrospectively and found that leading mode of failure was bulk fracture (4.6%) followed by tooth fracture (1.9%) and marginal ridge fracture (1.3%)

Dent mater 1989;5:115-121

Secondary caries.

Amalgam blues

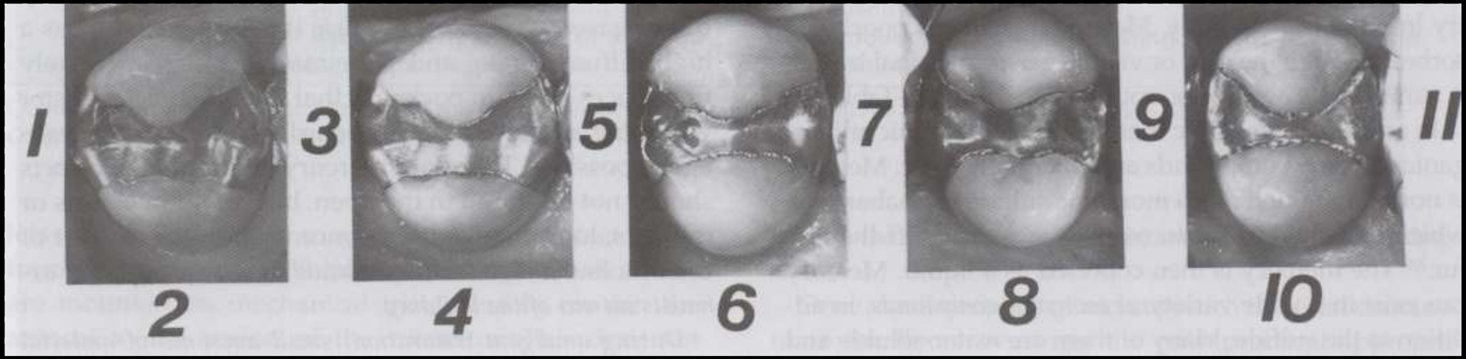
Amalgam tattoo

Marginal deterioration of amalgam restorations are mainly caused by:

1. Improper marginal preparation
2. Improper carving and finishing
3. Excess mercury
4. Use of gamma-2 containing amalgams
5. Amalgam expansion

Mahler scale for rating degree of marginal deterioration

GOOD(none) -------------- > OK(moderate) ----------- > FAILURE (extensive)



Causes of Amalgam Failure

- **FAILURES DUE TO FAULTY CAVITY PREPARATION**
- **FAILURE DUE TO POOR MATRIX ADAPTATION**
- **FAILURES DUE TO FAULTY AMALGAM MANIPULATION**

DUE TO FAULTY CAVITY PREPARATION

- Greatest single factor for failure

- Healey & philips (1949)
  * 56% - cavity
  * 42% - manipulation

- Faulty cavity preparation → recurrance of caries and fracture

Causes for failure occuring at various steps

1.Inadequate occlusal extension:

inadequate extension to pits and fissure increase chance of caries recurrence particularly in high caries risk individuals

2. Inadequate extension of proximal box:

If inadequately extended into embrasures, they are not amenable to brushing and cleaning by mastication →secondary caries.

3.Overextension of cavity preparation walls:

- Ideal faciolingual width of cavity is ¼ of intercuspal distance
- If the width is more than ½ ,capping should be considered
- If width more than 2/3, capping is a must

- Chance of fracture because restoration act as wedge and tend to split opposing cusps apart

- DURING CAPPING THERE SHOULD BE AN AMALGAM THICKNESS OF 2mm ON FUNCTIONAL AND 1.5mm OVER NON-FUNCTIONAL CUSPS

4. Amalgam cavity should have minimum depth of 1.5mm TO PROVIDE IT BULK AND HENCE RESISTANCE TO FRACTURE

5. If pulpal floor is not flat→ restoration produces wedging effect →fracture of tooth

6.Cavosurface angle →butt joint

if acute → tooth fracture

If obtuse → collapse of marginal amalgam

7.Failure to round off line angles

concentration of stresses→# of tooth/restoration

8.Inadequate proximal retention form/narrow isthmus

→fracture at isthmus portion

9.Extensive mesio-distal extension

→undermining of marginal ridge enamel

→fracture

10. Incomplete removal of carious tooth material

→ Failure of amalgam restoration

11. Retentive devices

should be prepared entirely in dentin

without undermining enamel

12. Post operative pain

reduced by high speed rotary instruments , intermittent cutting and cooling

DUE TO POOR MATRIX ADAPTATION

- Proper contacts and contour in restoration obtained by matrix
- Instability of matrix →distorted restoration,gross marginal excess and uncondensed soft amalgam with voids
- Cervical excess can result in periodontal irritation destruction of periodontium

DUE TO FAULTY AMALGAM MANIPULATION

A. Mercury alloy ratio:

- If residual mercury is in excess of 55%→loss of strength
- Increased flow and Increased susceptibility to tarnish and corrosion
- Better to use minimal mercury technique with dispensers for correct proportioning.
- Mulling → continuation of trituration to assure all alloy particles are coated with mercury.

B. Condensation

- Rationale → reduce residual mercury,

  To ensure amalgam reach all parts of the preparation and obtain homogenous restoration devoid of voids

- Freshly prepared amalgam has desirable working properties

- Effectiveness of removing residual mercury is possible only if used within 4 minutes from trituration

- Delayed use → do not allow proper condensation and also do not remove mercury from the restoration

- Larger cavities →multiple mix should be used to get homogenous restoration

- Excessive removal of mercury →reduces strength

- Condensation should be done using steping process to drive away voids
- Condensor size should not be too small or too large
- Small increments should be used to ensure proper condensation
- Mechanical condenser should be used with caution as it would cause fracture of enamel margins

ontamination

- Moisture contamination can occur during

  -trituration

  - Mulling

  -condensation

- Weaken the restoration especially if zinc containing

- It result in marginal flaws, tarnish, pitting, corrosion, and blistering. Expansion may also lead to pain

.Finishing and polishing

- Amalgam should be finished gently
- Excess spur like overhangs or thin flakes of amalgam on margins can fracture easily which can leave crevices in vulnerable areas
- Overcarving should be avoided as it would reduce the thickness of amalgam resulting in fracture
- Amalgam with tendency for tarnish and corrosion don’t retain polish for long,rough and corroded surface predispose to failure

- Failure to polish accelerate corrosion due to surface irregularities ,rough surface promotes accumulation of plaque resulting in gingival irritation

- Polishing should be done judiciously, temperature above 65 ^{0}c leads to release of mercury leading to defective restoration

ost operative pain

This occurs because of:

1. Hyperocclusion leading to inflammation of apical periodontium
2. Cracks in tooth such cracks cause pain during chewing because of expansion or contraction of tooth structure with every bite
3. Galvanism: may be due to dissimilar adjacent metal restoration or poorly condensed amalgam due to variation in silver concentration
4. Delayed expansion

- Inadequate pulp protection leading to conduction of heat
- Varnish should be applied under amalgam restoration to avoid leakage around restoration which may lead to post operative sensitivity and *amalgam blues* due to penetration of corrosion products into dentinal tubules
- Restoration fracture may occur if patient does not follow instruction properly and bites on restoration before it sets

Amalgam removal

- Masks
- Rubberdam application
- High volume suction evacuation
- Do not drill entire filling – remove in parts

Amalgam repair

- For a small localized marginal defect, recontouring and repolishing should be the first choice.
- Application of sealant around the defective margins can also improve the life span of the old restoration.
- However in high caries risk patient – not useful.

Amalgam restorations should be repaired by cutting the required defect and making the area self retentive. The amalgam side is wetted with mercury rich layer and the rest is condensed with conventional amalgam.

Disadv : mercury vapours

it was found that the total strength of such restorations is decreased by 50%

“Long term survival of repaired versus replaced amalgam restorations”

RJ.Smales . WS Hawthorne

Percentage survival rates

Amalgams	5years	10 years	15years
Replaced	78.9	62.8	49.9
Repaired	76.1	37.2	--

Op dent 2004 29-3,249-253

Amalgam alternatives

Alternatives may be classified as

- Metal alloys
  - Gold
  - Consolidated silver alloy
  - Gallium alloys
- Tooth colored alternatives
  - Composites
  - Ceramics
  - GIC’s
    - GI – Silver – Cermet restorative materials
    - Traditional GIC’s
    - Resin modified GIC’s
    - Poly acid – modified resin composites/ Compomers

- Consolidated Silver Alloy System:

-Developed by National Institute of Standards and Technology.

-It uses fluorboric acid solution to keep the surface of the silver alloy particles clean.

-The spherical alloy is condensed into a prepared cavity similar to placing compacted gold.

-Problem with insertion of this material is that the alloy strain hardens (Brittle-as the metal bent and burnished repeatedly) so difficult to compact it and to eliminate internal voids and achieve good adaptation to the cavity.

Recent Advances

- Bonded amalgam

- Silver-based mercury-free restorative alloys

- Nanocrystalline melt spun ag-sn-cu alloy ribbons

- Powder coated technology

Bonded Amalgam:

-Amalgam is an inert material that shows no interaction with the host structure and hence requires mechanical interlocking device within the cavity

-For some years resin-dentine bonding systems have been used in an attempt to develop a long term adhesion between the tooth structure and amalgam.

- Concept was introduced by Baldwin in 1897

During 1900’s some of the clinicians began to routinely bond amalgam restorations to both enamel and dentin.

An admixture of small polymethyl methacrylate powder particles in the bonding agent is used.

Thickness of bonding layer is generally 20-50µm.

Enhances bonding strengths by 20 MPA.

Various agents that have been tried are:

Amalgam bond
Amalgam bond with HPA(high performance additive powder)
All Bond 2 (Bisco)
Optibond 2(Kerr)
Panavia 21 (Kuraray)
Clearfill Linerbond 2 (Kuraray)
Scothbond MP (3M)

Chemical composition:

Amalgam bond plus:

- Activator/Conditioner: 10% citric acid, 3% ferric chloride.
- Adhesive: HEMA (Hydroxyethyl methacrylate).
- Catalyst: TBB(Tri-N-Butyl-Borane oxide).
- Base: 4META(4-Methacryloxyethyl trimellitate anhydride).

Indications of Bonded Amalgam restorations

- In situations that warrant - auxillary retention
  - reinforcement
  - conservative preparations
  - improvement of marginal seal

- In teeth with low occluso-gingival height where conventional amalgam pin retained, inlays,onlays and cast metal crown difficult to place

- As a temporary restoration, which later can be reduced to a core under a cast crown.

Bonded amalgam – clinical procedure

Upper second premolar with a fractured disto occlusal amalgam restoration

Rubber dam placed with interproximal wedging , and showing the fractured amalgam has been removed along with any caries

After etching and priming a thin layer of bonding resin is applied to the cavity using a disposable brush

Wax coated stainless steel matrix band placed and wedged

Bonded amalgam – clinical procedure

Amalgam placed and heavily burnished

A gel is placed occlusally and interproximally to allow complete anaerobic setting of adhesive resin

Initial carving and removal of matrix

After removal of the rubber dam, occlusal adjustment , final carving and polishing

Advantages:-

- Permits conservative cavity preparation
- Reinforces tooth structure weakened by caries and cavity preparation
- Eliminates use of retention pins
- Decreases the incidence of marginal fracture
- Minimizes microleakeage, recurrent caries and post operative sensitivity

- Allows biological sealing of the pulpodentinal complex

- Permits restoration of a tooth in single appointment compared to cast or ceramic restorations

- Cost effective

Limitations:-

- Technique sensitive
- Requires time to adapt
- Long term results are yet documented
- Increases the cost of amalgam restoration

“The effect of amalgam bonding on the stiffness of teeth weakened by cavity preparation”

Omar Zidan , Usama abdul-kareim

Cavity preparation reduced the stiffness & weakened the tooth. Restoring the prepared tooth with unbonded amalgam did not restore the lost tooth stiffness.

It was concluded that bonding amalgam to tooth structure could partly restore the strength & rigidity lost by the cavity preparation. This might lead to a reduction in cuspal flexure & the incidence of tooth fracture due to fatigue.

Dent materials 2003 Nov ;19(7) : 680-5

- **Bonded amalgam sealants and adhesive resin sealants:Five-year clinical results**

- Bonded amalgams were used as pit-and-fissure sealants without mechanical preparation.
- They were compared with resin-based pit-and-fissure sealants for retention over a 5-year period.
- Clinical examinations at 6 months, 1 year, 2 years, and 5 years revealed no difference between the two techniques.
- They can be used to seal pits and fissures surrounding very conservative preparations, in the "preventive amalgam restoration."
- Conventional amalgam retentive features and 90-degree cavosurface margins may not be necessary when bonding is used with amalgam.

(Quintessence Int 2004;35)

- **Effect of surface roughness on amalgam repair using adhesive systems**
- **Result**
- The use of adhesives has been suggested for repairing amalgam restorations associated with the roughening of an old amalgam surface .
- The application of an adhesive system could improve bonding between old and new amalgam through mechanical interlocking between the adhesive system and freshly condensed amalgam .
- The irregular surfaces are micromechanical retentions for bonding of primer to old amalgam and can be created with a carbide bur, diamond bur or aluminum oxide particle abrasion

(Braz. Dent. J. vol.13 no.3,2002)

Development of silver-based mercury-free restorative alloys

Although, amalgam remains the most inexpensive, reliable and popular restorative material for posterior teeth.

Recent controversy surrounding mercury has renewed interest in developing a mercury free restorative material with physical properties comparable to dental amalgam

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

GALLIUM ALLOYS

Puttkammer suggested the use of gallium in dental restoration in 1928.

However, attempts to develop satisfactory gallium restorative materials were unsuccessful until Smith and others in 1956, showed that improved Pd-Ga and Ag-Ga materials has physical and mechanical properties that were similar to or even better than those of silver amalgam.

(dental materials 2000,vol 16,97-102)

- **Reaction**

The alloy and liquid are mixed as usual. The structure of gallium alloy resembles that of amalgam. The reaction between AgSn particles and liquid Gallium involves the formation of AgGa phase and a pure tin phase.

$$AgSn + Ga \rightarrow AgGa + Sn$$

- **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

- **Disadvantages**

In early gallium alloys, surface roughness, marginal discoloration and fracture were reported. With improvement in composition, these defects were reduced but not eliminated

The gallium alloys could not be used in larger restorations as the considerable setting amount of expansion leads to fracture of cusps and post operative sensitivity.

The cleaning of instruments tips was also difficult

It was also less popular because it was costlier than amalgam.

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 intermetallic 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.

International Dental Journal (1998) Vol. 48/No.1

- This technology involves electrochemical powder treatment and a condensation technique which is similar to that used for direct filling gold foil.
- During consolidation, the adherence of silver surfaces is enhanced after immersion of the silver-based particles in a solution of 10 per cent fluoroboric acid (HBF4).
- The metal segments must be stored in this special acid solution prior to use to remove surface oxides and to enhance cold welding.
- Thus, this product may be more technique sensitive than dental amalgam and may require more time for proper condensation.

Advantages

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

A NEW DENTAL POWDER FROM 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.

- As-spun ribbons exhibited a multi-phase microstructure with preferred existence of (Ag_4Sn) phase formed during rapid solidification (RS) due to supersaturating of copper (Cu) atoms and homogenous nanostructure with subgrain size of about (40-50) mn, which seems to be developed during RS process and can be caused by eutectic reaction of the Ag_3Sn/Ag_4Sn-Cu_3Sn system.

- In heat treated ribbons the clustering of Cu atoms was always favored and stable in an ageing temperature and time interval determined by Cu content.
- The heat treatment led to essential changes of subgrain morphology, resulted in the appearance of large-angle boundaries with fine Cu_3Sn precipitates and forming typical recrystallization twins.

- Such a microstructure variation in melt-spun ribbons could eventually yield enhanced technological, clinical and physical properties of the dental products, controlled by the ADA Specification NO.1 and reported before.
- Thus, using the rapid solidification technique a new non-gamma-two dental material of high quality, nanocrystalline ribbon powder, can be produced

Summary

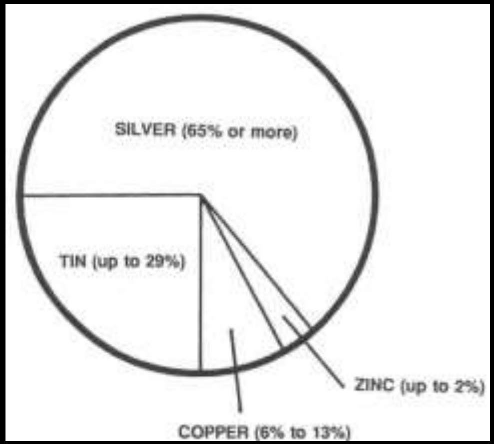
- Dental Amalgam is an alloy of mercury, silver, copper and tin, which may also contain palladium, zinc, and other elements to improve handling characteristics and clinical performance.

Basic constituents are –

- Silver
- Tin
- Copper
- Mercury

Others -

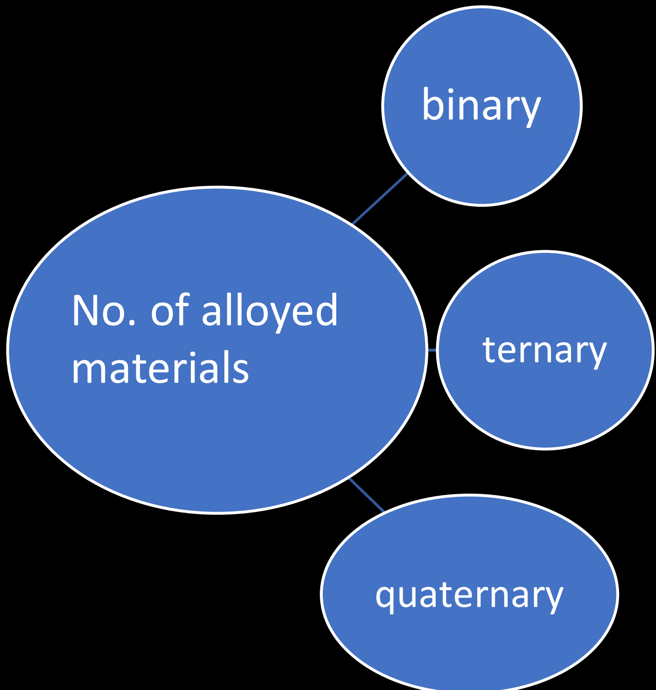
Zinc
Indium
Palladium

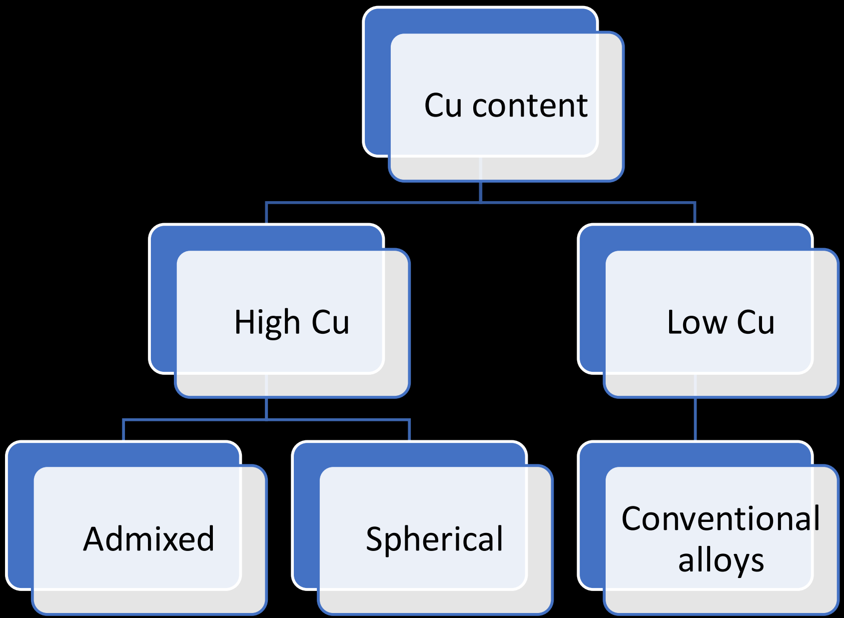


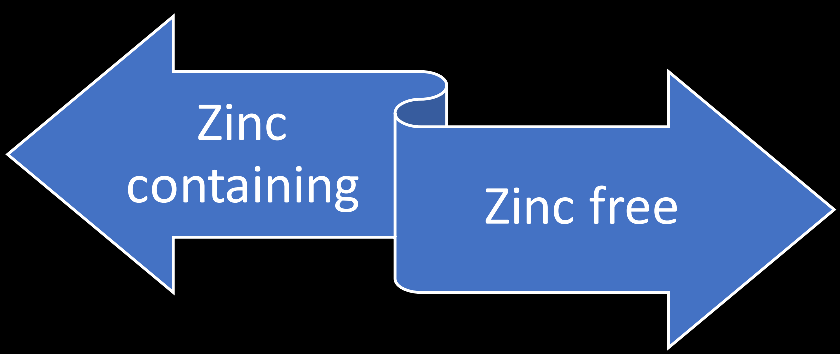
Alloy composition:

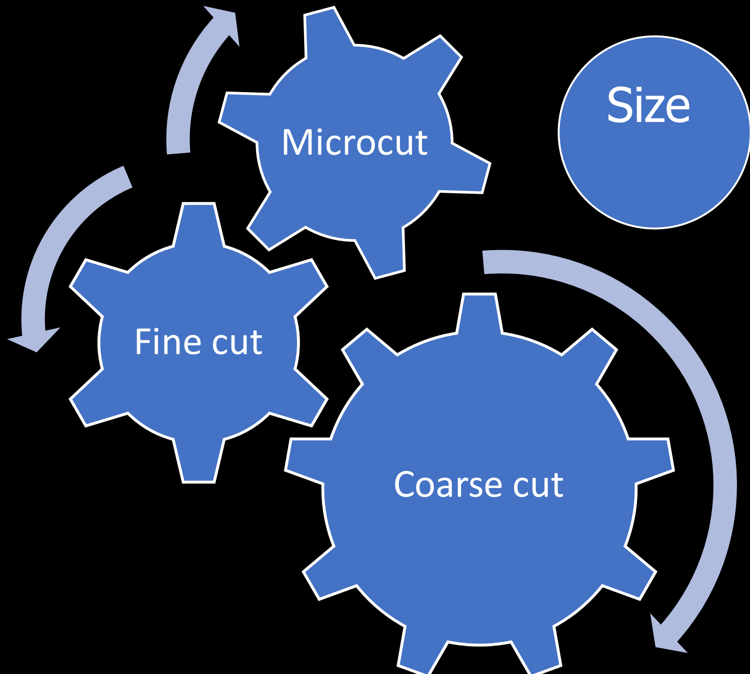
Silver (65%)	Increases expansion, increases strength and whitens the alloy
Tin (29%)	Decreases expansion, decreases strength, hardness and reduces tarnish and corrosion resistance.
Copper(6%)	Increases hardness, strength and expansion.
Zinc (1%)	Scavenger / deoxidiser, increases the longevity of the restoration.

classification

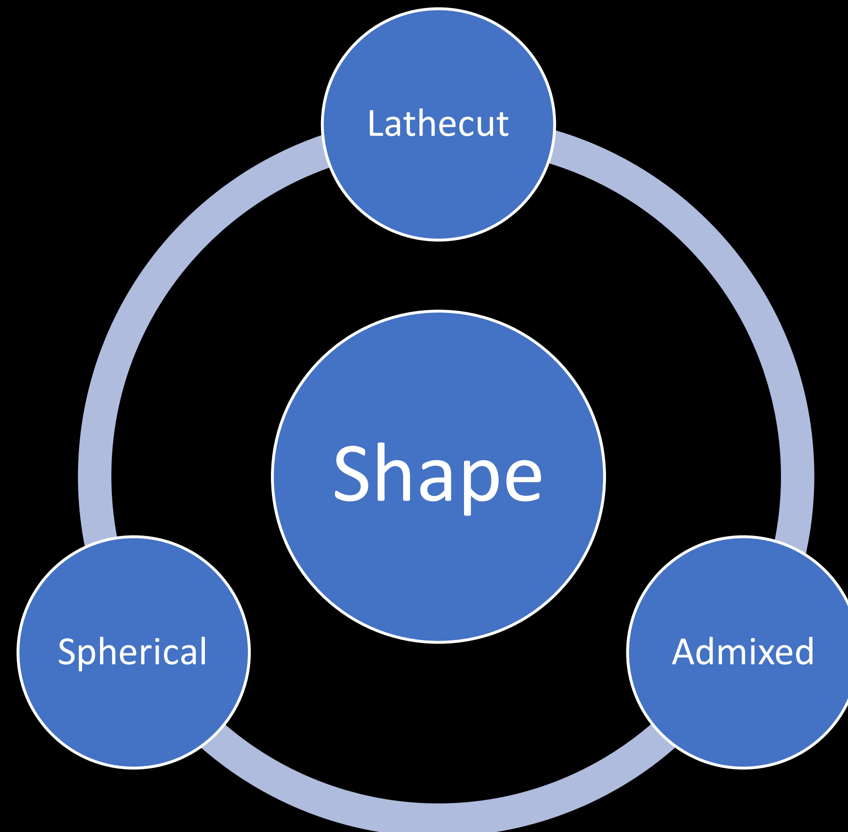




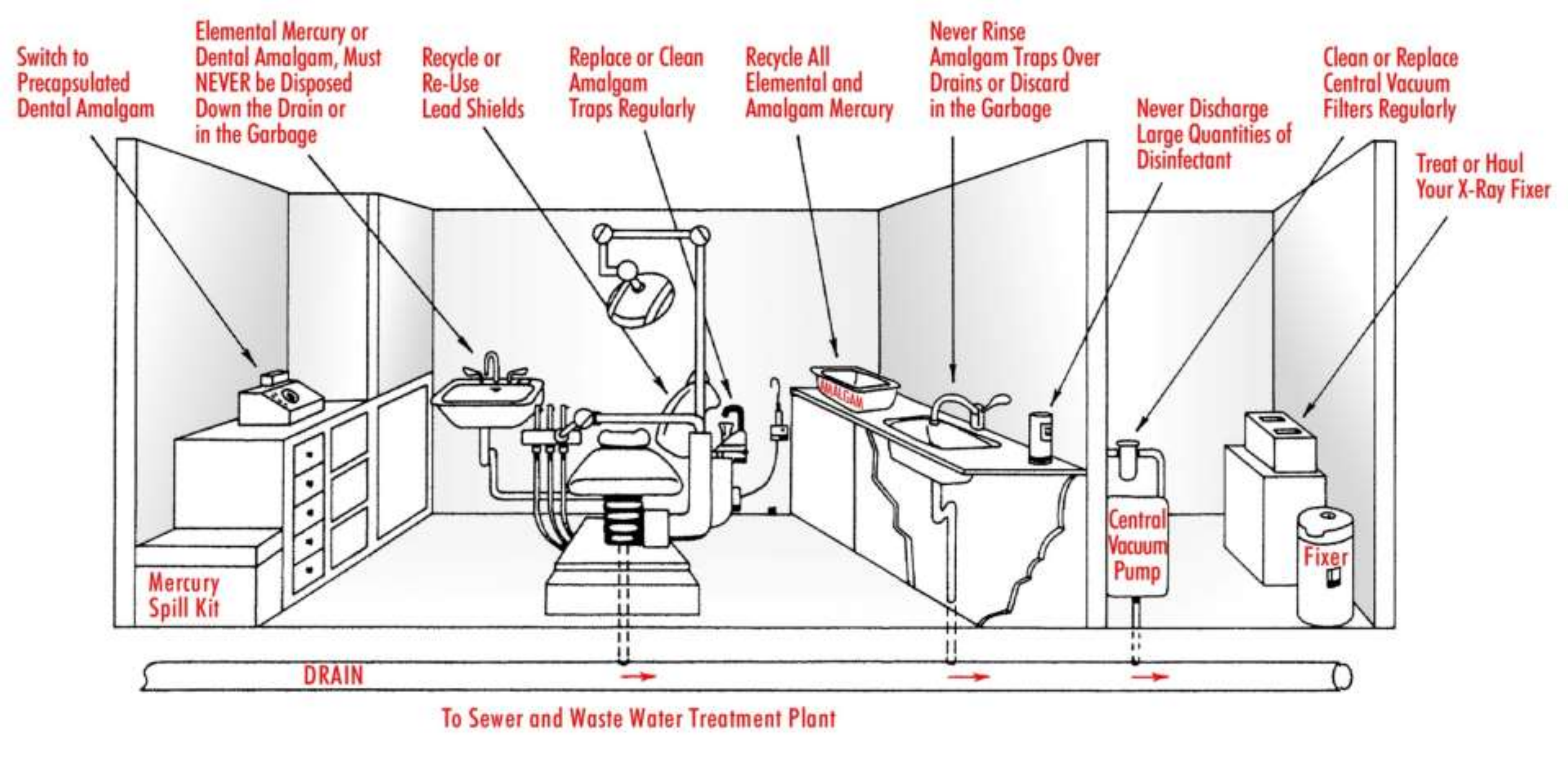




Generations – 1st ,2nd, 3rd.4th,5th and 6th



Dental Office Waste Management



CONCLUSION

Amalgam has served as a excellent and versatile restorative material for many years, despite periods of controversy. It remains the material of choice for direct restoration of posterior teeth.

It is a successful clinical material when careful technique is applied to all parts of the restorative process, such as cavity preparation, mixing of the alloy and mercury (trituration),packing of plastic amalgam mix into the preparation (condensation) and finishing.

It should be handled with hygiene precautions followed for the safety of both patient and dental office staff

APPLICATIONS

1. As permanent filling material in class 1,2 & 5cavities
2. Pin amalgam and amalgapins .
3. For making dies.
4. In retrograde root canal fillings.
5. Foundations for crown or metallic onlay.