





LEARNING OBJECTIVE

- 1. To understand basic chemistry, physical properties, and nature of material as a restorative material.
- 2. To know about mercury toxicity and follow the protocols related to mercury hygiene in clinical setups.





CONTENT

- Introduction
- History
- Composition
- Classification Of Dental Amalgam
- Manufacturing Process Of Alloy Powder
- Setting reaction
- Properties Of Dental Amalgam
- Conclusion
- Take home massage
- Probable SAQS & LAQS





DEFINITION

AMALGAM: is an alloy of mercury with one or more other metals.

<u>DENTAL AMALGAM</u>: An alloy of mercury ,silver, copper, and tin which may also contain palladium and other elements to improve handling characteristics and performance





DENTAL		
YEAR OF EVENTS	AUTHOR	CONTRIBUTION
656 AD	SU KUNG	Was 1 st one to document about dental amalgam
1578	LI SHIHCNEN	Introduce the formula of dental amalgam i:e (100 parts of mercury ,45 parts of silver ,900 parts of tin)
1819	BELL	Advocated the use amalgam as a restorative material in England.





1896	G.V BLACK	Formulated modern amalgam alloy(67%siliver 27%tin, 5%copper, 1%zinc)
1962	DAMAREE, TAYLOR	Developed spherical dental alloy particle
1973	KAMAL ASGAR	Tytin – (Kerr) a ternary system of (siliver ,tin, copper) was developed in university of Michigan







- Silver-mercury restorations were introduced to the Western world in France in 1830s.
- 1833 CRAWCOUR BROTHERS introduced dental amalgam in United States
- In 1845, American Society of Dental Surgeons condemned the use of all filling material other than gold as toxic, thereby igniting "first amalgam war".
- In the 1850s, American dentists who used amalgam were threatened with malpractice actions by dentists who were not using amalgam.
- In mid 1920's a German dentist, Professor A. Stock started the "second amalgam war".
- Evidence showing that mercury could be absorbed from dental amalgam, which leads to serious health problems.
- Expressed concerns over health of dentists, stating that nearly all dentists had excess mercury in their urine..







"Third Amalgam War' began in 1980 primarily through the seminars and writings of Dr. Huggins, a practicing dentist in Colorado.

He was convinced that mercury released from dental amalgam was responsible for human diseases affecting the cardiovascular system and nervous system

Stated that patients claimed recoveries from Multiple sclerosis, Alzheimer's disease and other diseases as a result of removing their dental amalgam fillings.





INDICATIONS

POSTERIOR TEETH –

Class I Class II and

Class V cavity (unaesthetic areas)

ANTERIOR TEETH-

Distal surface of canine

OTHER USES –

Post obturation restoration.

In past it was used as retrograde root canal filling











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CONTRAINDICATIONS

- Use of amalgam is avoided in aesthetic areas(class III, IV, V)
- Not strong enough to reinforce the weakened tooth structure.
- It is contraindicated when different metal is restored in oral cavity.





ADVANTAGES

Inexpensive

Ease of use

Proven track record>100 years

Familiarity

Resin-free





DISADVANTAGES

- Doesn't match tooth color.
- Can cause discoloration.(Amalgam tattoo and amalgam blue)
- Amalgam filling does not bond with tooth.
- Mercury toxicity





COMPOSITION

ADA Specification No. 1 require that amalgam alloy should be predominantly silver and tin.

Other elements like copper ,zinc , gold and mercury are in concentration less than silver or tin

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Alloy	Particle Shape	Ag	AL Sn	Cu	Zn
1) Low Cu	Lathe cut+ Spherical	63-70%	26-28%	2-5%	0-1%
2) High Cu - Admixed	Lathe cut + Spherical	60-65%	15-25%	9-13%	0-2%
- Single composition	Spherical	60-65%	15-25%	13-30%	0-2%





BASIC CONSTITUENTS

Silver (Ag)

- Increases strength
- Increases expansion
- Whitens the alloy



- Decreases expansion
- Decreased strength
- Increases setting time





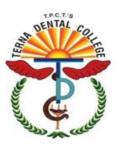




Copper (Cu)

- Silver and Copper reacts with tin
 - reducing gamma-2 formation
- Increases strength
- Reduces tarnish and corrosion
- Reduces creep
 - Reduces marginal deterioration







Zinc (Zn)

- Used in manufacturing
 - Decreases oxidation of other elements

 sacrificial anode
- Provides better clinical performance
 - Less marginal breakdown
- Causes delayed expansion with low Cu allo
 - If contaminated with moisture during condensation

$$H_2O + Zn ZnO + H_2$$









Mercury (Hg)

- Activates reaction
- Only pure metal that is liquid at room temperature
- Spherical alloys
 - Require less mercury
 - Smaller surface area easier to wet
- Admixed alloys
 - Require more mercury
 - Lathe-cut particles more difficult to wet

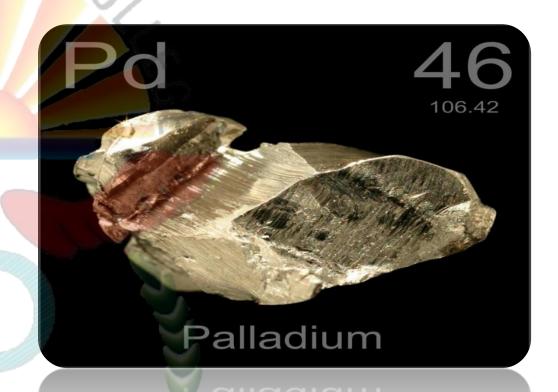






OTHER CONSTITUENTS

- Palladium (Pd)
 - Reduced corrosion
 - Greater luster
 - Example
 - 0.5% palladium







Indium (In)

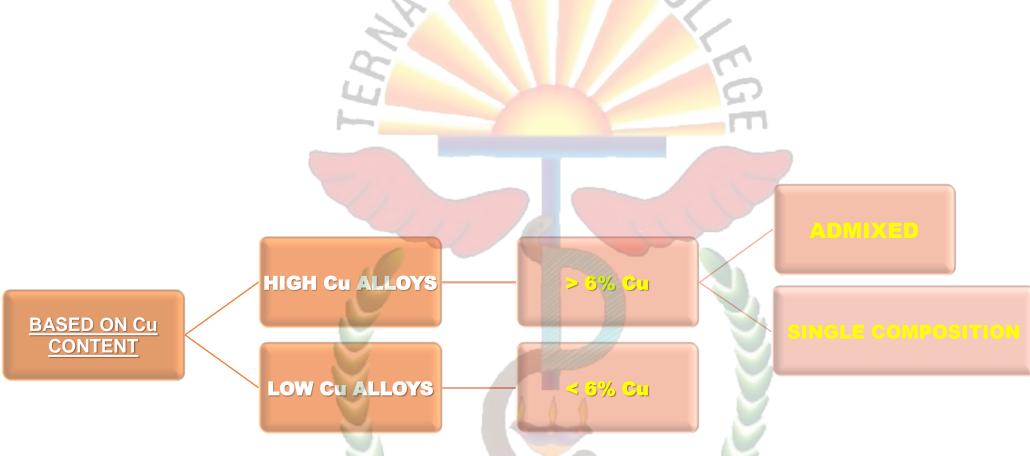
- Decreases surface tension
 - Reduces amount of mercury necessary
 - Reduces emitted mercury vapor
- Reduces creep and marginal breakdown
- Increases strength
- Must be used in admixed alloys
- example
 - Indisperse (Indisperse Distributing Company)
 - 5% indium







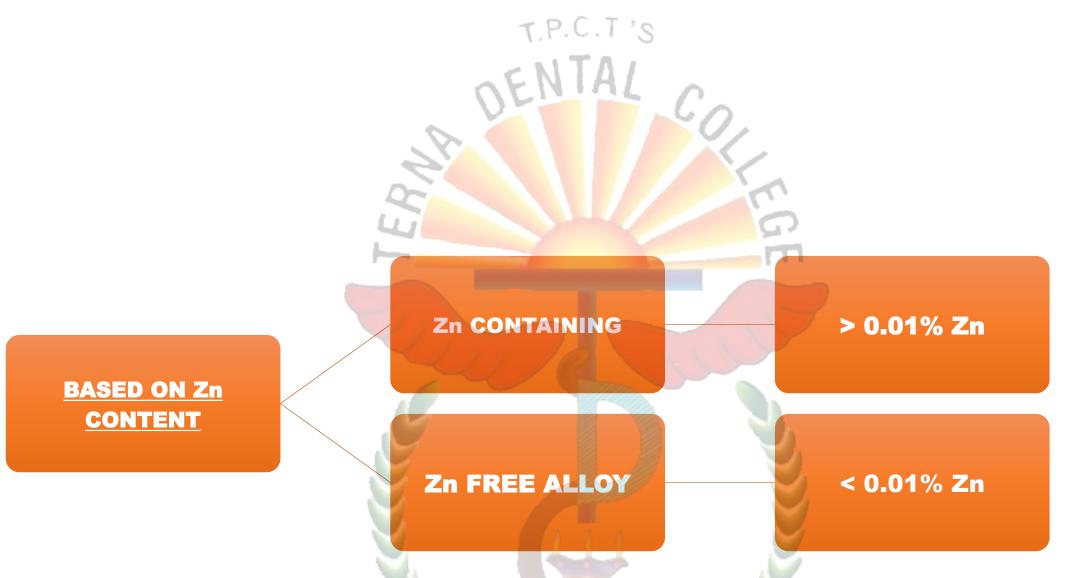
CLASSIFICATION

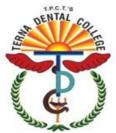




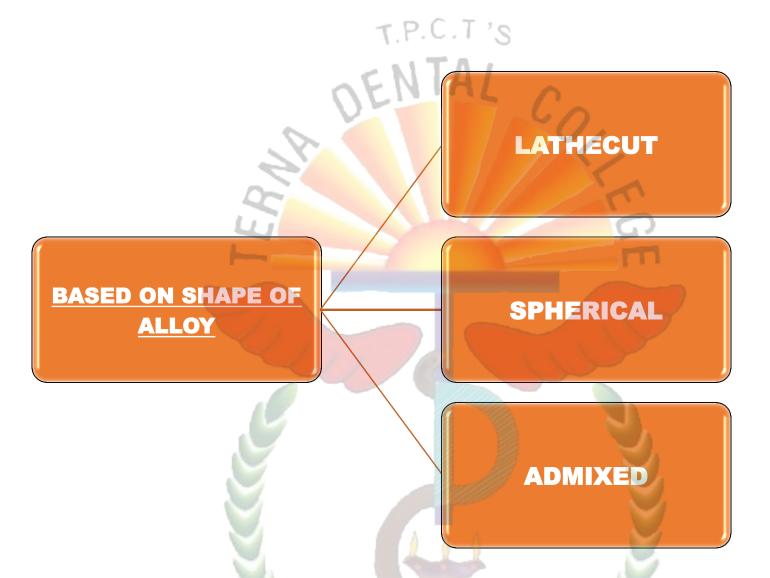
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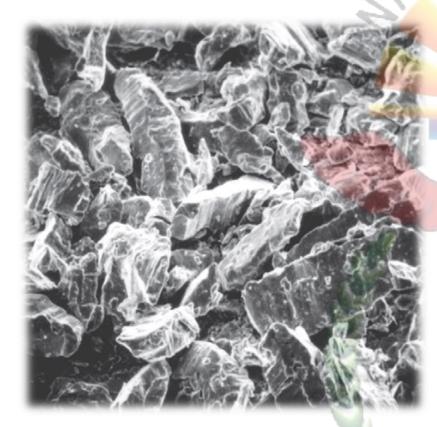


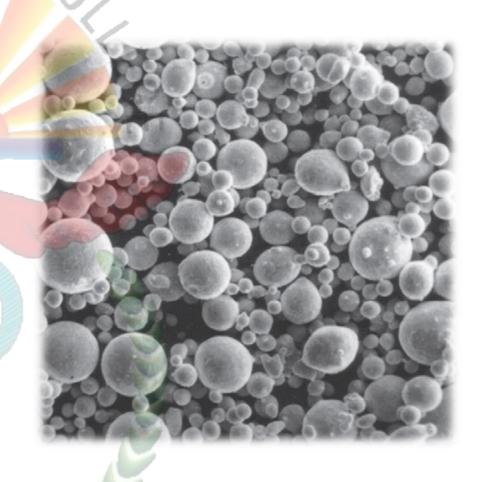


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MANUFACTURE OF ALLOY PARTICLES







Lathe cut alloy particles



Lathe-cut alloys

- Ag & Sn melted together
- Then poured in a mold to from an ingot.
- Alloy cooled
 - Phases solidify
- Again ingot is heated up
 - 400 °C for 8 hours.
- Ingot is then reduce by Grind, ball mill to 25 50 microns

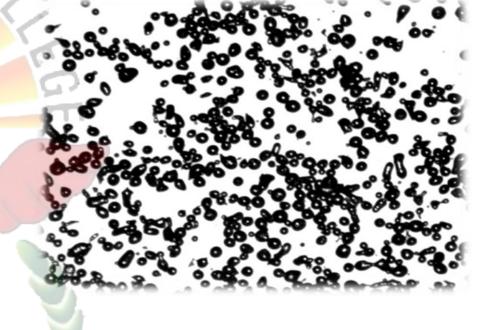






Spherical alloys

- All desired elements melted together.
- In molten stage its forms desired alloy
- Liquid alloy is sprayed under high pressure of inert gas (helium, neon)
- Sizes range from 5 40 microns







LATHE CUT

- 1. Requires more mercury (50%)
- 2. Requires more condensation force
- 3. Less ease in carving and burnishing
- 4. Less overhang and strong proximal surface

SPHERICAL

- 1. Requires less mercury (42%)
- 2. Requires low condensation force
- 3. Smooth surface during carving and burnishing.
- 4. Overhangs and weak proximal surface





LOW COPPER ALLOY

Composition of Conventional Amalgam Alloys: (G.V. Black's: Silver-tin alloy or Low copper alloy).

Low copper composition:

Silver : 63-70%

Tin: 26-28 %

Copper: 2-5 %

Zinc: 0-2%





OENTAL

- Dissolution and precipitation
- Hg dissolves Ag and Sn from alloy
- Intermetallic compounds formed

Ag₃Sn + Hg
$$\rightarrow$$
 Ag₃Sn + Ag₂Hg₃ + Sn₈Hg
 γ γ γ γ 2





< NTA/			
<u>GAMMA</u>	GAMMA 1	GAMMA 2	
X	<u>y1</u>	<u>y2</u>	
Gamma (γ)	Gamma 1 (γ1)	Gamma 2 (γ2)	
Ag ₃ Sn	Ag_2Hg_3	Sn ₈ Hg	
Un reacted alloy	matrix for un reacted alloy	 weakest and softest phase 	
• strongest phase and corrodes the	• 2nd strongest phase 10 micron	• corrodes fast, voids form	
least	grains binding gamma	• corrosion yields Hg which reacts	
•forms 27-30% of volume of set	• 54-60% of volume	with more gamma	
amalgam		• 11-13% of volume	
		• volume decreases with time due	
		to corrosion	







Photographs were made by superimposing microprobe X-ray scans of the elements through colored filters; blue for silver, red for copper, and green for tin. The blue/black matrix phase is Ag_2Hg_3 (γ^1). The green colored Sn_8Hg (γ^2) phase in the low-copper alloy.



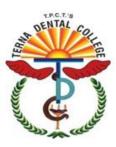


HIGH COPPER AMALGAM ALLOY

Youdelis and Innes in 1963 introduced high copper content amalgam alloys.

High Copper alloys are of two types:

- 1) Admixed alloy powder.
- 2) Single composition alloy powder.





ADMIXED HIGH COPPER ALLOY

Ag-Cu eutectic alloy (71.9% Ag and 28.1% Cu) particles are added to lathe cut low copper amalgam alloy particles.

- STRONGER- Due to increase in residual alloy particle & decrease in matrix.
- Contains 30-55% spherical high copper particle.
- Composition:-

Ag-69%

Sn-17%

Cu-13%

Zn-1%





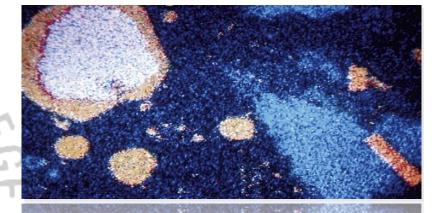


- Ag enters Hg from Ag-Cu spherical eutectic particles
 - eutectic
 - an alloy in which the elements are completely soluble in liquid solution but separate into distinct areas upon solidification
- Both Ag and Sn enter Hg from Ag₃Sn particles





- Sn diffuses to surface of Ag-Cu particles
 - reacts with Cu to form (eta) Cu_6Sn_5 (η)
 - -around unconsumed Ag-Cu particles
- (Gamma 1 (γ_1) (Ag₂Hg₃) surrounds (η) eta phase (Cu₆Sn₅) and gamma (γ) alloy particles (Ag₃Sn)



The Tangerine colored Cu₆Sn₅ (n') phase is minimal in alloy

it is due to the increased copper is in the spherical <u>silver-copper eutectic phase</u> where the \underline{n}' surrounds this spherical particle

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





Properties of Dental Amalgam

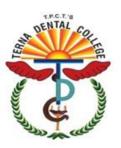
1.Compressive strength

-Amalgam is strongest in compression and much weaker in tension and shear.

Leas allowable compressive strength 1 hr after

setting, 0.25mm/min, is 80 MPa.

GE	1 HOUR	7 DAYS
Low Copper	145MPa	343MPa
Admixed	137MPa	431MPa
Single Composition	262MPa	510MPa







2.Tensile Strength:

- -Amalgam is strongest in compression and much weaker in tension and shear.
- -HCU materials have the highest early tensile strength.
- Strength of various phases:
 - -Unreacted $Ag_3Sn(\gamma)$ phase. (strongest)
 - -Ag₂Hg₃(γ 1)phase.
 - $-Sn_8Hg (\gamma 2) phase.(weakest)$

Low copper	60 MPa
Admix	48 MPa
Single composition	64 MPa





DENTAL

3.Elastic Modulus:

- -High- copper alloys are stiffer than low-copper alloys.
- -Amalgam are viscoelastic.
- elastic modulus dental amalgam in the range of 40 to 60 GPa





CREEP:

"Creep is the time dependent plastic deformation of hardened material."

- Creep rate has been found to co-relate with marginal breakdown of traditional low copper amalgam
 - higher the creep greater is the degree of marginal deterioration
- The margins of high creep amalgam are severely ditched and the marginal break down is greater.
- 1.Static creep- measured under constant load
- 2 Dynamic creep Measured under fluctuating load ,biting forces





Measurement of creep:

Creep= Change in dimension X 100

Original dimension

Creep Values:-

Low copper amalgam	0.8 to 8.0%
High copper amalgam	0.4 to 1%





- High-copper amalgams have creep resistance
 - prevention of gamma-2 phase
 - requires >12% Cu total
 - single composition spherical
 - eta (Cu₆Sn₅) embedded in gamma-1 grains
 - interlock
 - admixture
 - eta (Cu₆Sn₅) around Ag-Cu particles
 - improves bonding to gamma 1





Tarnish / Corrosion

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

• Corrosion:

Chemical or electrochemical process in which a solid, usually a metal, is attacked by an environmental agent, resulting in partial or complete dissolution.



Fig: showing tarnish



Fig: showing corrosion





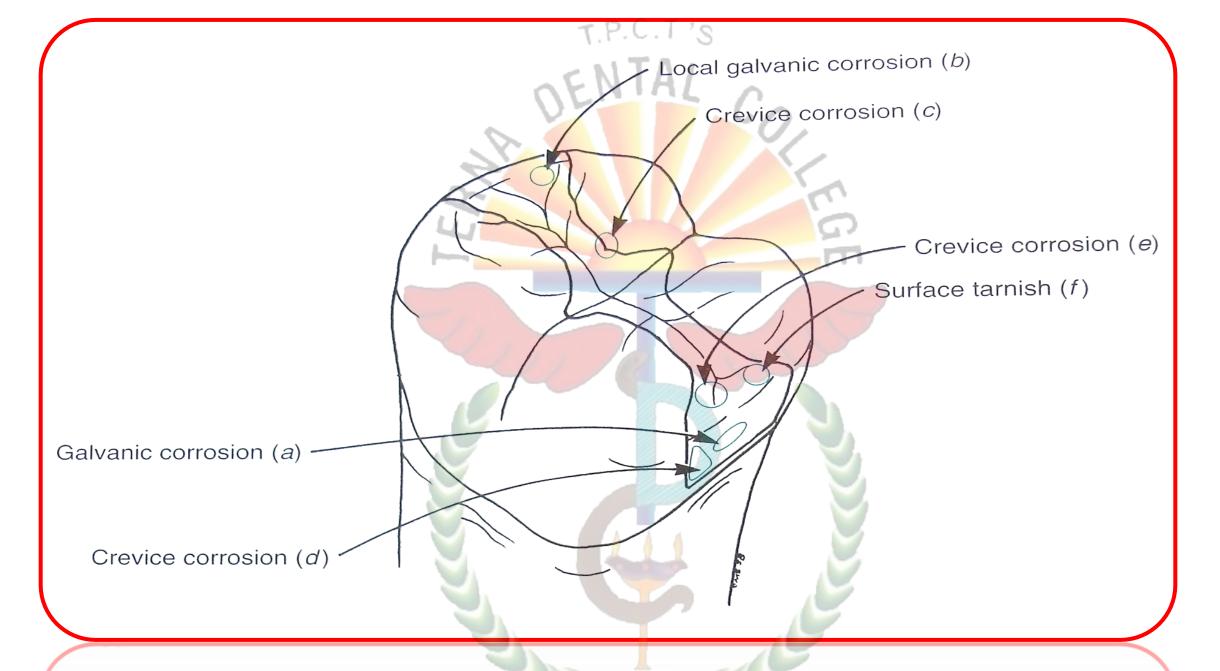
Amalgam undergoes 2 types of corrosion:-

Chemical & Electrochemical

- Chemical corrosion- In which metal reacts to form oxides sulfides in the absence of electrolytes. Eg: silver sulfide in dental alloys containing silver.
- Electrochemical corrosion This requires the presence of water or fluids electrolytes. There
 is a formation of free electrons and electrolyte provide the pathway for the transport of
 electrons.
- Types:
 - Galvanic, Crevice & Stress Corrosion.
- The most common corrosion products of traditional amalgam alloys are oxides & chlorides of tin.







Sturdevant's- Art and science of operative dentistry 5th edition

Excessive corrosion can lead to:

- Reduced strength i.e., a corroded amalgam restoration is predisposed to fracture.
- Marginal degradation ("ditching") which is a stress/corrosion type of degradation
- Dimensional changes i.e., a corroding amalgam restoration increases in size
- Increased internal porosities and surface roughness
- Discoloration
- Galvanic effects, rarely including a metallic taste
- Biological effects, including allergy to corrosion products and possible toxic reaction in extreme situations.



Mahler scale

It is used to compare the image of clinical restoration of interest to a series of five photographs (scale values of No.2,4,6,8,10) representing increasingly worse marginal breakdown.

The rest of the rating scale deals with the **severity of marginal ditching** that is **(No.1,3,5,7,9,11)**.

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EXPANSION

- Two types:
- Mercucroscopic expansion
- Delayed expansion
- Mercucroscopic expansion: Expansion that occurs due to reaction of Hg with alloy components is termed Primary expansion or Mercuroscopic expansion.
- Delayed expansion Expansion that occurs after 3 to 5days due to moisture contamination during trituration or condensation before the amalgam mass is set, is termed Secondary expansion or Delayed expansion.

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DENTAL

• Mercuroscopic Expansion

phase during electrochemical corrosion results in additional formation of phases on reaction with unreacted γ phase, causing further expansion.

Delayed Expansion-

zinc containing amalgam is contaminated with moisture during trituration or condensation, a large expansion occurs.

- This is due to release of H₂ gas within the restoration creating an internal pressure.
- The gas is formed as follows:

$$Zn + H2O = ZnO + H2$$

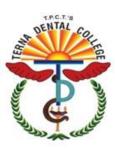
Complications that may result due to delayed expansion are:

Protrusion of the entire restoration out of the cavity.

- Increased micro leakage space around the restoration.
- Restoration perforations.
- Increased creep.
- Pulpal pressure pain. Such pain may be experienced 10-12 days after the insertion of the restoration

CONCLUSION

The percentage of posterior teeth that are restored with resin composite continues to grow. In most of the world, however, dental amalgam remains the most widely used material for load-bearing restorations in posterior teeth. In the United States, amalgam is used for approximately 60% of all direct posterior restorations. Dental schools throughout the world continue to teach amalgam as the material of choice for large and complex posterior restorations.





TAKE HOME MESSAGE

T.P.C.T'S

Amalgam is an very old restorative material, the idea behind this lecture is that the clinician should be fully aware about the indications and handling of this unique restorative material in all clinical situations.





PROBABLE SAQS AND LAQS

- 1. What is the ideal mercury/alloy ratio for an admixed amalgam and a spherical particle amalgam? What are the consequences of insufficient and excess amounts of mercury for amalgam restorations?
- 2. How should the optimal trituration time be determined for a given dental amalgam product?



