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of Dentistry

RESTORATIVE MATERIALS IN DENTISTRY

A graduation project Submitted to the college of Dentistry in partial fulfillment of the requirement for the Degree of Bachelor in dental and oral surgery (B.D.S)

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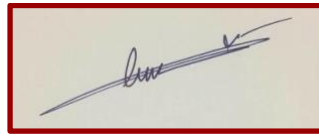

Supervisor Certification

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DEDICATION

To the fountain of patience and optimism and hope. To each of the following in the presence of God and His Messenger, my dear mother. To those who have demonstrated to me what is the most beautiful of my brothers in life. To the big heart my dear father. To the people who paved our way of science and knowledge. All our doctors Distinguished. To the taste of the most beautiful moments with my friends.

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ABSTRACT

Restorative dental materials are substances that are used to repair, replace, or enhance a patient's teeth. These materials include metals, porcelains, and composite resins (often made from plastics).

Restorative dental materials are used to create fillings, bridges, crowns, and inlays in order to restore a tooth's appearance, structure, or function.

Key word :

Restorative materials ،Teeth، Caries ،Occlusal surface، Esthetic

INTRODUCTION

Dental restorative materials are required to fulfill basic prerequisites including similarity to tooth structures in their mechanical, physical, and esthetic properties. Although dental restorative materials differ significantly in their characteristics, they are all, once placed as restorations, subjected to the harsh conditions of the oral cavity.

After placement, dental restorative materials are in constant interaction with the surrounding tissues. Although dental restorative materials are fabricated to be as durable and inert as possible, restorations may deteriorate, degrade or fail, and during these processes, constituents of these materials may be released into the oral cavity.

Not only are these materials expected to maintain their integrity in such harsh conditions, but also to preserve these features during function for prolonged periods. As most restorative materials have a long lifespan, their functionality may alter their basic properties, including those related to biocompatibility.

Restorative materials in function need to endure chewing forces, aqueous conditions, numerous microorganisms, fluctuations in pH, food products, temperature swings, and active enzymes.

The replacement of lost teeth is desired for two primary reasons: aesthetics and restoration of function.

Therefore the main challenge for centuries has been to develop and select ideal dental materials that can withstand the adverse conditions of the oral environment. An ideal restorative material should :

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1. Be biocompatible – not toxic or irritant, it should not cause allergies or discomfort to the patient.

2. Bond permanently to tooth structure or bone.

3. Match the natural appearance of tooth structure and other visible tissues, which means it looks acceptable (aesthetics). This is more concerned with the anterior teeth.

4. Exhibit properties similar to those of tooth tissues (enamel and dentin)because the enamel and dentin are subject to different stimuli in oral cavity (e.g., chewing, biting, drinking acidic/alkaline drinks, hot stimuli …etc). So when the material is subject to the oral environment; it should handle it.

5. Be capable of initiating tissue repair or regeneration of missing or damaged tissues. e.g. Calcium hydroxide (Dycal): when placed on an exposed pulp it will close this exposure by forming a calcified bridge on top of it.

Amalgam restoration

An amalgam is formed when an alloy of two or more metals is mixed with mercury. This reaction is called amalgamation. Dental amalgam is the product of the amalgamation between mercury and an alloy containing silver, tin, often copper, and sometimes other elements combined in varying amounts.

1.1 History

Dental amalgam has been used to treat teeth for many centuries. Substantial research during this time and particularly in the past 40 years has resulted in refinements of the constituents, culminating in the alloys which are used today. All this work has ensured the consistent handling, properties and clinical performance of the material. It is indeed a testimony to the material's many attributes that despite the huge advances in dental materials science, dental amalgam is still widely used

Figure (1) : Amalgam restoration.

1.2 Composition

The basic amalgamation reaction is that of mercury reacting with the surface of the alloy particles.

1.2.1 Mercury

The mercury used for dental amalgam is produced by distillation. It is distilled three times (like Irish whiskey!) to remove any impurities. This is important as contamination leads to inferior physical properties and adversely affects the setting characteristics of the amalgam. Contaminated mercury has a dull surface. Most dental amalgam products used in dentistry today are presented in encapsulated form. This means the dentist should have less concerns about the purity of the mercury as this is packaged in the manufacturing plant

1.2.2 Alloy

Prior to 1986, all alloys, whatever their composition, were referred to as conventional alloys. However, work in the preceding decade evaluating the differing elemental compositions of the alloys increased the understanding of the structure and properties of the dental amalgam formed.

These newer alloys produced dental amalgams which exhibited superior clinical performance.

Conventional alloys :

The typical constituents of commercially available conventional alloys, their functions and clinical influence are shown in Table 1

Table 1: Constituents of dental amalgam alloy:

Function	Element
Main constituent of alloy, combines with tin	Silver
Combines with silver	Tin
Increases mechanical properties, decreases creep, increases corrosion resistance, decreases the amount of the γ2 phase formation	Copper
Acts as a scavenger of oxygen	Zinc
Sometimes added to increase the rate of reaction (pre-amalgamation)	Mercury
All increase corrosion resistance and improve certain mechanical properties of the final product. Decrease creep	Indium, palladium, selenium, platinum, gold

High copper amalgam alloys : There are two types of high copper amalgam alloy:

1. Dispersed phase alloys – in these alloys, the copper is dispersed throughout the alloy and has the effect of increasing its strength. The alloy particles consist of either silver–tin or silver–copper. This means that the total silver content may be kept the same as in conventional alloys.

2. Ternary alloys – ternary means a compound containing three elements, usually silver, tin and copper in this case. Ternary alloys are sometimes called unicompositional alloys as they have all three components in one particle.

Many manufacturers reduce the silver and tin content when increasing the copper content. A small amount of zinc is sometimes added to high copper amalgam to improve its clinical performance, in particular by decreasing marginal breakdown. Table 2 gives the general composition of the three types of alloy.

Table 2: Typical percentage composition of amalgam alloys by weight:

Alloy type	Silver	Tin	Copper	Zinc
Conventional	63-70	26-28	2-5	0-2
Dispersed phase	40-75	0-30	2-40	0-2
Ternary	40-60	17-30	13-30	0

Setting reaction of high copper amalgam:

The setting reaction of these alloys is the same as the reaction for conventional alloys. After the formation of the $\gamma 2$ phase, there is a reaction between this and the silver–copper component, leading to the formation of a copper–tin phase and $\gamma 1$. Although silver is present in the alloy particles, there is a preferential reaction between the copper and tin, thus forming a silver–tin–copper complex. The result is that little or no $\gamma 2$ is left in the final amalgam.
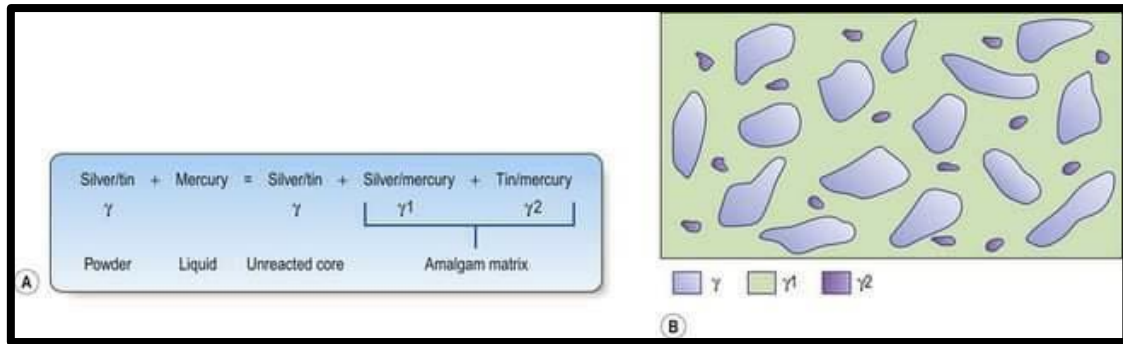
Figure (2) : Setting reaction of high copper amalgam.

1.3 Types of alloy

Currently, three types of dental amalgam alloys are available: lathe cut, spherical and admixed . Their handling characteristics are all very different and it is important that they are manipulated correctly when used in the clinic for optimal performance of the set product :

1. **Lathe cut (irregular) alloys**

These alloys are formed by grinding an ingot of the alloy, which produces irregular particles of varying size ranges. The different sizes of particle require different handling and their reactivity with mercury also varies. A blend of various particle sizes is used by the manufacturer to control the properties and working and setting times of the amalgam. Sometimes, after the machining process, the particles are too reactive to be used. If they are used in this state, the setting reaction would be too rapid (especially for the smaller particles as their surface area to volume ratio is higher). During commercial production, the alloys are placed in boiling water to reduce their reactivity.

2. **Spherical alloys**

These alloys are made by heating the alloy components to a molten liquid and then spraying this liquid into an inert atmosphere, usually argon. The particles coalesce as they fall, forming solidified spheres.

3. Admixed alloys

As the name suggests, admixed (sometimes called blended) alloys contain a combination of irregular and spherical particles.

1.4 Advantages

1. Strength – Dental amalgam is the strongest direct restorative material.
2. Durability – Dental amalgams durability is good to excellent in large load bearing (chewing) areas and lasts for many years. It is generally less durable than gold and more durable than composite resin.
3. Relative ease of placement – Dental amalgam is relatively tolerant to the presence of moisture during placement.
4. Resistance to decay – Once placed, a small amount of corrosion takes place between the dental amalgam and the tooth, filling microscopic voids and acting as a fluid resistant coating that resists the growth of bacteria, which cause tooth decay.
5. Relative lower cost – Dental amalgam is much less expensive than gold and other indirect restorations,It is also fairly less expensive than composite resin.

1.5 Disadvantages

1. Esthetics – Dental amalgam does not mimic tooth color and often changes color from silver to black.

2. Sacrifice of healthy tooth structure – Removal of healthy tooth structure is required solely for adequate retention and strength of the dental amalgam.

3. Weakening of the tooth – Dental amalgam expands over time and may lead to significant tooth fracture especially since dental amalgam is typically used in large load bearing areas.

4. Higher incidence of thermal sensitivity – Metal is a good conductor of cold and heat to the nerve of the tooth.

5. Set Time – Dental amalgams do not harden immediately. Patients should avoid chewing on newly placed dental amalgams for approximately 24 hours while the material reaches its maximum strength.

6. Presence of bound elemental mercury and other metals – Concerns regarding toxicity and allergy are mounting concerns.

1.6 Properties

1. Strength

The dental amalgam must be strong enough to withstand forces during function, and ideally develop early strength so that it is not damaged before it is fully set. The material (as with other brittle materials) is strongest in compression and weakest in tension. The properties exhibited by the final set material depend on the structure of its various phases, their proportions and their individual strengths. The weakest phase is the $\gamma 2$ phase so that any increase in the amount of this phase weakens the material. High copper and spherical alloys have higher early compressive and tensile strengths than conventional alloys.

2. Thermal diffusivity and thermal expansion

As dental amalgam is metallic, it transmits heat readily (the material has a high thermal diffusivity, 9.6 mm2/s). Its coefficient of thermal expansion ($22–28 \times 10^{-6}$/°C) is greater than that of the surrounding tooth. During thermal cycling, significant expansion and contraction may lead to:

A. Microleakage

Fracture of a tooth that has been weakened by tissue removal during cavity preparation for the treatment of dental caries

B. Risk of pulpal damage in a deep cavity due to temperature rise.

3. Dimensional stability

When dental amalgam is setting, a dimensional change occurs.

Initially the material contracts slightly as the mercury diffuses into the outer surface of the alloy particles and reacts with the silver and tin portions. The material then expands as the amalgam is setting because the ($\gamma 1$) crystals expand by growth. From a clinical perspective, the combination of these two phenomena should not lead to any significant expansion or contraction:

A. Excessive contraction leads to a large marginal gap between the material and the cavity.

B. Expansion leads to extrusion of the material out of the cavity. Other factors that can affect dimensional change of the amalgam are the size and shape of the particles and the type of alloy used. As previously mentioned, zinc-containing alloys expand significantly if contaminated with water at placement. The quality of the clinical condensation also affects dimensional change, so thorough condensation is important

4. Working time0

The working time of a dental amalgam is influenced by:

A. Chemical composition

B. Particle size of the alloy

C. Any ageing treatments carried out during its manufacture. Fast-, regular- and slow-set amalgams are available on the market and which of these is used is largely a matter of the dentist's preference as to the speed of set required

1.7 Cavity design

Correct cavity design is important for the success of the final (amalgam) restoration.

•A minimum cavity depth of 2 mm is required because of the risk of fracture.

•No sharp internal line angles should be left as this will lead to stress concentration in the juxtaposed material or lead to fracture.

•Attention should also be paid to the cavo-surface angles so that neither weak amalgam nor weak unsupported tooth is left at the margin.

Composite restorative

composite restorative materials consist of a continuous polymeric or resin matrix in which an inorganic filler is dispersed. This inorganic filler phase significantly enhances the physical properties of the composite (compared with previous tooth-colored materials) by increasing the strength of the restorative material and reducing thermal expansion.30 Composites possess LCTEs that are one-half to one-third the value typically found for unfilled acrylic resins and nearer to that of tooth structure.

For a composite to have good mechanical properties, a strong bond must exist between the organic resin matrix and the inorganic filler. This bond is achieved by coating the filler particles with a silane coupling agent, which not only increases the strength of the composite but also reduces its solubility and water absorption.

Figure (3) : Composite restoration.

2.1 Compostion

The material consists of three components: resin matrix (organic content), fillers (inorganic part) and coupling agents.The resin matrix consists mostly of Bis-GMA (bisphenol-Aglycidyldimethacrylate). The fillers are made of quartz, ceramic and or silica.

2.2 Indications

1. Class I and Class II Tooth Preparations :
   - For restoration of mild to moderate class I and class II tooth.
   - Preparations, as pit and fissure sealants and as preventive.
   - Restorations of all teeth.

2. Class III, IV and V Preparations :
   - Restoration of class III, IV and V preparations of all teeth.
   - Especially when esthetics is important.

3. Class VI Preparations :
   Restoration of class VI preparations of teeth where high Occlusal stress is not present.

4. Esthetic Improvement Procedures: For Example:
   - Laminates.
   - Partial veneers.
   - Full veneers.
   - Treatment of tooth discolorations.
   - Diastema closures.

5. Erosion or Abrasion Defects : to restore erosion or abrasion defects in cervical areas of all the surfaces of premolars, canines and incisors where esthetics is the main concern.

6. Hypoplastic or Other Defects : for restoration of hypoplastic or other defects on the facial or lingual areas of teeth.

7. Core Build : as core builds up for grossly damaged teeth and endodontically treated teeth.

8. Luting Cement : for cementation of indirect restorations like inlays, onlays and crowns.

9. Miscellaneous :

   - for periodontal splinting of weakened teeth or mobile teeth.

   - For repair of fractured ceramic crowns.

   - For bonding orthodontic appliances.

2.3 Contraindications

1. Difficult Moisture Control :

   - When isolation of operating field is difficult or accessibility.

   - Problem is present for example in extremely posterior region.

   - Where very high occlusal forces are present or in patients with heavy occlusal Stresses.

2. Bruxism are not good choice for composite restorations.

3. Class V Lesions : class V lesions where esthetics is not the prime concern.

4. Lack of Technical Skill : when clinician does not possess the necessary technical skill.

5. For restoration caries on Canine : small lesions on distal surface of canines where metallic restoration is treatment of choice.

6. High Caries Susceptibility and Poor Oral Hygiene

7. Patients with high caries susceptibility and poor oral hygiene.

8. Pose great risk of secondary caries and marginal discoloration.

9. Subgingival or Root Caries : when preparation extends subgingivally or root surface, composites do not provide a favorable marginal seal.

2.4 Advantages

1. Conservation of tooth structure : since composite restoration requires minimal tooth preparation, maximum conservation of tooth structure is possible.

2. Esthetically acceptable.

3. Composite resin can be used in combination with other materials, such as glass ionomer, to provide the benefits of both materials.

4. Low thermal conductivity : composites have low thermal conductivity, thus no insulation base is required to protect underlying pulp.

5. Mechanical bonding to tooth structure : restorations are bonded with enamel and dentin, hence show good retention.
   Composite restorations can bond directly to the tooth, making the tooth stronger than it would be with an Amalgam filling.

6. Immediate finishing and polishing : restoration with composite resins can be finished immediately after curing.

7. It can be repaired rather than replaced.

8. Low microleakage : composite restoration show low microleakage than unfilled resins.

9. Extended working time : extended working time of composites makes their manipulation easier.

10. Restoration can be completed in one dental visit.

11. Indirect composite fillings and inlays are heat-cured, increasing their strength .

12. No galvanism because composite resins do not contain any metals.

2.5 Disadvantages

1. Polymerization shrinkage : Because of polymerization shrinkage, gap formation on margins may occur, usually on root surfaces This can result in secondary caries, staining and postoperative sensitivity.

2. Time consuming : Composites restorations require good isolation and number of steps for their placement. Therefore composites restorations are more difficult to place and are time consuming.

3. Expensive : Composite is more expensive than amalgam.

4. Technique sensitive : It is more technique sensitive than amalgam because composite placement requires careful attention to all steps of placements.

5. Low wear resistance : Composites have low wear resistance than amalgam.

6. High Linear Coefficient of Thermal Expansion : high LCTE may result in marginal percolation around composite restorations.

7. Composite resins have adequate radiopacity to enable their detection in radiographs.

2.6 Types

2.6.1 Microfill Composites :

Microfill composites were introduced in the late 1970s. These materials were designed to replace the rough surface characteristic of conventional composites with a smooth, lustrous surface similar to tooth enamel. Instead of containing the large filler particles typical of the conventional

composites, microfill composites contain colloidal silica particles whose average diameter is 0.01 to 0.04 µm.this small particle size results in a smooth, polished surface in the finished restoration that is less receptive to plaque or extrinsic staining. Because of the greater surface area per unit volume of these microfine particles, however, microfill composites cannot be as heavily filled because of the significant surface area per unit of volume. Typically, microfill composites have an inorganic filler content of approximately 35% to 60% by weight. Because these materials contain considerably less filler than do conventional or hybrid composites, some of their physical and mechanical characteristics are inferior. Nonetheless, microfill composites are clinically highly wear resistant. Also, their low modulus of elasticity may allow microfill composite restorations to flex during tooth flexure, better protecting the bonding interface. This feature may not have any effect on material selection for Class V restorations in general, but it might make microfill composites an appropriate choice for restoring Class V cervical lesions or defects in which cervical flexure can be significant (e.g., bruxism, clenching, stressful occlusion).

2.6.2 Macrofill (or Conventional) Composites :

Macrofill composites were the first type of composites introduced in the early 1960s. Although these types of composite restorations are sometimes found in some older patients, they are no longer used in clinical practice. Macrofill composites generally contained approximately 75% to 80% inorganic filler by weight. The average particle size of conventional composites was approximately 8 µm.29 Because of the relatively large size and extreme hardness of the filler particles, macrofill composites typically exhibit a rough surface texture. The resin matrix wears at a faster rate than do the filler particles, further roughening the

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surface. This type of surface texture causes the restoration to be more susceptible to discoloration from extrinsic staining. Macrofill composites have a higher amount of initial wear at occlusal contact areas than do the microfill or hybrid types.

2.6.3 Packable Composites :

Packable composites are designed to be inherently more viscous to afford a "feel" on insertion, similar to that of amalgam. Because of increased viscosity and resistance to packing, some lateral displacement of the matrix band is possible. Their development is an attempt to accomplish two goals:

(1) easier restoration of a proximal contact and

(2) similarity to the handling properties of amalgam.

Packable composites do not completely accomplish either of these goals. Because of the increased viscosity, it is typically more difficult to attain optimal marginal adaptation, prompting some clinicians to first apply a small amount of flowable composite along proximal marginal areas to enhance adaptation.

2.6.4 Hybrid Composite Resins :

Hybrid composites are named so because they are made up of polymer groups (organic phase) reinforced by an inorganic phase. Hybrid composites are composed of glasses of different compositions and sizes, with particle size diameter of less than 2 µm and containing 0.04 µm sized fumed silica .filler content in these composites is 75 to 80% by weight. This mixture of fillers is responsible for their physical properties

similar to those of conventional composites with the advantage of smooth surface texture.

Advantages :

- Availability in various colors
- Different degrees of opaqueness and translucency in Different tones and fluorescence.
- Excellent polishing and texturing properties.
- Good abrasion and wear resistance.
- Similar coefficient of thermal expansion.
- Ability to imitate the tooth structure.
- Decreased polymerization shrinkage.
- Less water absorption.

Disadvantages

- Not appropriate for heavy stress bearing areas
- Not highly polishable as microfilled because of presence of larger filler particles in between smaller ones.
- Loss of gloss occurs when exposed to tooth brushing with abrasive toothpaste

2.7 Properties

1. Coefficient of Thermal Expansion : coefficient of thermal expansion of composites is approximately three times higher than normal tooth structure. This results in more contraction and expansion than enamel and dentin when there are temperature changes resulting in loosening of the restoration . It can be reduced by adding more filler content. Microfill composites show more

Coefficient of thermal expansion because of presence of more polymer content.

2. Water Absorption : composites have tendency to absorb water which can lead to the swelling of resin matrix, filler debonding and thus restoration failure.

   Composites with higher filler content exhibit lower water absorption and therefore better properties, than with lower filler content.

   Factors Affecting Water Absorption of Composites :

   - More is the filler content, lesser will be water sorption.
   - Lesser degree of polymerization causes more sorption.
   - Type and amount of monomer and dilutent affect water Sorption. For example, UDMA based composites show less sorption and solubility.

3. Wear Resistance : wear resistance refers to material's ability to resist surface loss as a result of abrasives contact with opposing tooth structure, restorative material or toothbrushing.Wear resistance is a property of filler particles depending on their size and quantity.

   Composites are prone to wear under masticatory forces, toothbrushing and abrasive food.

   Site of restorations in dental arch and occlusal contact relationship, size, shape and content of filler particles affect the wear resistance of the composites.

   Two principal modes of wear are:

- Two-body wear: When there is direct contact of restoration with opposing tooth or adjacent proximalsurface of tooth, it leads to high stress development.
- Three-body wear: Three-body wear is caused due to contact with the food bolus as it is forced across the occlusal surface. This type of wear depends upon degree of monomer conversion, filler loading, type of filler particles and stability of silane coupling agent.wear of composites leads to fracture or loss of the restoration.

4. Surface Texture : size and composition of filler particles determine the smoothness of surface of a restoration. Microfill composites offer the smoothest restorative surface. This property is more significant if the restoration is in close approximation to gingival tissues.

5. Radiopacity : resins are inherently radiolucent. Presence of radiopaque fillers like barium glass, strontium and zirconium makes the composite restoration radiopaque.

6. Modulus of Elasticity : modulus of elasticity of a material determines its rigidity or stiffness.
   Microfill composites have greater flexibility than hybrid composite since they have lower modulus of elasticity.

7. Solubility : composite materials do not show any clinically significant solubility in oral fluids. Water solubility of composites ranges between 0.5 and 1.1 mg/cm2.

8. Creep : creep is progressive permanent deformation of material under occlusal loading. More is the content of resin matrix, more is the creep.

For example, microfilled composites show more creep since they contain more of resin matrix.

9. Polymerization Shrinkage : composite materials shrink while curing which can result in gap between restoration and the tooth surface.

Polymerization Shrinkage can Result in :

- Postoperative sensitivity.

- Recurrent caries.

- Failure of interfacial bonding.

- Fracture of restoration and tooth.

Polymerization Shrinkage can be Reduced by :

- decreasing monomer level

- Increasing monomer molecular weight

- Improving composite placement technique: Placing successive layers of wedge-shaped composite (1–1.5 mm)

10. Configuration or C-factor :

cavity configuration or C-factor was introduced by

Professer Carol Davidson and his colleagues in 1980s.

C factor is the ratio of bonded surface of restoration to unbonded surfaces .

Higher the value of 'C'-factor, greater is the polymerization.

2.8 Failures

Composite restorations may show failure because of :

1. Incomplete removal of carious lesion.

2. Incomplete etching or incomplete removal of residual

3. acid from tooth surface.

4. Excess or deficient application of bonding agent.

5. Lack of moisture control.

6. Contamination of composite with finger/saliva.

7. Following bulk placement technique during polymerization of composite

8. Improper polymerization method.

9. Incomplete finishing and polishing of composites.

10. Inadequate occlusion of restored tooth.

11. Discoloration, especially at the margins .

12. Fracture of margins.

13. Secondary caries.

14. Postoperative sensitivity.

15. Gross fracture of restoration.

16. Loss of contact after a period of time.

17. Accumulation of plaque around the restorations.

18. Marginal Defects in Composite Restorations.

19. Surface fracture of excess material.

20. Voids in restoration because of air entrapment during placement.

21. Composite wear resulting in progressive exposure of axially directed wall.

22. Gap formation.

Figure (4) : Discoloration of composite restoration.

Guidelines to minimize chances of composite failure:

1. Tooth preparation should be kept as small as possible

2. Since composite in bulk leads to failure.

3. Avoid sharp internal line angles in tooth preparation.

4. Deeper preparations should be given base of calcium Hydroxide or glass ionomer cement.

5. Strict isolation regime is to be followed.

6. Avoid inadequate curing, because it leads to hydrolytic breakdown of composites.

7. Use small increments, holding each increment with Teflon coated instruments.

8. Fill proximal box separately and create proper contact areas.

9. Composite, especially at beveled areas, should be finished and polished properly.

Ceramic restoration

Dental ceramic materials are used to fabricate lifelike restorations. Ceramic's translucency and toothlike color contribute to highly esthetic restorations. Ceramic is a very hard and strong material capable of sustaining biting forces but, being a brittle glasslike material, can fracture when subjected to extreme forces or sharp impact.

Because of the natural hardness of ceramic, these restorations are highly resistant to wear. However, if they are not highly polished and smooth, they rapidly can wear opposing restorations or natural teeth. Over the years, laboratory-fabricated all-ceramic restorations have become very popular owing to their excellent esthetic

Figure (5) : Ceramic restoration.

3.1 Composition

Ceramic used in dental application differs in composition from conventional ceramic to achieve optimum aesthetic components such as translucency.

As example the composition of dental feldspathic porcelain is as follows:

- Kaolin 3-5%

- Quartz (silica) 12-25%

- Feldspar 70-85%

- Metallic colourants 1%

- Glass up to 15%

Figure (6) : Replacement of amalgam restoration by ceramic restoration.

3.2 Types

The range of dental ceramics determined by their respective firing temperatures are:

3.2.1 Ultra-low :

Fired below 850 °C - mainly used for shoulder ceramics (aims to combat the problem of shrinkage, specifically at the margins of the prep, when the early sintered ceramic state is fired to produce the final restoration), to correct minor defects and to add colour/shading to restorations.

3.2.2 Low fusing :

Fired between 850 and 1100 °C - to prevent the occurrence of distortion, this type of ceramic should not be subjected to multiple firings.

3.2.3 Higher fusing : This type is used mainly for denture teeth.

3.3 Advantages

1. Highly esthetic

2. No display of metal

3. Strong once bonded to tooth

4. Does not stain

5. Low thermal conductivity

6. Suitable for large tooth preparations

7. Long lasting

8. Low coefficient of thermal expansion

9. Biocompatible.

3.4 Disadvantage

1. More costly than amalgam or composite

2. Accurate occlusion can be difficult to achieve

3. Takes two appointments

4. Intraoral finishing and polishing is a time-consuming procedure

5. Fragile and brittle

6. Abrasive to the opposing enamel

7. Very technique sensitive

Figure (7) : Decay tooth filled by ceramic restoration.

3.5 Indications

Ceramic restorations are indicated for most dental applications including:

1. Veneers

2. Inlays

3. Onlays

4. Crowns

5. Bridges

6. Implant supra- and sub-structures

7. Denture teeth

However, each system will have its own set of specific indications and contraindications which can be obtained from the manufacturers guideline.

3.6 Contraindications

Ceramic restorations are contraindicated when a patient presents with the following:

1. Parafunction; individuals who suffer from bruxism or clenching.

2. Short clinical crown.

3. Immature teeth.

4. Unfavourable occlusion.

5. Supragingival preparations (when used alongside adhesive cements).

Gold restoration

Pure gold has been in use in dentistry in the United States for more than 100 years.1-6 Various techniques have been advanced for its use in the restoration of teeth. It is generally agreed that this noble metal is a superior restorative material for treatment of many small lesions and defects in teeth, given sound pulpal and periodontal health.

Success is achieved with direct gold restorations if meticulous care is given to an exacting technique in tooth preparation design and 7 manipulation. Direct gold restorations can last for a lifetime if attention is paid to details of restorative technique and to proper home care. The longevity of direct gold restorations is a result of the superb biocompatibility of gold with the oral environment and its excellent marginal integrity**.**

4.1 Materials and Manufacture

Several physical types of direct-filling gold have been produced.7 All are "compactable" in that they are inserted into tooth preparations under force and compacted or condensed into preparation line and point angles and against preparation walls. Gold foil is manufactured by beating pure gold into thin sheets. The gold foil is cut into 4×4 inch (10×10 cm) sheets and sold in books of sheets, separated by pages of thin paper. The books contain 1/10 oz or 1/20 oz of gold. The sheet of foil that weighs 4 g is termed No. 4 foil; the sheet weighing 3 g is termed No. 3 foil; and the

sheet weighing 2 g is termed No. 2 foil. Because the 4×4 inch sheets are too large to be used in restorative procedures, they are rolled into cylinder or pellets before insertion into tooth preparations.

Pellets of gold foil are generally rolled from 1/32 -inch,1/43 inch,1/64 - inch, or 1/128 -inch sections cut from a No. 4 sheet of foil. The book of foil is marked and cut into squares or rectangles (see, A). Each piece is placed on clean fingertips, and the corners are tucked into the center (see, *B* and *C*), and then the foil is lightly rolled into pellet form (see, D). In addition, cylinders of gold foil may be rolled from the segments of a sheet (see, A). After pellets of gold are rolled, they may be conveniently stored in a gold foil box , which is divided into labeled sections for various sizes of pellets. Cylinders of foil and selected sizes of other types of gold also may be stored in the box. Preferential contamination is suggested by placing a damp cotton pellet dipped into 18% ammonia into each section of the box. This serves to prevent deleterious oxides from forming on the gold until it is used.

Figure (8) : Gold foil box.
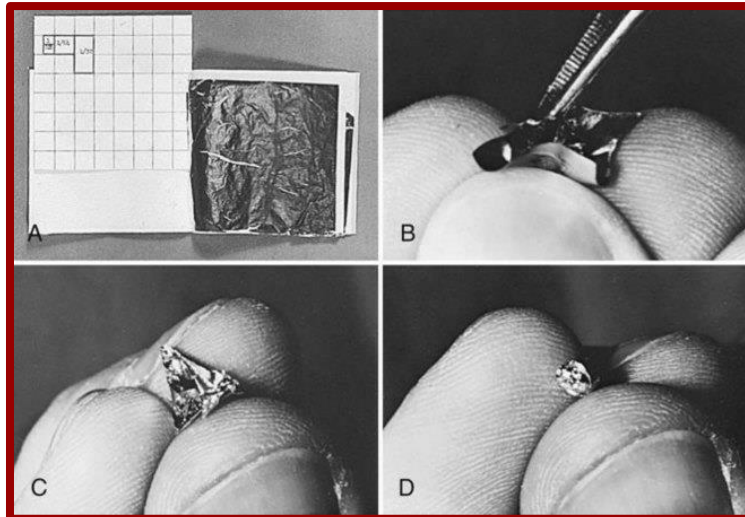
Figure (9) : Manufacturing of gold foil.

Powdered gold is made by a combination of chemical precipitation and atomization, with an average particle size of 15 mm (see A). The atomized particles are mixed together in wax, cut into pieces, and wrapped in No. 4 or No. 3 foil (see B). Several sizes of these pellets are available. This product is marketed as Williams E-Z Gold (Ivoclar-Williams, Amherst, NY).
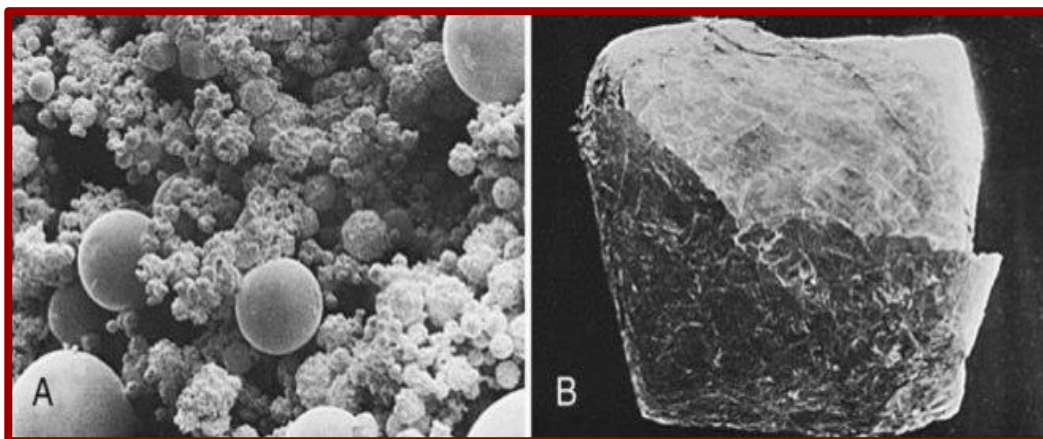
Figure (10) : Scanning electron micrographs of direct-filling golds.

E-Z pellet that contains spheres. (Courtesy of Ivoclar-Williams Company, Inc., Amherst, NY.)

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4.2 Cohesion and Degassing

Direct gold is inserted into tooth preparations under force. The purpose of the force is to weld the gold into restorations containing minimal porosity or internal void spaces.Welding occurs because pure gold with an absolutely clean surface coheres as a result of metallic bonding. As the gold is forced and compressed into a tooth preparation, succeeding increments cohere to those previously placed.

For successful welding to occur during restoration, the gold must be in a cohesive state before compaction, and a suitable, biologically compatible compacting force must be delivered.

Direct gold may be either cohesive or noncohesive. It is noncohesive in the presence of surface impurities or wax, which prevents one increment of gold from cohering to another.

The manufacturer supplies books of gold foil or pre-rolled cylinders in a cohesive or noncohesive state. E-Z Gold pellets are supplied with a wax coating that must be burned off before compaction. Because gold attracts gases that render it noncohesive, such gases must be removed from the surface of the gold before dental compaction.

This process usually is referred to as *degassing* or *annealing* and is accomplished by application of heat. The term *degassing* is preferable because the desired result is to remove residual surface contamination (although further annealing, resulting in additional internal stress relief or recrystallization, also may occur in this process). All directfilling gold products are degassed immediately before use except when noncohesive foil is specifically desired. Underheating during degassing should be avoided because it fails to render the gold surface pure.

Over-heating also should be avoided because it may cause the gold to become brittle or melt and render it unusable. Degassing is accomplished

by heating the gold foil on a mica tray over a flame or on an electric annealer or by heating each piece of gold over a pure ethanol flame.
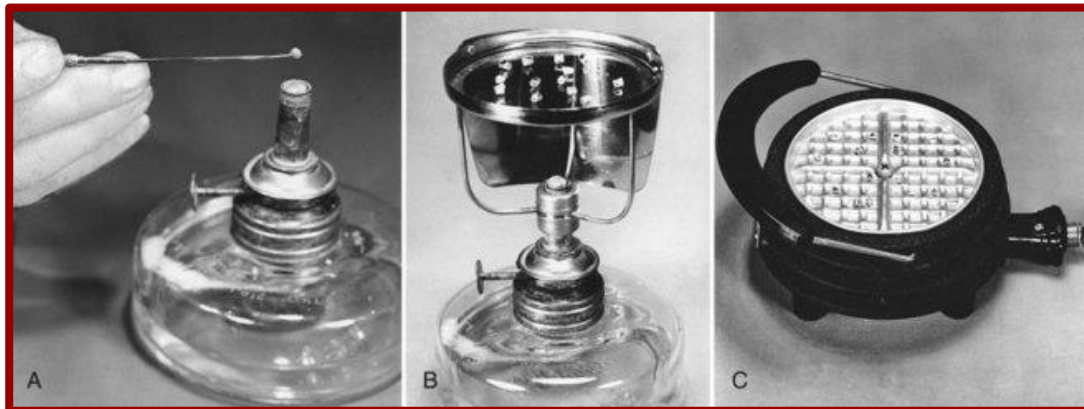
Figure (11) : Degassing of gold foil.

4.3 Advantages

1. A gold foil restoration is a filling technique of decayed teeth that exploits the properties of gold of being welded in its cold state, due to its highly cohesive nature.

2. The resilience of dentine and the adaptability of gold allow an almost perfect seal between the tooth structure and gold. The malleability of gold, which is the property of being worked into very thin foils, make it possible to add gold in very small amounts that are building up the filling.

3. Gold is resistant to corrosion, shows no shrinkage or expansion, and therefore is an ideal dental filling material. The advantages of gold foils restorations are that they can last for a long time if correctly done.

4.3 The disadvantages

1. these restorations are technique sensitive, and to achieve excellence great skill, patience and time is required. The consequences of an improper restoration finishing with a coarse or crystallised surface can affect the periodontal

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ligament. The welding technique, with or without a mallet, can generate a pulpar trauma that can lead to RCT.

2. Because of the high thermal conductivity of gold, larger restoration can enhance sensitivity, and a larger restoration is very complex to finish and polish.

3. Gold foil is more expensive than any other restoration material not only because of the gold (dental bonding is by far more expensive), but because it requires a lot of operative time and a full set of instruments requiring sterilisation and assistance. Multiple restorations are no faster, and each one requires at least a full hour in the hands of a very expert dental surgeon to be completed to perfection.

4. Gold restorations are out of fashion, especially when patient and operator-friendly procedures are a valid alternative.

4.5 Indication

Generally, gold foil restorations are used for incipient or early lesions, generating small cavities in non stress-bearing areas, and where aesthetic concern is limited. The technique is also used to repair of endodontic openings in gold crowns or for gold crown margins, onlays and inlays.

4.6 Contraindication

They are not generally used in children and young adults.

4.7 Types

Gold used for conservative procedures is classified in crystalline and fibrous, according to its microscopic structure6. The former is produced by melting of pure gold into ingots that appear made up of intertwined fibres, giving great strength.

The latter is produced by electrolytic precipitation, and appears granular under microscope magnification .

Gold foil is produced by fibrous gold ribbons which can be either flattened using round head mallets to produce five square inches foils, or by rolling mills to produce rolled gold foil. Gold foils are classified in cohesive and not cohesive.

Gold foils produced by ' beating ' or ' rolling ' are both non-cohesive, which means that the cohesive property has to be obtained by slow heating, the annealing process .

Non-cohesive gold foils are more flowable, and are used basically in the proximal portions of class 2 restorations and class 3 lingually. Its use prevents the possible damages to enamel rods involved in the use of the mallet necessary for cohesive gold foil. Cohesive gold is used for all surfaces subject to wear .

Crystallised gold is used as filler to build up in class 5 and class 1. It should not be used for external surfaces of restoration, because it shows a tendency to surface pitting

4.8 Storage of gold foils

Exposure to air and dust can affect the cohesive properties of gold foils. Cohesiveness properties are conveniently maintained storing gold foils in the presence of ammonia (an open bottle or sachets), in a drawer or in a box. They should never be handled directly with bare hands in order to avoid salts and moisture from the skin to contaminate the surface.

Glass ionomer Restoration

Glass ionomer cement was developed in early 1970 by Wilson and Kent who combined technology of zinc. polycarboxylate and silicate cement. Earlier these were called as alumino silicate polyacrylate (ASPA).Conventional glass ionomers contain ion leachable fluoroaluminosilicate glass of silicate cement but avoid their dissolution by substituting of carboxylic acid from zinc polycarboxylate for phosphoric acid.

The type of application depends on the consistency of cement which ranges from a very high viscosity to low viscosity by adjusting the particle size distribution and P/L ratio.Maximum particle size for restorative cement is 50 μm and for luting agents 15 μm. Another name for this cement is 'glass polyalkanoates cement.The chemistry of GICs have evolved overtime incorporation of metal particles results in metal reinforcedGIC. Replacing part of polyacrylicacid with hydrophilic monomers results in light curable/chemical curable material called Resin modified GIC or hybrid ionomer cement.

Acid-base curing process is part of the setting reaction,therefore, they are called 'dual cured GIC . If all these three reactions are involved it called tricured GIC.

Figure (12) : Glass ionomer restoration.

5.1 Composition

- Glass ionomer powder is an acid soluble calcium fluoroaluminosilicate glass.

- Raw materials are fused to a uniform glass by heating them to a temperature of 1100-1500°C.

- Lanthanum, strontium and barium/ZnO are added to provide radiopacity.

- Originally the liquids for GICs were aqueous solutions of polyacrylic acids in concentration of 40-50%, this was quite viscous and tended to gel overtime. In most of the current cements the acids is in the form of a copolymer with itaconic acid, maleic acid, or tricarboxylic acid.

- Tartaric acid is also present in the liquid which improves handling characteristics and increases working time but it shortens the setting time.

As a means of extending working time of GICs freeze dried polyacid powder and glass powder are placed in same bottle. Liquid consist of water/water with tartaric acid. When water liquid is added the acid powder dissolves and reconstitute liquid acid and this process is followed by acid-base reaction, this is called as water- settable GIC or anhydrous GIC

5.2 Classification

5.2.1 Type I Luting Use:

- Cementation of crowns

- Bridges

- inlays

- ortho appliances. Setting rate: Fast P/L ratio: 1.5:1.

5.2.2 Type II Restorative

1. Restorative esthetic

    Use: Esthetic restoration.

    Autocure: Slow resistance to water uptake and loss.

Resin modified: Fast setting immediate resistance to water.

P/L ratio: 3:1 or greater.

2. Restorative reinforced

   Use: Where physical properties are required.

   Setting rate: Fast

   P/L ratio: 3:1 or greater.

5.2.3 Type III Liners/Bases

Lining: Used in thin sections under metallic restorations

Setting rate: Fast

P/L ratio: 1.5:1

Base: Use in combination with composite resins as lamination/sandwich technique.

Setting rate: Fast

P/L ratio: 3 : 1 or greater

5.3 Advantages

1. Adhesion to tooth structure

2. Anticariogenic effect because of fluoride release.

3. Acceptable esthetics.

4. Biocompatability.

5. Less technique sensitivity compared to composite resin.

5.4 Disadvantages

1. Low fracture resistance

2. Low wear resistance

3. Moisture sensitivity

4. Water solubility.

5.5 Modifications

5.5.1 Metal modified:

- Silver cermet cement

- Miracle mix

5.5.2 Resin modified:

- Hybrid glass ionomer or resin modified glass ionomer

- Dual cure

- Tri cure

- Compomer

5.6 Clinical Application

Their clinical application is wide range suiting variety of clinical situations.

1. As a restorative material glass ionomers are not used in stress bearing areas of posterior and anterior teeth.

2. Abrasion and erosion lesions

3. Class III lesions involving exposed root dentin

4. Occlusal lesions on deciduous teeth

5. Temporary anterior and posterior restorations

6. Repair crown margins Cavity liners and bases

7. Cement base under composites, amalgams

8. Blocking undercuts

9. Cementation of crowns, inlays, onlays, bridges.

5.7 Tooth Preparation

- Adhesive quality of the glass ionomer cements dictates that an ultraconservative approach be adopted.

- No undercuts or dovetails are necessary.

- Cavosurface margins be butt joint and not beveled.

5.8 Isolation

A clean dry field is mandatory for both better adhesion of glass ionomer to tooth structure and also for strength of the restoration.

5.9 Preparation of Dentinal Surfaces

Dentinal surface nature varies in noncarious cervical lesions and in carious lesions.

5.9.1 Abrasion/Erosion Lesion

- Dentinal surface is cleaned using pumice and brush.

- This is followed by conditioning of dentin by polyacrylic acid for 30 seconds.

- This will ensure that the dentin surface is clean and will also result in dentin tubules opening which would have sclerosed in abrasion/erosion.

5.9.2 Class III, Class V and Other Carious Lesions

- It is not necessary to clean the dentin with pumice.

- But dentin smear layer that is formed during tooth preparation is removed by application of polyacrylic acid for 10 seconds.
- Other dentin conditioners like citric acid, EDTA, ferric chloride can also be used.

5.10 Pulpal Protection

- When glass ionomer cement is placed directly over the pulp it can result in pulp necrosis.
- When a layer of dentin remains, dentin bridge can form when glass ionomer is placed.
- In cases where a layer of caries is left behind calcium hydroxide liner could be used to stimulate dentin bridge formation.

5.11 Mixing and Insertion

- For the powder/liquid systems, correct powder/liquid ratio should be maintained.
- Tap the powder bottle to ensure powder is compacted in the bottle. Any excess powder in scoop is scraped off with a spatula to ensure correct powder quantity.
- Mixing could be done either on glass slab or mixing pad using a agate spatula. No cooling of powder or liquid or glass slab is required.
- Powder is mixed into liquid in two increments in folding motions. Maximum mixing time is 20 seconds.
- In preproportioned capsules it is mixed in an amalgamator at high speed at about 4000 rpm for 10 seconds.

5.12 Finishing and Polishing

- After the required time for setting of cement, the matrix if used is removed. The restoration surface is protected by waterproof varnish.

- Gross excess in cement is removed using a BP blade.

- Any removal of excess cement with rotary instrument is best delayed after 24 hours.

- Final finishing delayed after 24 hours, final finishing is done with fine diamond, 12-bladed tungsten carbide or flexible finishing disks.

5.13 Surface Protection

- Varnish application to restoration surface after the cement has set is essential. Polyurethane varnish or nitrocellulose varnishes are other alternatives.

- Light activated bonding resin can also be used to protect glass ionomer surface.

- Use of vaseline to protect the glass ionomer surface is of limited use as vaseline is easily removed by action of lips.

5.14 Clinical Performance

5.14.1 Advantages of glass ionomer as a restorative material are:

- Placement in bulk

- Adhesive bonding ability to tooth structure.

- Fluoride release.

5.14.2 Advantages of glass Ionomers as Liners and Bases are:

- Better biocompatibility. • Tooth surface adhesion.

- Fluoride release.

- Can be used to block out undercuts in indirect tooth preparation.

- Radiopaque formulation.

- Glass ionomer liner and base application is same as for glass ionomer restoration with regard to cement manipulation and placement on tooth preparation.

- Powder liquid ratio for base application is 3 : 1 and for lining purposes it is 1.5 : 1.

- This lining or base cement is used in sandwich technique. Here glass ionmer cement is laminated with composite resin restoration.

There are three types of glass ionomer sandwich restoration they are :

  1. Open sandwich restoration

  2. Closed sandwich restoration

  3. Centripetal sandwich restoration

Figure (13) : Glass ionomer materials.

Conclusion

All restorations perform one of three main functions. They repair, replace, or enhance. Among the types of restorations that repair are fillings. These are used to restore tooth damage that occurs as a result of dental caries (tooth decay). Metal amalgams or composite resins are used to fill cavities and restore the function and esthetics of a tooth. Inlays and crowns, used to repair damage to the teeth, replace tooth structure lost to decay or injury, protect what remains, and restore the tooth's shape and function. Inlays are more durable than amalgam fillings.

Crowns may be necessary when a tooth cracks, has its entire structure weakened by decay, or becomes brittle after a root canal. Crowns can also cover dental implants or abutment (adjacent) teeth when fitting a bridge.

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