Cement Materials

Cement: Substance that hardens from a viscous state to a solid union between two surfaces; for dental applications, these materials act as:
(1) luting agents to bond preformed restorations and orthodontic attachments in or on the tooth.

(2) cavity liners and bases to protect the pulp and foundations and anchors for restorations.

(3) restorative materials.

This multiplicity of applications requires more than one type of cement, because no one material has yet been developed that can fulfill the varying requirements.

Requirements of Dental Cements (in luting and restorative applications):

1. The cement must have adequate resistance to dissolution in the oral environment and be biocompatible.
2. It must also develop an adequately strong bond through mechanical interlocking and adhesion.
3. High strength in tension, shear, and compression is required, as is good fracture toughness to resist stresses at the restoration-tooth interface.
4. Good manipulation properties, such as adequate working and setting times, are necessary for successful use.
5. The manipulation, including dispensation of the ingredients, should allow for some margin of error in practice.

Most cements are powder/liquid materials that may be dispensed and mixed manually or predispensed in capsules that are mixed mechanically. Some recent materials are composed of two pastes. Cements set by chemical reaction between the ingredients (often an acid-base reaction) or by polymerization of a monomeric component.

five basic types of cements are available, classified according to the matrix-forming species:

1. Phosphate bonded
    a) Zinc phosphate
    b) Zinc silicophosphate
2. Phenolate bonded
    a) Zinc oxide- eugenol
    b) Calcium hydroxide salicylate
3. Polycarboxylate bonded
    a) Zinc polycarboxylate
    b) Glass ionomer

4. Dimethylacrylate bonded

5. Polycarboxylate and dimethylacrylate combinations

1. Phosphate-Based Cements

a) Zinc phosphate cement:

Applications

1. Cementation (luting) of fixed cast alloy and porcelain restorations and orthodontic bands.
2. As a cavity liner or base to protect pulp from mechanical, thermal, or electric stimuli.

Composition and setting

- The powder is mainly:

- zinc oxide
- up to 10% magnesium oxide
-small amounts of pigments.

It is fired at high temperature (> 1,000°C) for several hours to reduce its reactivity.

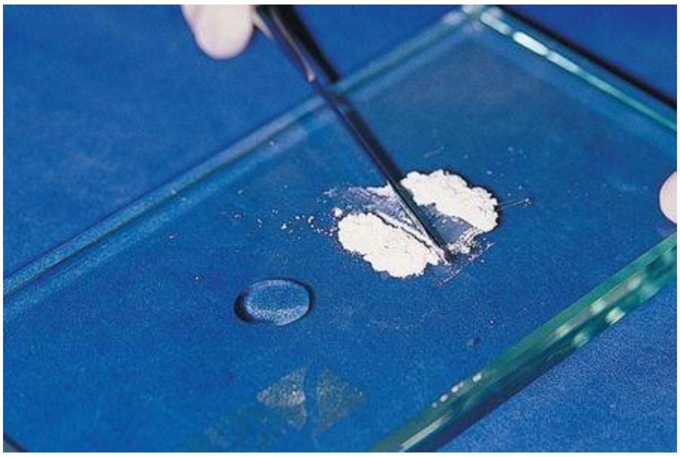
- The liquid is:

- 45% to 64% H_3PO_4 phosphoric acid
- 30% to 55% water.
- 2% to 3% aluminum (essential to the cement-forming reaction)
- 0% to 9% zinc (a moderator of the reaction between powder and liquid, allowing adequate working time and permitting a sufficient quantity of powder to be added for optimum properties in the cement).

Modified zinc phosphate cements are used as a cavity liner and has 8% aluminum and only 25% H_3PO_4 in the liquid and a powder that contains calcium hydroxide. Others may contain as much as 10% stannous fluoride (used in orthodontics).

Manipulation

The mixing slab must be thoroughly dried before use. A chilled (5°C) thick glass slab will slow the initial reaction and allow incorporation of more powder, giving superior properties in the set cement. The measurement of the components and the timing of mixing are necessary. The powder is added to the liquid in small portions to achieve the desired consistency.
Increasing the powder/liquid ratio gives a more viscous mix, shorter setting time, higher strength, lower solubility, and less free acidity. Dissipation of the heat of reaction by mixing over a large area on a cooled slab will allow a greater incorporation of powder in a given amount of liquid. The cement must be undisturbed until the end of the setting time. It is kept sealed with a stopper to prevent changes in the water content. Cloudy liquid should be discarded.



Properties

The higher the powder/liquid ratio, the better the strength properties and the lower the solubility and free acidity.

At room temperature (21°C to 23°C) the working time for most brands at luting consistency is 3 to 6 minutes, and the setting time is 5 to 14 minutes.

Extended working times and shorter setting times can be achieved by use of a cold mixing slab, which permits up to an approximate 50% increase in the amount of powder, improving both strength and resistance to dissolution. The cement must have the ability to wet the tooth and restoration, flow into the irregularities on the joining surfaces, and fill in and seal the gaps between the restoration and the tooth. The minimum value of film thickness is a function of powder particle size, powder/liquid ratio, and mix viscosity.

- The strength is strongly and almost linearly dependent on powder/liquid ratio.
- The tensile strength is much lower than the compressive strength.
- The solubility in organic acid solutions, such as lactic or citric acid is high. Dissolution contributes to marginal leakage around restorations and bacterial penetration. This occurrence may be facilitated by dimensional change. The cement has been found to contract about 0.5% linearly, giving rise to slits at the tooth-cement and cement-restoration interfaces.

Advantages

- They can be mixed easily
- They set sharply to a relatively strong mass from a fluid consistency.
- Unless the mix is extremely thin (for instance, with a very low powder/liquid ratio), the set cement has a strength that is adequate for clinical service, so manipulation is less critical than with other cements.

Disadvantage

- Pulpal irritation (The freshly mixed zinc phosphate is highly acidic, with a pH between 1 and 2 after mixing, and, even after setting 1 hour, the pH may still be below 4. After 24 hours, the pH is usually between 6 and 7. This necessitate some form of pulpal protection)
- Lack of antibacterial action
- Brittleness
- Lack of adhesion
- Solubility in oral fluids.

b) **Silicophosphate cements:** They are combinations of zinc phosphate and silicate cements. The presence of the silicate glass provides a degree of translucency, improved strength, and fluoride release (contains 12% to 25% fluoride).

Applications:

- Type I: for the cementation of fixed restorations and orthodontic bands
- Type II: as a provisional posterior restorative material
- Type III: as a dual-purpose material

Manipulation: The mixing is the same as zinc phosphate cement.

Properties:

- They have shorter working times and a coarser grain size, leading to a higher film thickness than with zinc phosphate cements.
- The durability in bonding orthodontic bands to teeth is greater, and less decalcification is observed.
- Solubility in organic acids and in the mouth is less than for phosphate cements. In the presence of oral fluids, fluoride will leach out.
- The glass content gives greater translucency than phosphate cements, making silicophosphate cements useful for cementation of porcelain restorations.

Biologic effects Because of the acidity of the mix and the prolonged low pH (4 to 5) after setting, pulpal protection is necessary on all vital teeth. Fluoride and other ions are leached out from the set cement by oral fluids, resulting in increased enamel fluoride and probable anticariogenic action.

Advantage: Silicophosphate cements have better strength, toughness, and abrasion-resistance properties than zinc phosphate cements and show considerable fluoride release, translucency, and, under clinical conditions, lower solubility and better bonding.

Disadvantage:

- the initial pH and total acidity are greater than those for zinc phosphate cements; thus, pulpal sensitivity may be of longer duration.
- Manipulation with these cements is more critical than with zinc phosphate cements.

2. Phenolate-Based Cements

a) Zinc oxide–eugenol cements

Applications

- the provisional cementation of crowns and fixed partial dentures
- in the provisional restoration of teeth
- as a cavity liner in deep cavity preparations.

Composition and setting:

- The powder is pure zinc oxide.
- Commercial materials may contain small amounts of fillers, such as silica.
- About 1% of zinc salts, such as acetate or sulfate as accelerator.
- The liquid is purified eugenol or, in some commercial materials, oil of cloves (85% eugenol). - -
- 1% or less of alcohol or acetic acid may be included to accelerate setting together with small amounts of water, which is necessary for the setting reaction.

A chemical reaction occurs between zinc oxide and eugenol, with the formation of zinc eugenolate (eugenate). The reaction is reversible because the zinc eugenolate is easily hydrolyzed by moisture to eugenol and zinc hydroxide. Thus, the cement disintegrates rapidly when exposed to oral conditions.

Manipulation

The zinc oxide is slowly wetted by the eugenol; therefore, prolonged and vigorous spatulation is required, especially for a thick mix.

A powder/liquid ratio of 3:1 or 4:1 must be used for maximum strength.

Properties

The working time is long because moisture is required for setting. Mixes of cementing consistency set very slowly unless accelerators are used and/or a drop of water is added. Commercial materials set in 2 to 10 minutes, resulting in adequate strengths at 10 minutes for amalgam restorations to be placed.

Biologic effect

- The presence of eugenol in the set cement under clinical conditions appears to lead to an anodyne and obtundent effect on the pulp in deep cavities.
- At the same time, eugenol is a potential allergen.
- When exposed directly to oral conditions, the material maintains good sealing characteristics despite a volumetric shrinkage of 0.9% and a thermal expansion. The sealing capacity and antibacterial action appear to facilitate pulpal healing
- When in direct contact with connective tissue, the material is an irritant.
- Reparative dentin formation in exposed pulp is variable.

Advantages and disadvantages

- their bland and obtundent effect on the pulpal tissues
- good sealing ability and resistance to marginal penetration.

Disadvantages

- low strength and abrasion resistance
- solubility and disintegration in oral fluids
- little anticariogenic action.

b) Calcium hydroxide cement

It is used as a pulp-capping material that facilitates the formation of reparative dentin due to its alkaline pH and consequent antibacterial and protein-lyzing effect.

Applications These cements are used as liners in deep cavity preparations.

Equal lengths of the two pastes are mixed to a uniform color

Biologic effects

- These cements appear to exert a strong antibacterial action when free calcium hydroxide is available and to assist in remineralization of carious dentin.
- They facilitate the formation of dentin bridges when used for pulp capping on exposures. Their effect on exposed pulp is superior to that of zinc oxide–eugenol materials.
- These materials can also exert a pulpal protective action by neutralizing and preventing the passage of acid and by acting as a barrier to the penetration of other agents, such as methyl methacrylate.

Advantages

- easy to manipulate
- they rapidly harden in thin layers
- they have good sealing characteristics
- beneficial effects on carious dentin and exposed pulp.

Disadvantages

- they show low strength even when fully set
- exhibit plastic deformation,
- weakened by exposure to moisture,
- will dissolve under acidic conditions and if marginal leakage occurs.

3. Polycarboxylate (Carboxylate)-Based Cements

a) Zinc polycarboxylate cements They are adhesive dental cements that combined the strength properties of the phosphate system with the biologic acceptability of the zinc oxide–eugenol materials.

Applications

- used for the cementation of cast alloy and porcelain restorations and orthodontic bands
- as cavity liners or base materials
- as provisional restorative materials.

Composition:

The powder in these cements is mainly zinc oxide. The liquid is aqueous solution of polyacrylic acid or an acrylic acid copolymer with other organic acids.

The powder and liquid should be stored under cool conditions and kept sealed with a stopper. However, prolonged or cold storage may cause the liquid to gel. To reverse this effect, the gel must be warmed to 50°C.

21fluid as a zinc phosphate mix, resulting in a low powder/liquid ratio and thus poor cement properties.

The working time is 2.5 to 3.5 minutes at room temperature, and the setting time is 6 to 9 minutes at 37°C; the water mix materials tend to give slightly longer setting times. As with other cements, working time can be substantially increased by mixing the material on a cold slab and by refrigerating the powder. The liquid should not be chilled, as this encourages gelation due to hydrogen bonding.

Bonding to clean enamel and dentin surfaces can occur through calcium complexation. In practice, adhesion to dentin may be limited because of debris and contamination. The material also sticks to clean stainless steel, amalgam, chromium-cobalt, and other alloys.

Advantages:

-The main advantages of these materials are the low irritation, adhesion to tooth substance and alloys, easy manipulation, strength, solubility, and film thickness properties comparable with those of zinc phosphate cements.

Disadvantages

- The need for accurate proportioning for optimal properties and thus more critical manipulation
- the lower compressive strength and greater viscoelasticity than zinc phosphate cements
- the short working time of some materials
- the need for clean surfaces for adhesion

b) Glass-Ionomer Cements: It is a translucent, stronger cement that can be used for luting and restorative materials.

Applications

- are used for the cementation of cast-alloy and porcelain restorations and orthodontic bands
- as cavity liners or base materials
- as restorative materials, especially for erosion lesions.

The correct cementing mix is fluid, similar to zinc phosphate. The lining mix is more viscous, depending on the brand.

The restorative mix should have a putty-like consistency and a glossy surface.

Tooth surfaces should be clean and free from saliva but not dehydrated. Restoration surfaces should be free from debris and contamination. The cement hardens slowly and should be protected from loss or gain of moisture when set clinically. Restoration margins or filling surfaces should be protected with a varnish or a light-curing sealant. This is less important with light-cured materials.

Properties For the luting materials Glass-ionomer cements exhibit bonding to enamel, dentin, and alloys in a manner similar to zinc polycarboxylates.

Biologic effects

Antibacterial action has been attributed to low initial pH, leaching, release of silver and other ions, or a combination of these. Light-cured materials have been observed to show greater cytotoxicity.

Advantages

- easy mixing
- high strength and stiffness
- leachable fluoride
- good resistance to acid dissolution
- potentially adhesive characteristics
- translucency.

Disadvantages

- initial slow setting and moisture sensitivity
- variable adhesive characteristics
- radiolucency
- possible pulpal sensitivity.

4. **Dimethacrylate cements** Cements of this type are usually based on the bis-GMA system: They are combinations of an aromatic dimethacrylate with other monomers containing various amounts of ceramic filler. They are basically similar to composite restorative materials.

Applications Dimethacrylate cements are used for bonding crowns (usually porcelain), fixed partial dentures, inlays, veneers, and indirect resin restorations.

Classification is by method of curing:

1. Chemically (or auto-) cured: Paste-paste systems used to cement metal and opaque ceramic core
2. Dual cured: Cements that start curing with light and continue with chemical curing. The chemical cure will polymerize more thoroughly than light curing alone. These products are used to cement translucent restorations (eg, porcelain, indirect resin restorations).
3. Light cured/dual cured: These products are used for both lightcure applications (eg, thin porcelain veneers) and dual-cure applications when dual-cure catalysts are added to the light-cure base.

In the powder/liquid materials:

- the powder is generally a finely divided borosilicate or silica glass together with fine polymer powder and an organic peroxide initiator.
- The liquid is a mixture of bis-GMA and/or other dimethacrylate monomers containing an amine promoter for polymerization.

Some materials contain monomers with potentially adhesive groups, such as phosphate or carboxyl, similar to dentin bonding materials.

The two-paste materials are of similar overall composition but with the monomers and fillers combined into two pastes.

In light-cured and dual-cured materials, light-sensitive polymerization systems such as diketones and amine promoters are present, respectively, in the two cement components in addition to the chemical-initiator systems.

Biologic effects

Some patients experience objectionable odors.

Cases of allergy among dental personnel have occurred, especially where reactive dentin bonding systems have been used.

Skin contact should be avoided.

Pulpal pathology may be due to poor seating, polymerization contraction, and consequent microleakage.

All systems show some microleakage, which may contribute to tooth sensitivity and clinical failure.

Advantages These cements have high strength, low oral solubility, and high micromechanical (and possibly chemical) bonding to prepared enamel, dentin, alloys, and ceramic surfaces.

Disadvantages

- the need for a critical technique
- more difficult sealing
- higher film thickness than traditional cements
- possible leakage and pulpal sensitivity
- difficulty in removal of excess cement.