Casting Alloys, Wrought Alloys, and Solders
• **Alloys** are mixtures of metallic or nonmetallic elements; alloys have better properties for dental restorations than any single element.

• Nearly two-thirds of the table of the elements is composed of metals. Most elements used in dental alloys or solders are metals, but nonmetals also play important roles.

• In dentistry, metals are subdivided into two major groups:

• **1-Noble metals**: are defined by their resistance to corrosion even under extreme conditions that occur in the oral cavity. There are seven noble metals in the table, but only three are common in dental casting alloys: gold (periodic table symbol Au), palladium (Pd), and platinum (Pt).
• **2-base metals:** are metals that are not noble metals. In dental casting alloys, common base metals are titanium (Ti), nickel (Ni), copper (Cu). Base metals are required in alloys to ensure the strength, flexibility, and wear resistance that is necessary for dental restorations.

• However, in pure form, base metals have a greater tendency to corrode in the oral environment than noble metals. For this reason, pure base metals are almost never used for dental restorations.
precious metal content $\geq 60\%$

precious metal content $\geq 25\%$

precious metal content $< 25\%$

gold content $\geq 40\%$

gold content not required

gold content not required

**High Precious Alloys**
- Au - Pt
- Au - Cu - Ag

**Precious Alloys**
- Ag - Au - Cu
- Pd - Cu
- Ag - Pd

**Nonprecious Alloys**
- Co
- Ti
Crystal Structure and Grains of Alloys

• Dental alloys have a crystal structure like ice. When a molten (liquid) alloy freezes after casting, crystals form and grow as the alloy cools. These crystals, or grains as they are called in metallurgy

• Each grain consists of a crystal lattice of metal atoms. The boundaries where individual crystals meet are called grain boundaries.

• The size of the grains is important; a small grain size is generally more desirable in an alloy because it ensures uniform properties of the alloy. Elements called grain refiners often are added to gold-based alloys to reduce the grain size
Important Physical and Mechanical Properties of Alloys

- **Color**: White (silver) to yellow hues — Has little significance other than personal preference; not predictable for cost or performance

- **Melting range (°C)**: Range of temperatures over which alloy goes from solid to liquid
  - Soldering (alloy melting range must be higher than melting range of solder)
  - Application of ceramic (alloy melting range must be higher than ceramic sintering temperature)
  - Ease of casting (higher ranges are more difficult to cast)

- **Density (g/cm³)**: Mass of alloy per volume of alloy
  - Ease of casting (alloys with higher densities are easier to cast)
  - Cost of purchasing alloy (restorations containing alloys with higher densities are more expensive per restoration)
• **Modulus (GPa):** Stiffness or flexibility of the alloy
  — High moduli (stiff) are important for restorations in which flexure causes failure
  — Low moduli (flexible) are important for ortho wires and partial denture clasps, in which flexure is needed
• **Strength (MPa):** Force required to break alloy (usually in tension, by pulling)
  — High strength needed to avoid distortion or fracture of restorations, instruments
• **Hardness:** Resistance to indentation
  — Hardness of restorations to resist scratching (harder is better)
  — Hardness of restoration for cutting or adjustment (softer is easier)
  — Ease of polishing (softer is easier)
  — Wear of opposing teeth (if hardness of restoration is higher than enamel)
Types of Fixed Indirect Restorations

• Fixed restorations cannot be removed from the oral cavity; they are luted (cemented) in place

• Classification by Amount of Tooth Structure Restored
  • A. Inlays: are intra coronal (inside the crown) restorations that replace small to medium amounts of tooth structure,
  • B. Onlays: involve replacing more tooth structure than inlays replace.
  • C. Veneers A veneer is a thin layer of material that covers another material (like the shell of a hard-boiled egg).
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• D. Crowns: are used to restore teeth that have lost a significant amount of tooth structure. when the tooth needs to be surrounded and held together by the restoration.

• E. Dental Bridge: A bridge replaces missing teeth, at each end. The retainers are supported by teeth called abutments. The replacement teeth are called pontics. A bridge may replace one tooth or several teeth
Classification by Material

• **A. Metals** A variety of metals are used to restore teeth. Most metallic indirect restorations are made by a casting procedure. Casting involves melting the metal and then pouring or forcing the liquid metal into a mold.

• **B. Ceramic Materials**: are used when esthetics are important, Ceramic materials can simulate the natural colors and translucency of teeth. Porcelain is the ceramic material most commonly used in dentistry.

• **C. Ceramometals**: The tough, strong metal supports the weak but esthetic ceramic material. The restorations are called ceramometal restorations (or porcelain-bonded-to-metal and are considered to be an important “workhorse” in modern restorative dentistry.
Metal ceramic

Metal gold
CASTING ALLOYS

• High-noble alloys
• Au-Pt (Zn) (gold-platinum-zinc) 
  • -Full-alloy restorations (without ceramic)
  • -Ceramic–alloy restorations ("porcelain fused-to-metal")
• Some alloys contain small amounts of zinc to harden the alloy.
• Alloy has low modulus and tends to corrode.
• Au-Pd (Ag) (gold-palladium-silver)
  • -Full-alloy restorations
  • -Ceramic–alloy restorations Implant substructures
• Alloys may or may not contain silver.
• Most versatile high-noble alloy.
• Low corrosion under diverse oral conditions.
Noble alloys

Au-Ag-C (gold-silver-carbon)

- Full-alloy restorations (without ceramic), Reduced gold alloy.
- Cannot be used for ceramic–alloy restorations.
- Higher corrosion than Au-Cu-Ag high-noble alloy above.

Pd-Cu (palladium-copper)

- Full-alloy restorations (without ceramic)
- Ceramic–alloy restorations
- Higher modulus than Au-based high-noble alloys.
- Corrosion is higher than Au-based alloys.
- High strength; moderate hardness.
- Difficult to cast and manipulate.
• Predominantly base-metal alloys
• Ni-Cr (Be)(nickle-chrom-Beryllium)
• Ceramic–alloy restorations
• Partial denture frameworks
• Alloys contain beryllium.
• Casting, finishing, and ceramic application challenging.
• Among strongest and hardest of the casting alloys.
• High modulus, excellent rigidity for restorations.
• Highest corrosion among all cast
- Co-Cr (chrom-cobalt)
- Ceramic–alloy restorations
- Partial denture frameworks
- Implant substructures
- Casting, finishing, and ceramic application are challenging.
- Strongest and hardest of the casting alloys.
- High modulus, excellent rigidity for restorations.
- Corrosion intermediate between noble and Ni-Cr alloys.
- Allergy to cobalt possible but less common than nickel.
CERAMIC-BONDING CASTING ALLOYS

- Ceramic-bonding alloys are formulated to chemically bond the alloy to ceramic via an oxide layer on the alloy surface. Ceramic-bonding alloys are used to make esthetic dental crowns.

- The most fundamental property of ceramic-bonding alloys is their ability to durably bond to ceramic. The composition and thickness of the metal oxide are crucial to successful long-term bonding of ceramic.

- For many base metal alloys (e.g., Ni-Cr and Co-Cr alloys), an oxide layer forms naturally on the surface of the metal and may even be too thick. The oxide films on these alloys must be reduced in thickness before application of the ceramic.

- However, because of the low reactivity of gold, high-noble and some noble alloys do not form a sufficient oxide layer to ensure reliable ceramic bonding. For these alloys, elements such as iron, indium, or tin must be added in small quantities to form a surface oxide layer.
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• The solidus of ceramic-bonding alloys is critical to the successful fabrication of ceramic–alloy restorations. The ceramic is sintered and fused to the alloy in an oven at temperatures that range from approximately 850° to 1350° C.

• The alloy substructure must remain intact and undistorted during the firing of the ceramic, or the fit and function of the crown will be compromised. Thus, the solidus of ceramic-bonding alloys must be higher than the sintering temperature of the ceramic.

• For this reason, elements with high melting points such as platinum and palladium are often more abundant in ceramic-bonding alloys.

• Alloy and ceramic manufacturers specify which ceramics are compatible with a given alloy.
The thermal expansion of ceramic-bonding alloys is another property critical to ceramic–alloy bonding. Alloys and ceramics expand when heated and contract when cooled. The amount of expansion (or contraction) is called the coefficient of thermal expansion. A high coefficient of thermal expansion indicates more expansion on heating and more contraction on cooling.

When ceramic is heated with the alloy at a high temperature (e.g., about 1000° C), the ceramic interacts with and bonds to the alloy through the oxide layer.

As the ceramic–alloy combination is cooled, the contraction of the two materials together must be compatible or the ceramic will crack while cooling to room temperature.

In practice, the alloy should contract slightly more than the ceramic to reduce the risk of fracture during cooling or during service.
WROUGHT ALLOYS

- A wrought alloy is shaped into its final form by mechanical force of some type. These forces change the properties of the alloy to be more advantageous clinically.

- When an alloy is shaped by rolling, drawing, twisting, or machining the alloy after casting, the alloy is called a wrought alloy.

- Wrought alloys have a grain structure described as fibrous. The fibrous structure is what remains of the original grain structure after the mechanical forces act on the grains of the cast form. Importantly, the fibrous structure is responsible for the increased yield strength and hardness compared with the cast form of the alloys. Thus, the mechanical work improves some properties of the alloy.

- The fibrous structure of wrought alloys reverts to the original grain structure if too much heat is applied to the wrought form. Therefore, heat applied to these alloys during soldering or other manipulation degrades important clinical properties.
USES OF WROUGHT ALLOY

1. Orthodontic wires (Ti, Ni-Ti or stainless steel)

2. Endodontic files (Ni-Ti or stainless steel)

3. Removable partial denture clasps
SOLDERS

• Solders are special alloys used to join other alloys. The alloys to be joined are generally called substrate alloys.
• In dentistry, solders may be used to join an orthodontic wire to a band in the construction of a space maintainer, to join a clasp wire to a partial denture framework, or to join two units of a fixed partial denture together after each is cast separately.
• Solders also may be used to add a proximal contact to a crown or repair an occlusal defect in a casting.
• Brazing operations are done above 425° C. Because all dental applications are done above 425° C, the processes used in dentistry should be called brazing. However, soldering is the term used most commonly.
Property of solders

- Solders have several special properties that enable them to function successfully.

- 1-The solder must melt (have a liquidus) below that of the solidus of the substrate alloy; a 50°C differential is commonly advised.

- 2-Solders must flow freely against the substrate alloy and must wet the substrate alloy well. The property of wetting is the same in principle as impression making or pouring. The ability to flow and wet the substrate alloy ensures a strong bond between the solder and substrate.
Denture base materials

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Definition and Requirements

- **denture base**: the part of a denture that rests on the foundation tissues and to which teeth are attached.
- **denture base material**: any substance of which a denture base may be made.

**Requirements**

1. Biocompatible, Readily cleansable
2. High flexural and impact strength, high modulus of elasticity (higher rigidity)
3. High abrasion resistance, High craze resistance and high creep resistance
4. High thermal conductivity
5. Low density, Low solubility and sorption of oral fluids
6. High softening temperature, dimensionally stable and accurate
7. Superior aesthetic and colour stability, Radiopaque
8. Good adhesion with teeth and denture liners
9. Ease of fabrication, inexpensive, Easily repaired
Classification

Denture base materials

Metallic denture base
1. Chrom-Cobalt
2. Stainless steel, Aluminium
3. Gold, Titanium

Non metallic denture base material

acrylic resin
vinyl resin

Heat cured PMMA
Conventional
High impact
unfilled
reinforced

Injection molded
PMMA
Polycarbonate
nylon
Denture base resin

- **Resins** are compositions of either monomers or macromolecules blended with other components to provide a material with a useful set of properties.
- The particular form and morphology of the macromolecule determine whether it is a fiber, a rigid solid, or an *elastomer* (rubberlike) material.
- Monomer resins are useful in dentistry because they can be shaped and molded and then transformed to a solid to take on a permanent shape when they polymerize.
- Synthetic polymer resins are often called *plastics*, which are substances that, although dimensionally stable in normal use, can be permanently reshaped by irreversible deformation.
- The utility of plastics is derived from their ability to be permanently formed and molded into complex shapes, either by the application of heat and pressure or by a chemical reaction.
Polymerization
Polymerization is a chemical reaction that links a starting compound, a monomer, into long chains of repeating monomer units, a polymer chain. The polymer chains formed by polymerization entangle with one another but in the simplest case are not themselves linked together. These entangled chains form the polymer. Depending on the type of reaction, polymerization may produce by-products that are initially trapped in the polymer. Furthermore, not all monomer reacts, leaving residual monomer trapped in the polymer. Both residual monomer and reaction by-products may have negative clinical consequences because they may leach out of the polymer into the oral cavity over time, potentially affecting oral tissues and changing the clinical properties of the polymer itself.

![Diagram of polymerization process](image)

- **Monomer**
- **Polymer chain**
- **Reaction by-product**
- **Polymer**
- **Residual monomer**
CROSS-LINKING
Several polymers in dentistry use a phenomenon called cross-linking in the polymerization process. In this case, a cross-linking agent is added to the monomer. The cross-linker is a small molecule and is difunctional, meaning that each end of the molecule can be polymerized into a different polymer chain. The net effect is a web of polymer chains that are all linked together. Crosslinking has profound effects on the melting temperature, strength, and flexibility of polymers. In prosthodontics it is used in denture teeth to increase resistance of the teeth to degradation from solvents in foods such as alcohol and to increase the rigidity of the teeth to provide a more solid biting sense for the patient.
COPOLYMERIZATION
The macromolecule may be formed by polymerization of a single type of structural unit. However, in order to improve the physical properties, it is often advantageous to use two or more chemically different monomers as starting materials. The polymers thus formed may contain units of these monomers. Such a polymer is called a copolymer and its process of formation is known as copolymerization.

IMPORTANCE OF COPOLYMERIZATION
Copolymerization is used to
1- improve the physical properties of resins. Many useful resins are manufactured by copolymerization.
2- Small amounts of ethyl acrylate may be copolymerized with methyl methacrylate to alter the flexibility.
3- Block and graft polymers show improved impact strength.
1) Heat-cured acrylic

• **Composition**

  • Poly(methyl methacrylate) (PMMA) is the most common acrylic polymer used in prosthodontics. It is formed by an addition polymerization of methyl methacrylate monomer, initiated by free radicals.

• -PMMA is used for complete and partial dentures

• -The bulk of denture base acrylic is supplied form of a free-running powder and a liquid. Originally the powder was produced by grinding blocks of PMMA.

• -The liquid (monomer) is supplied in tightly sealed amber colored bottles (to prevent premature polymerization by light or ultraviolet radiation on storage).
- Properties of PMMA
  - It has a good tensile strength and a modulus of elasticity.
  - It is also extremely stable: it does not discolor in ultraviolet light and it exhibits remarkable aging properties.
  - It is chemically stable to heat below 125 °C, softens at 125 °C, and can be molded as a thermoplastic material.
  - Overall, PMMA is easy to handle, tough, wear-resistant,
  - able to be pigmented to a lifelike appearance, able to be sterilized, easily cleaned, biologically safe, and very durable.
2) High-impact acrylic

• The impact strength of a polymer predicts its resistance to fracture if placed under high, short-term stress such as during dropping.

• The addition of copolymers of butadiene with styrene rubber fillers to PMMA improves the impact strength significantly. Because these fillers also decrease the modulus of the base.

• Rubber-modified denture bases are only used in patients who have a high risk of dropping the denture or experiencing facial blows or excessive occlusal forces.
• **phase inversion**: rubber begins to precipitate out. The nature of this precipitation is complicated by the fact that some of the growing chains of PMMA may have become grafted to the butadiene rubber, resulting in dispersion throughout the bead of tiny islands of rubber.

• **ADVANTAGE**
  • 1- Improved impact strength
  • 2- Low free-monomer Content
  • 3- Good adhesion with teeth and liners
  • 4- the inclusion of rubber does have a craze-inhibiting effect

• **DISADVANTAGE**
  • 1- expensive
  • 2- Reduced stiffness
3) Injection-molded plastic

The plastics still offered for use as injection-molded denture base acrylic are polycarbonate and nylon. They offer a real alternative to metal dentures for patients sensitized to conventional methacrylate or to nickel or cobalt.

**Polycarbonate.** This tough plastic is supplied as granules but is not suited to injection into damp molds. It has a high melt viscosity and may depolymerize explosively if overheated in the presence of water. Again, absence of cross-linking results in poor solvent resistance and craze resistance. The high melt viscosity exacerbates problems of tooth attachment.

**Nylon or polyamides.** The first dental use of nylon was not a success because of the excessive water absorption of the type chosen, which resulted in excessive creep and some biodegradation. More recent work on glass-reinforced nyongs with much lower water absorptions (eg, nylon 66) has produced more encouraging results. The glass fibers increase the stiffness of the nylon to about that of a conventional heat-cured denture base from a stiffness of half that when only glass-bead reinforcement is used. Glassfiber reinforcement should be used with care, and patients should be warned not to abrade the fitting surface so as to avoid exposing irritation-causing fibers.
• ADVANTAGE
  • 1- Dimensional accuracy
  • 2- Low free-monomer content
  • 3- Good impact strength

• DISADVANTAGE
  • 1- High capital costs
  • 2- Difficult mold design problems
  • 3- Less craze resistance
  • 4- Less creep resistance
4) Rapid heat polymerized polymer

• Same as conventional heat cured acrylic material except that they contain altered initiation system
• These initiators allow them to be processed in boiling water for 20 min
• The problem with these is that areas of the denture base thicker than 6mm have high risk of porosity
• Short duration of heat also leaves high level of residual monomer 3-5 times greater than conventional heat cured acrylic
5) Light-activated materials

- It is supplied in premixed sheet or rope form. A baseplate is made by adapting the material to a cast and polymerizing in a light chamber at 400 to 500 nm.
- Teeth are added to the base with additional material followed by a second light exposure.
- The system eliminates the need for flasks, wax, boil-out tanks, packing presses, and heat-processing units required for the construction of conventional dentures.
- The manufacturer claims a significant time savings in both the dental office and the laboratory.
• ADVANTAGE
  1- No methacrylate monomer
  2- Decreased polymerization shrinkage
  3- Possible improved fit compared to conventional material
  4- Requires little equipment
  5- Time savings
• DISADVANTAGE
  • Decreased elastic modulus
6) Fiber Reinforced Resins

- Poor impact strength and poor fatigue resistance is primary issue with PMMA.
- Mostly dentures break are due to a combination of fatigue and impact.
- Fiber reinforcement leads to an improvement in strength.
- In the weak area of denture, fibers are placed [Figure 3]
- 1- Reinforcements are placed 90 degrees to the fracture [Figure 4]
- 2- Unidirectional fibers are stronger [Figure 5]
- 3- Mesh is to be placed on the exterior of resin surface
- Metal Fiber Strengthened, Carbon Fiber Reinforced, Polyethylene Fortitude Armor-plated, Glass Fibers have been used as fiber reinforcing agent
Fiber placed in weakest area

Fiber at 90° to fracture

Unidirectional fibers are stronger

Mesh placed on exterior of prosthesis
7) Valplast

- Thermoplastic materials for dental prostheses, Valplast (Valplast Int. Corp.-USA) and Flexiplast (Bredent - Germany), were first introduced to dentistry in the 1950s.

- **Objective:** Both materials were similar grades of polyamides (nylon plastics) to create a type of partial denture that was able to address the fundamental requirements of retention, support and stability, at the same time it provides beautiful aesthetics that was far superior to their metal counterparts.

- Thermoplastic resins are used for a broad variety of applications:
  - 1- removable flexible partial dentures, preformed partial denture clasps,
  - 2- fiber reinforced fixed partial dentures, provisional crowns and bridges
  - 3- obturators and speech therapy appliances,
  - 4- orthodontic retainers and brackets,
  - 5- impression tray and border molding materials
  - 6- occlusal splints, sleep apnea appliances
• ADVANTAGE
  • 1- More acceptable esthetics, since there are no metal clasps.
  • 2- The material has good flexibility like Titanium. Therefore, even if there is a little bit of bending, it comes back to the original shape and position.
  • 3- Even if there is slight shifting of the remaining teeth over time, the flexibility of the denture material, allows the use of prosthesis with little adjustment.
  • 4- The denture can be heated up in hot water for about a minute and can easily be adjusted and inserted in the undercut area.
• DISADVANTAGE
  • 1- Being a plastic material, it cannot be made into thin sections like metal. It is likely to break if cut thin sections.
  • 2- It does not conduct heat and cold like metal. Therefore, the patient may not enjoy certain food like hot soup or ice cream.
  • 3- Requires more chair-side time for adjustment.
  • 4- Requires special instruments (knives and polishing kit) to make the adjustment.
  • 5- A Flexible denture is very hard to repair if fractured. No additions can be made onto it
Removable Prostheses and Acrylic Resins
A. What Is an Acrylic Resin?

- Acrylic resins are hard, brittle, glassy polymers.

- Acrylic resin is clear and colorless, Acrylic resins are easily colored.

- In dentistry, however, acrylic resins are handled more like a thermoset material; after it sets, it is not heated and molded.

- The most common acrylic monomer is methyl methacrylate, Note the CC bond in this illustration. Acrylic resins are long chains of such monomers.
Acrylic Resins as Biomaterials

- Uses of acrylic resin in dentistry
  - 1- temporary crowns
  - 2- custom trays and
  - 3- baseplates for denture construction
A. Cold-Cure or Chemically Activated Acrylic Resins are supplied as a powder and a liquid. These are the same materials used for the “brush-bead” buildup technique for artificial nails.

1. Liquid: The liquid is mostly monomer, methyl methacrylate. A cross-linking agent, such as glycol dimethacrylate, is added.

Methyl methacrylate is a powerful solvent. It can dissolve permanent marker (used for labeling things) and even some polymers. The ability of methyl methacrylate to dissolve acrylic resin, polymethyl methacrylate resin, is an important property that has a significant effect on the handling properties of acrylic resin systems.

2. Powder: The powder is predominantly polymethyl methacrylate resin with added colorants and benzoyl peroxide. When activated, benzoyl peroxide forms free radicals to initiate polymerization.
B. Heat-Activated Acrylic Resins داخلاً

• Heat-activated acrylic resin systems are very similar to chemically activated systems. The major exception is that no chemical activator is present in the liquid.

• Heat-activated systems are supplied as powder/liquid systems similar to those of cold-cure resins.

• When the powder and liquid are mixed, they go through the same initial stages of the setting process. Because no chemical activator is present, the mixed material stays in the dough stage for an extended period of time.

• Material is heated in a water bath. The heat breaks down the benzoyl peroxide, forming free radicals.

• Products that are properly heat-cured are a bit stronger and tougher than cold-cure acrylic resins.
c. light-activated and dual-cure acrylic resins systems,

• light activated and dual-cure composite materials for temporary crowns, custom trays, and other uses have been introduced. Because these composite materials are stronger, they are gaining acceptance. As prices decrease, they may completely replace acrylic resins for some uses.
Physical Changes During Setting

• When the powder and liquid of an acrylic resin system are mixed, several stages in the setting process occur.

• During the initial stages,

• sandy stage: The mixed powder and liquid have a “grainy” feel. The powder and liquid are separate phases. As some powder dissolves, the mixed material becomes thicker and less “runny.” As more powder is dissolved,

• dough stage: At this point, the material is easy to handle and mold, and up to this point, the changes are mainly physical.

• Polymerization Reaction: typically during the dough stage, chemical changes occur, and the polymerization reaction proceeds.

• The doughy material thickens and becomes stiffer.

• The reaction generates heat (exothermic reaction), and the material becomes warm. The material becomes rigid and solid as polymerization reaches completion.
Complete Dentures
• A complete denture or full denture replaces an entire arch of missing teeth. A complete denture also replaces alveolar bone, which is resorbed when teeth are missing. Dentures are made with acrylic materials that are colored to simulate the missing tissues.
A. Components of a Denture

• A complete denture has two major components: the white denture teeth and the pink denture base. Denture teeth

• B. Denture Teeth Denture teeth come in a variety of shapes, sizes, and shades. The shape is chosen to match that of the patient’s natural teeth, usually as judged from an old photograph. Another technique is to use the shape of the face to select the tooth shape.

• The size is determined by the size of the patient’s arch.

• The shade of the teeth is chosen to match the patient’s natural complexion.
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1. Acrylic Resin Teeth: Today, most denture teeth are made from acrylic resin much like that used to construct the denture base. They are stronger than the acrylic material used for the denture base. Acrylic denture teeth are “chemically” bonded to the acrylic denture base during processing of the denture.

2. Porcelain Teeth are made by manufacturers in much the same shapes, sizes, and shades as acrylic teeth. Porcelain teeth are much harder and more stain resistant compared to acrylic teeth.

Porcelain teeth are rarely used, however, both because they excessively wear the opposing teeth and because it is generally believed they cause trauma and bone loss in the supporting and opposing alveolar ridges.

Porcelain teeth are held in the denture by the mechanical undercuts of pins that are embedded in the back of the denture tooth.
FIGURE 11.5 Photograph of a porcelain (left) and an acrylic (right) denture tooth. Note the pin protruding from the back of the porcelain tooth. The pin serves to anchor the tooth firmly in the denture base.
C. Denture Base The denture base is constructed on the master cast made from the final impression. The denture base is the pink part of the denture that sits on the alveolar ridge.
Dental Implants
• Dental implants (also known as oral or endosseous implants) have been used to replace missing teeth

• They are considered to be an important contribution to dentistry as they have revolutionized the way by which missing teeth are replaced with a high success rate. This success depends on the

• ability of the implant material to integrate with the surrounding tissue. However, this integration is influenced by several factors, such as

• 1- implant material,

• 2- bone quality and quantity, and

• 3- the implant loading condition
Dental implant types

• The one-piece implant

• In the first type, the implant and the abutment are formed as a single solid unit. In this case, there is no screw-joint between the implant and the abutment.

• The lack of a screw-joint is considered an advantage as there is no screw-loosening, dangerous fracturing or micro-motions between the abutment and the implant.

• The one-piece implants may be used when narrow implants are indicated, such as in the replacement of the maxillary lateral incisors and lower incisors, or

• when bone volume is limited and the use of standard implants is not suitable.
• **The two-piece implant**
  • consists of an implant to which an abutment or a restoration/attachment is connected, usually with a screw. It is more commonly used than the one-piece implant type.
  • With this implant type, both the one- and the two-stage implant surgery protocol can be implemented.
  • Angled implants in which their coronal part is angled in relation to the main implant body are also available.
  • These angled implants are useful in the anterior region when placing non-angled implants in their optimum position is not possible. In which the neck is at an angle to the long axis of the implant body.
  • angled abutment (Straumann) is also available and can be used to overcome angle mismatching problems.
  • Implants are also available as hollow and solid. Hollow implants allow more contact with bone but are weaker
  • than solid implants, which makes them more susceptible to mechanical failure and fracture.
A schematic presentation of an implant placed according to the one-stage (left) and twostage (right) implant placement methods. Note the transmucosal part (the neck) penetrating the peri implant mucosa in the one-stage method.
Components of implant

1-Fixture of implant: an implant provides the anchor or foundation for a restoration. It is screwed into the bone of the jaw providing a fixed platform on which an abutment can be screwed. Bone tissue can grow around the implant regenerating and strengthening the jaw reducing the bone loss which occurs when natural teeth are lost. It is made from titanium for biocompatibility with the body (fig 1).

2-Abutment: an abutment provides support for the crown. It is also the interface between the crown and the implant. Rotation (twist) is controlled by lugs shaped on the abutments stem. (fig 1).

3-Crown: crowns are the top part of a restoration and are the part that we see in the mouth. They replicate the original teeth to provide a biting surface and aesthetic appearance. (fig 1). The completed crown is either cemented or screwed onto an abutment. It is made from Porcelains (metal supported or metal free) or metal (normally gold)
Figure: 1 Components of restored implant. A, Implant crown. B, Abutment. C, Implant fixture
Implant materials

Dental implant materials

- Ceramic
  - Bioactive ceramic
    - Bioactive glasses
  - Inert ceramic
    - Calcium phosphate
    - Zirconia
    - Carbon
    - Alumina
  - Cobalt chromium
  - Titanium

- Metal
• The most commonly used materials in dental implants are either bioinert, such as commercially pure titanium (Cp Titanium) and titanium alloy
• bio-active ceramics such as hydroxyapatite, tri- and tetra-calcium phosphate and bio-glass.

**Metallic implant**
• Metallic implant undergo several surface modification to become suitable for implantation
• Titanium most commonly used implant materials it consider the gold standard
Titanium was the most commonly used material in dental implants due to its properties:

- Modulus of elasticity closer to that of bone
- Low weight
- High heat resistance
- Ensure uniform distribution of stress along bone implant interface

Advantages:
- Biocompatibility
- High strength
- Resistance to corrosion

Disadvantages:
- High cost
- Difficult equipment
Zirconia vs Titanium

The implant body and the abutment are connected.
**Cobalt-Chromium molybdenum alloy**

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<thead>
<tr>
<th>Properties</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- high strength</td>
<td>1- good biocompatibility</td>
<td>Poor ductility</td>
</tr>
<tr>
<td>2- resistance to corrosion</td>
<td>2- easy of fabrication and low cost</td>
<td></td>
</tr>
</tbody>
</table>

Ceramic implant

• To speed up the healing process and osseointegration, implant surfaces are coated with ceramics.

• The ceramics may be bio-active, such as calcium phosphates, or inert, such as aluminium oxide and zirconium oxide. Examples of calcium phosphate coating materials are hydroxyapatite and fluorapatite.

• The bio-active ceramics are reported to act as osseoinductive materials which encourage and accelerate bone apposition around the implants.

• Furthermore, coatings that have similar properties to that of the extra-cellular matrix provide a favourable environment for osteoblasts, osteoclasts and their progenitor cells, that are responsible for the healing of bone. Therefore, an early and strong implant stability is achieved and the risk of implant failure is reduced.
Ceramics are initially used in the additive methods in which ceramic coatings are added to the metal implant. However, high bond strength between the coating material and the substrate is required to withstand functional stresses and to avoid fragmentation of the coating materials.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- high compressive strength</td>
<td>1- excellent biocompatibility</td>
<td>1- low shear and tensile resistance under fatigue load</td>
</tr>
<tr>
<td>2- low resistance to shear and tensile stress</td>
<td>2- minimal thermal and electrical conductivity</td>
<td>2- variation in structural characteristics</td>
</tr>
<tr>
<td>High modulus of elasticity</td>
<td>3- color match to bone</td>
<td>3- low attachment strength for some coatings</td>
</tr>
<tr>
<td>4- brittle</td>
<td>4- chemically similar to constituent of natural biological tissue</td>
<td></td>
</tr>
</tbody>
</table>
• With improvement in technology, ceramic materials are extended for use as implant substrates.

• This is because ceramics such as zirconia polycrystalline have improved mechanical properties, superior wear and corrosion resistance, with a high flexural strength. These characteristics may make them a potential alternative to conventional titanium implants for supporting overdentures.

• These nonmetallic materials are expected to replace Cp titanium and its alloys.

• In particular, zirconia implants are not yet suitable as an alternative to titanium implants. Nevertheless, they potentially could be a successful material for use in implants.
Zirconia Implant Components:

Two-Piece Implant

- Two Pieces Joined With Cement
- Abutment

One-Piece Implant

- One Solid Piece
- Implant Body
• **Polymers**

  • First used in 1930, During that time the polymers that were used are Polymethyl methacrylate (PMMA) and Polytetrafluoroethylene (PTFE).
  
  • As compared with the other biomaterials, the polymeric implants possess
  
  • 1- low mechanical strength, susceptible to fracture
  
  • 2- their sterilization only is accomplished by gamma radiation
  
  • 3- physical properties influenced by change in temperature, environment and composition
  
  • Recently, a new addition to polymers being used for the dental implant fabrication is polyether ether ketone (PEEK).
  
  • The main benefit of this material (PEEK) over other materials like titanium and zirconium is its
  
  • 1- elastic modulus, which is closer to bone.
  
  • 2- being reinforced with carbon fiber so as to achieve a modulus of elasticity of 17.4 Gpa, which is close to cortical bone.
  
  • 3- this material possesses better aesthetic properties and it is suitable in patients who are allergic to titanium
GUIDELINES FOR SELECTING IMPLANT BIOMATERIAL

• The ADA has given some guidelines for selection of implants biomaterials:
  • 1- Evaluation of physical properties that ensure sufficient strength
  • 2- It should be easy to fabricate and capable of being sterilized without getting degraded.
  • 3- Evaluation of safety and biocompatibility, including cytotoxicity testing & tissue interference characteristics.
  • 4- Freedom from defects. (At least two independent longitudinal clinical studies presenting its efficacy)
Waxes

م.م اريج مفيد
Dental waxes

- Dental waxes are composed of a mixture of components from natural and synthetic sources.

- **Natural waxes** are produced from plants, used in carnauba wax;

- **insects**, used in beeswax; and

- **minerals**, used in paraffin wax.

- These natural waxes contribute properties to the wax but are rarely used in their pure form.

- They are combined or mixed with synthetic waxes, gums, fats, oils, resins, and coloring agents.
• Each component is added to attain the physical properties desirable for the wax application. Use of the wax will determine properties that are desirable for its application.

• Properties that contribute to the melting range, flow, thermal expansion, and excess residue are important considerations for dental wax. The operator must regard these properties when making a wax selection, as well as during manipulation of the wax.
• **The primary use** of waxes in dentistry is to make a pattern of appliances prior to casting as many dental restorations are made by **lost-wax technique**, in which a pattern is made in wax and put in the mold (investment materials). After setting, the wax is burnt out and the space is filled with molten metal or plastic acrylic.

• **Chemically** waxes are polymers consisting of hydrocarbon and their derivatives like ester and alcohol. Dental waxes are mixture of natural and synthetic waxes gums, fat, oils, natural and synthetic resins and coloring agents.
Requirements of dental waxes

• 1. Must conform to the exact size and shape and contour of the appliance which is to be made.
• 2. Should have enough flow when melted to reproduce the fine details.
• 3. No dimensional changes should take place once it is formed.
• 4. Boiling out of the wax without any residue.
• 5. Easily carved and smooth surface can be produce.
Classification of waxes

• According to origin:

1. Mineral:
   • a. Paraffin: Refined from crude oil, has relatively low melting point (50-70°C) and relatively brittle.
   • b. Ceresin: Refined from petroleum, has medium melting range (60°C).

2. Plants:
   • a. Carnauba: Obtained from palm trees, it is hard, tough, and has high melting point (80-85°C).
   • b. Candelilla: It is hard, tough, and has high melting point (80-85°C), used to increase the melting point and reduce flow at mouth temperature.
Carnauba

Candelilla Wax

Paraffin
• 3. Animal:
  • a. Stearin: Obtained from beef fat, has low melting point
    • (50 °C).
  • b. Bees: Obtained from honey-comb, consist of partially crystalline
    natural polyester. It is brittle, has medium melting temperature (60-
    70°C).

• 4- Synthetic:
  • They are used to modify some properties of natural waxes like
    polyethylene.
Classification According to use
PATTERN WAXES

- **Inlay Wax**
- Inlay waxes generally are used to fabricate wax patterns for crowns, inlays, or bridges.
- These waxes generally are available in round sticks of several colors such as red, yellow, blue, and green.
- They are also available in various hardnesses for different casting applications.
- The hardness is controlled by adjustment of the components.
- The composition of inlay wax is complex, and it may contain five or six different waxes, such as paraffin, carnauba, ceresin, and beeswax.
- Paraffin and ceresin are mineral waxes, carnauba is a plant wax, and beeswax is an insect wax.
• **Casting Wax**

• These waxes are used to form the wax pattern of the metallic framework of removable partial dentures

• They are available in sheets and in ready-made shapes, which are convenient for making the wax pattern of the partial denture.

• Many casting waxes possess a slight tackiness to help hold them in position on the gypsum cast before investing and casting.
PROCESSING WAXES

• Boxing and Utility Waxes.

• Boxing and utility waxes are soft, pliable waxes used primarily in taking and pouring impressions.

• The waxes are usually dark in color and have a slight tackiness, which allows them to be attached to each other or to stone models or impression trays. Their soft nature allows them to be adapted to impression materials that are easily distorted, such as alginate.

• Boxing wax is supplied as long (40 cm) strips. These strips are molded around an unpoured impression to help contain the stone when it is vibrated into the impression.

• Additionally, they are used around the periphery of an impression tray to reduce irritation of the tray on the soft tissues or to extend the tray before the impression is taken.
Boxing wax

Baseplate Wax

Utility Waxes
• **Baseplate Wax**

• Baseplates (or record bases) are used to build the contours of a denture and hold the position of the denture teeth before the denture is processed in acrylic.

• Baseplate wax is pink or red, which provides some esthetic quality during the construction of a denture.

• Three common hardnesses of baseplate wax are available.

• Type I wax is soft at room temperature and is used for contouring dentures.

• Type II is a medium wax to be used for patterns that will be placed into the mouth in a temperate climate.

• Type III waxes are hardest and are for mouth use in tropical climates. The flow qualities as a function of temperature of Type III wax are similar to inlay wax. As with all waxes, residual stress can easily be incorporated and, if released, will move teeth and change the occlusion of the denture.
• Sticky Wax

• Sticky wax is actually a somewhat misleading name for this wax because it is hard and brittle at room temperature. However,

• when heated, it is sticky and will adhere tenaciously to dry stone or other dental materials.

• It is used commonly to

• 1-assemble metallic or resin pieces temporarily in position or

• 2-to seal a plaster splint to a stone cast in the process of forming porcelain facings.

• Because it is brittle at room temperature, sticky wax will break rather than become distorted if the assembled pieces move.
• **Bite-Registration Wax**

• Bite-registration wax is used for accurate articulation of certain models of opposing arches.

• The flow of these waxes at 37.5° C is from 2.5% to 22%, which indicates that, these waxes are susceptible to distortion on removal from the mouth.

• To a large extent, addition silicone and polyether materials have replaced waxes for bite registration.
IMPORTANT PROPERTIES OF WAXES

• Melting Range
  • Because waxes are mixtures of different components, they do not melt at a single temperature and do not have a melting point. Rather, they have a melting range.
  • At the low end of the range, some but not all of the components melt, which causes the wax, still solid, to flow much more.
  • As the temperature increases through the melting range, more of the components melt and the wax flows severely, and eventually all components become a liquid.

• Excess Residue
  • Because wax patterns used in the lost-wax technique are melted or burned to remove them from the casting mold, the wax must not leave a residue, which would affect the quality of the final restoration.
• Flow

• Flow is the change in shape under an applied force. It is caused by the slippage of the long-chained wax molecules over each other.

• Flow is highly dependent on temperature and time. At low temperatures, waxes hardly flow at all, but as the temperature approaches the melting range of the wax, the flow increases dramatically.

• For pattern waxes, flow is generally not desirable at room or mouth temperature, because it results in a permanent distortion of the wax pattern.

• For processing waxes, flow is a highly desirable property because these waxes need to be pliable at room temperature.
Flow of wax. Flow is a function of time and temperature. If a small weight, W, is placed on top of a cylindrical wax sample (shaded area), no change in height occurs if the wax is at a low temperature relative to its flow temperature (top row). As the temperature approaches the flow temperature, some change in dimension occurs over time, medium temperature (second row). At the flow temperature, large changes in dimension occur, flow temperature (bottom row).
• Thermal Expansion

• When waxes are heated, they expand significantly. This expansion can be quantified as a percentage of the original dimension of the specimen. It usually is reported as parts per million of expansion per Celsius degree of the rise in temperature of the specimen.

• This number is called the “coefficient of thermal expansion of the wax,” and the higher this coefficient is, the greater the expansion as the wax is heated. In general, waxes have the highest coefficients of thermal expansion of any dental material.

• the thermal expansion is critical. Small changes in temperature can cause a sufficient change in dimension to make the pattern inaccurate.
Thermal expansion of wax.
• Residual Stress

Residual stress is stress remaining in a wax as a result of manipulation during heating, cooling, bending, carving, or other manipulation.

Manipulation of wax puts molecules of the wax into positions that they do not like but cannot change because of their solid state. These stresses that are present in wax generally are released as the temperature of the wax increases, and the wax molecules can move more freely.

To prevent residual stresses from forming, waxes should not be carved or burnished at temperatures well below their melting range. Wax patterns are carved with warm (37°C) instruments, and melted wax is added in small increments to prevent rapid or uneven cooling, which promotes residual stress.

To prevent the release of stress already created,

1-wax patterns should not be subjected to temperature changes or should not be stored at high temperatures.

2-The time between finishing and investing the pattern should be minimized (less than 30 minutes) because longer storage times allow time for stresses to be released.
CERAMICS IN DENTISTRY
The terms ceramic and porcelain are often used interchangeably, but incorrectly.

Ceramic refers to any material composed of the arrays of metallic oxygen bonds described previously.

Porcelain, on the other hand, is a type of ceramic that results when feldspar ($K_2O$-$Al_2O_3$-$SiO_2$), silica ($SiO_2$), and alumina ($Al_2O_3$) are fired together with fluxes such as sodium carbonate ($Na_2CO_3$) or potassium carbonate ($K_2CO_3$). During the firing, large areas of amorphous ceramic are formed, with small islands of a crystalline phase called leucite ($K[AlSi_2O_6]$).

Porcelains are often referred to as feldspathic ceramics and they are the most esthetic but weakest of the ceramics.
Types and Uses of Ceramics in Dentistry Today

• Dental ceramics may be roughly classified into four types:
• 1-traditional feldspathic (or glassy),
• 2-glass dominated,
• 3-crystalline dominated, and
• 4-crystalline
• all are a consequence of the ratio of amorphous to crystalline phases and how the phases interact with one another.
• داخل

• *Feldspathic or glassy ceramics* are porcelains that are composed primarily of an amorphous phase (often called a matrix) with embedded leucite crystals (see Figures 14-3 and 14-4). Leucite makes the porcelain more opaque, stronger, and higher fusing and creates expansion upon heating.

• These ceramics remain among the most esthetic of the dental ceramics and are primarily used as veneers over alloys or ceramic substructures that impart strength to the restoration and support the weaker veneer. Feldspathic ceramics also are used for veneers that are bonded directly to tooth structure, particularly in the upper anterior region.
Glass-dominated ceramics contain increased amounts of crystalline phase relative to the glassy ceramics; crystals may be leucite or fluoroapatite (see Figures 14-3 and 14-4). The increased crystalline phase gives the ceramic higher strength but sufficient translucency to serve in esthetic applications. The increased strength allows these ceramics to occasionally be used for anterior all-ceramic crowns that are not under excessive occlusal force.

Crystalline-dominated ceramics are composed, as their name implies, mostly (about 70 vol %) of a crystalline phase (see Figure 14-3). The spaces between the crystals are occupied by an amorphous silica glass, and the two phases synergize to increase the strength of the ceramics substantially.

Crystalline dominated ceramics are much more opaque and therefore are far less suitable in esthetic roles such as veneers or veneers on alloys.

Crystalline dominated ceramics often serve as cores for anterior or posterior all-ceramic crowns, onto which veneering porcelain (either glassy or glass-dominated) is added.
• **The crystalline ceramics** are the newest and strongest of the ceramics used in dentistry. These ceramics are formed from either alumina or zirconia that has been seeded, or “doped,” with other ions such as magnesium or yttrium to optimize them for use in dental applications.

• Crystalline ceramics have no glassy phase and are opaque. They cannot serve as esthetic veneers on alloys or teeth. However, as high-strength cores, they are plausible for use in nearly any other dental restoration, including posterior crowns and bridges. If esthetic considerations are not paramount,
FIG 14-3 Ceramics in dentistry can be roughly divided into four categories. Feldspathic or glassy ceramics (upper left) are the oldest ceramic in dentistry. They consist of mostly amorphous glass with islands of a crystalline phase, often leucite. Glass-dominated ceramics (upper right) have mostly a glassy phase but have an increased abundance of crystalline phase that may be leucite or other compounds. Crystalline-dominated ceramics (lower left) have mostly a crystalline phase, which may be composed of several types of crystals but have a glassy phase that surrounds the crystals. Finally, crystalline ceramics (lower right) have no glassy phase; these ceramics are the newest and strongest of the ceramics used in dentistry.
• **Physical Properties:** As a group, ceramics exhibit extremely high compressive strengths and moduli but relatively low tensile strengths and elongation. Thus, from a clinical perspective ceramics are inherently stiff, brittle materials relative to alloys or polymers; their brittleness has limited their use in restorative dentistry over the years.

• The hardness of most glassy or glass-dominated ceramics is substantially higher than human enamel and when ceramics occlude against natural teeth, the enamel may wear preferentially. Because of this fact, a denture opposing natural teeth generally will be constructed with polymer rather than porcelain teeth. Ceramic-induced wear of opposing enamel may be a problem for fixed prosthetic appliances as well.
Thermal Properties

• The coefficient of thermal expansion (CTE) is the degree of expansion or contraction of a material in response to heating or cooling, respectively.

• A ceramic with a high coefficient of thermal expansion expands a large amount when heated and contracts a large amount when cooled. The coefficient of thermal expansion is important when a ceramic is bonded to an alloy (ceramic–alloy restoration) or ceramic core (all-ceramic restoration).

• The expansion of the alloy or core and veneering ceramic must be appropriately matched, or the ceramic will fracture when the restoration cools from firing temperature to room temperature.
Optical Properties

- When evaluating the optical properties of ceramics, the differences between reflectance, translucency, opacity, and transparency are important. When incident light meets the surface of a ceramic, some of the light is reflected from the surface, the amount depending on the structure of the ceramic and the degree of surface roughness.

- The remaining light penetrates the ceramic. If the light’s path is unaltered as it passes through the material, the ceramic is transparent.

- Translucency occurs when the incident light penetrates the surface, but some is transmitted through and some is reflected back out of the material.

- The color of ceramics obviously is important to the esthetic success of a restoration clinically. Color results when a material reflects light from within, but the wavelength (or color) of the reflected light is changed. The material absorbs some of the light.
Biologic Properties

- The biologic response to ceramics is often assumed to be acceptable; ceramics are often reported in the literature or advertising to be inert, biocompatible materials. This assumption stems from the long and positive clinical experience with glassy ceramics, which generally have minimal adverse effects on biologic tissues
CLINICAL USES OF DENTAL CERAMICS

• Ceramic–Alloy Restorations: consist of several layers of ceramic bonded to an alloy substructure. The alloy substructure is generally less than 0.5 mm thick in areas that will be covered by the ceramic and is nearly always cast.

• Ceramic–alloy restorations have sufficient strength to be used in restorations for posterior teeth and long-span bridges.

• If done properly, ceramic–alloy restorations provide excellent esthetics. However, achieving a good esthetic result depends on careful attention to every detail at every step of the process,
• Ceramic–Alloy Bonding: The ceramic–alloy bond is of fundamental importance to the success of ceramic–alloy restorations because the stresses induced in the ceramic by oral forces can be shared and supported by the alloy.

• Any debonding of the ceramic from the alloy after the restoration has been permanently cemented can cause esthetic or functional failure of the restoration. Repair often requires complete replacement.

• The bonding of ceramic to alloy occurs through an oxide on the alloy surface. Alloys for ceramic–alloy restorations are nearly always specially formulated so that an oxide will form. When ceramic is fired onto the alloy surface, a chemical reaction between the oxide layer of the alloy and the ceramic occurs, which creates the ceramic–alloy bond.

• Achieving a good bond demands meticulous efforts to limit contamination of the alloy and ceramic and strict adherence to protocols for manipulating the ceramic.
Fabrication of Ceramic–Alloy Restorations

• The alloy thickness is generally less than 0.5 mm to maximize the space available for the ceramic, which promotes more esthetic optical properties of the ceramic.

• The substructure is then “degassed” in a ceramic. Degassing removes impurities from the alloy surface and promotes the formation of an oxide layer on the alloy.

• An opaquing ceramic is applied to hide the color of the alloy substructure. The opaque ceramic is condensed and sintered onto the alloy, the opaque layer forms a bond with the alloy and blocks the alloy color from being transmitted through the ceramic.

• Different types of alloys have different oxide shades that may be harder or easier to mask; for example, nickel- and cobalt-based alloys have dark gray oxides that require thicker opaque layers to mask.
Fabrication of ceramic–alloy restorations by stacking. Castings (A) are contoured and fired (degassed) to prepare surfaces for application of the ceramic. Opaquing ceramic is applied to mask the gray color of the metal oxide on the metal substructures (B). The dentinal ceramic is applied first (C), followed by the enamel ceramic to full contour (D). Once the ceramic is “stacked” to full contour, it is fired in the ceramic oven for 10 to 12 minutes (E). Additional ceramic may be added at this point, or stains and glaze may be applied to finish the restoration.
• After opaquing, the gingival and incisal ceramics are applied over the opaque layer
• The gingival ceramic is applied first to the gingival half of the crown. It is yellower and less translucent than the incisal ceramic and mimics the dentin of the tooth.
• The incisal ceramic is added primarily to the incisal third of the crowns. Its higher translucency mimics natural tooth structure well.
• Finally, a glaze layer, which is a thin, nearly transparent, low-fusing ceramic, is applied. The glaze seals the ceramic surface and provides a high luster to the surface
All-Ceramic Restorations

• The principal advantage of any all-ceramic restoration is the potential for better esthetics. Because all-ceramic restorations do not use an alloy substructure, all of the thickness of the restoration is ceramic, which allows the laboratory technician to create a more lifelike esthetic result. Furthermore, all-ceramic restorations have no alloy oxide color to mask.

• Today’s all-ceramic crowns take advantage of fabrication technologies that have improved ceramic strength and are reliable in anterior applications. All-ceramics also are used for posterior crowns, and some practitioners have extended the use of these materials to fixed partial dentures of three units or more.
Many all-ceramic restorations use a high-strength ceramic core covered with a veneering ceramic. For this type of restoration, the high-strength core replaces the alloy substructure in its role to support and strengthen the veneering layers.

The core ceramics have not been traditionally used for the entire restoration because they are opaque (because of their high crystalline). The esthetic nature of these all ceramic restorations has traditionally been created using a glassy or glass-dominated veneering ceramic. Veneering layers are commonly custom-stacked onto the core in a manner similar to that used for ceramic–alloy restorations.

These restorations are strong, may require less tooth reduction than ceramic–alloy or layered all-ceramic restorations, and are opaque enough to mask tooth defects.

They also take advantage of CAD-CAM fabrication techniques with a digital impression.

However, these restorations lack high esthetic qualities. Moreover, the high hardness of zirconia relative to tooth structure increases the risk of inappropriate wear of opposing teeth or restorations, particularly if the ceramic surface is not smooth enough.
The decision to use an all-ceramic or a ceramic–alloy restoration is complex, particularly for posterior restorations and especially for posterior bridges. Although all-ceramic restorations have improved tremendously in strength since the days of porcelain-jacket crowns, they are still relatively brittle materials that will fracture in service more often than ceramic–alloy restorations.

In some cases, layered all-ceramic restorations require the removal of more tooth structure to maximize the thickness of the restoration (and reduce fracture risk), which increases the risk of tooth pulpal pathology in some individuals. This requirement for greater thickness has become less important as the core ceramics have become stronger.

However, a well-constructed ceramic–alloy restoration may be just as esthetic in many clinical situations, without the complications, costs, and clinical risks of the all-ceramic material.
bonding of veneering ceramics to core ceramics. Because ceramics are all fundamentally similar in atomic structure many initially assumed that bonding ceramic veneer to ceramic core bonding would not be a major clinical concern. Clinically, debonding of veneering ceramics from core ceramics has emerged as a significant clinical problem.

An appropriate “match” between the CTEs of the veneer and core appears to be important, if incompletely defined. However, a lack of awareness of the requirement for a compatible CTE match between veneer and core, coupled with more complex cooling management of the fired restoration (because ceramics are inherently insulating) has made ceramic–ceramic debonding a significant clinical issue.
the veneering glassy ceramic has debonded from the zirconia crystalline core
Impression Materials

م.م اريج مفيد
• The function of an impression material is to record accurately the dimensions of oral tissues and their spatial relationships.

• In making an impression, a material in the plastic state is placed against the oral tissues to set. After setting, the impression is removed from the mouth and is used to make a replica of the oral tissues.

• The impression gives a negative reproduction of these tissues.

• A positive reproduction is obtained by pouring dental stone or other suitable material into the impression and allowing it to harden. The positive reproduction is called a model or cast when large areas of the oral tissues are involved or a die when single and multiple tooth preparations are recorded.

• Impressions may be taken of portions of a tooth, a single tooth, several teeth, a quadrant of the mouth, or an entire dentulous or edentulous arch. Examples of some of these types of impressions and the corresponding dies or casts are shown in Figure 8-3.
FIG 8-3 Final impression (in addition silicone material, A) used to capture fine details needed in a model (B) for fabrication of crown restorations and implant placement. (Courtesy Y-W Chen, University of Washington Department of Restorative Dentistry, Seattle, WA.)
Types of Impression Materials in Dentistry

- Hydrocolloid
  - Alginate
  - Agar Hydrocolloid
- Elastomeric
  - Addition Silcones
  - Polyether
  - Condensation Silicone
  - Polysulfide
- Bite Registration
  - Addition Silcones
  - Polyether
- Digital
  - Rigid
    - Impression Compound
    - Zinc oxide-eugenol
Desirable Properties of Impression Materials

- Ease of manipulation and reasonable cost
- Adequate flow and wetting properties
- Appropriate setting time and characteristics
- Compatibility with all die and cast materials
- Good shelf-life

- Sufficient mechanical strength—elastic recovery and resistant to tearing during removal
- Good dimensional accuracy—stable over time

- Taste and odor acceptable to patient
- Safe—not toxic or irritating
- No significant degradation of properties as a result of disinfection
RIGID IMPRESSION MATERIALS

• IMPRESSION COMPOUND: also called modeling plastic, is a thermoplastic material supplied in the form of sheets and sticks.

• There are two types of impression compounds available.

• Type I is a lower-fusing material for making impressions in the oral cavity; it may be supplied in either sheet or stick form (Figure 8-23).

• Type II is a higher-fusing material, also called tray compound, used for forming trays to be used in the oral cavity.
Manipulation and PROPERTIES

• Softening by heat is a prerequisite for the use of compounds. The fusion temperature of the compound corresponds to a definite reduction in plasticity of the material during cooling. Above this temperature, the material remains plastic while the impression is being made. Under no circumstances should the impression be disturbed or removed until it reaches oral temperature.

• **Dimensional Stability** Relaxation of the impression compound can occur in a comparatively short time, especially with an increase in temperature. The result is warping or distortion of the impression.

• The safest method of minimizing such distortion is to allow thorough cooling of the impression before removal from the mouth and to construct the cast or die as soon as possible after the impression has been obtained—at least within the first hour.
ZINC OXIDE–EUGENOL (ZOE) IMPRESSION

• These materials are classified as a hard paste (type I) or soft paste (type II).
• The reaction between zinc oxide and eugenol yields a relatively hard mass that has been involved in a wide range of applications in dentistry, including
• 1- use as an impression material for edentulous mouths,
• 2- a surgical dressing,
• 3- bite registration paste,
• 4- temporary filling material,
• 5- root canal filling material,
• 6- cementing medium, and
• 7- temporary relining material for dentures.
Manipulation and PROPERTIES

• Mixing of the two pastes is accomplished on an oil-impervious paper or glass mixing slab. A flexible stainless steel spatula is typically used for the mixing procedure. The two strips of contrasting colors are combined with the first stroke of the spatula, and the mixing is continued for approximately 1 min.

• Setting time The final set should occur within 10 min for a type I paste (hard) and 15 min for a type II paste (soft). The actual time will be shorter when setting occurs in the mouth, since humidity and temperature can accelerate the setting reaction.

• Dimensional Stability The dimensional stability of the impression pastes is quite satisfactory. A negligible shrinkage (less than 0.1%) may occur during hardening. No significant dimensional change subsequent to hardening should occur with high-quality commercial products.
HYDROCOLLOIDS

- Colloids are often classified as a fourth state of matter, the colloidal state.
- In a solution of sugar in water, the sugar molecules are uniformly dispersed in the water and there is no visible physical separation between the solute and the solvent molecules.
- If these particles are liquids, such as vegetable oil in water, the system is then called an emulsion.
- Somewhere between the extremes of the very small molecules in solution and the very large particles in suspension is the colloidal solution, or sol.
The setting of a reversible hydrocolloid, often called gelation, is a solidification process that involves phase changes from sol to gel states. The physical change from the sol to gel, and vice versa, is induced by a temperature change.

- The gel converts to the sol condition when it is heated to a certain temperature, known as the liquefaction temperature (70° to 100° C).
Properties

• **Accuracy** It has a long history of successful use for single units and for fixed partial denture applications.

• To achieve this accuracy, the clinician must ensure that the following conditions are achieved.

• **1-Viscosity of the Sol** After the material has been liquefied, it must be sufficiently viscous so that it will not flow out of the tray even if the tray is inverted, such as when malting a mandibular impression. On the other hand, its viscosity must not be so great that it will not readily penetrate evenly detail of the teeth and soft tissues.
• Gel Strength 'l'he gel can support considerable stress, without flow, provided the stress is applied rapidly. ‘

• However, the material will flow under sustained stresses. 'l'his flow will disturb the network relation between the dispersion medium and the fibrillar structure. For the reversible gel, the lower- the temperature, the stronger the gel (and vice versa). When the gel is heated, the kinetic energy of the fibrils increases, resulting in greater interfibrillar distances and a reduction in their cohesive interaction. As the temperature continue to rise liquefaction to the sol state occurs.

• Dimensional Effects The gel may lose water by evaporation from its surface or by exuding fluid onto the surface by a process known as syneresis. The gel shrinks. If a gel is placed in water, it absorbs water by a process known as imbibition. The gel swells during imbibition, thereby altering the original dimensions. since any change in dimension that occurs after the impressions are removed from the mouth will lead to inaccurate casts and models
Fig. 9-15  Water-cooled trays used to accelerate gelation of agar hydrocolloids.

Fig. 9-16  Agar hydrocolloid impression

FIGURE 8-16 Conditioning unit for agar impression materials. The three compartments are used for liquefying the material (left), storing after boiling (middle), and tempering the tray hydrocolloid (right). The number on the display shows the temperature setting in °F. Also shown in the figure are the tray hydrocolloid, a syringe for injecting hydrocolloids, and an impression tray. Note the two tubes are extending out from the handle of the tray for water circulation.
Alginate (IRREVERSIBLE) HYDROCOLLOIDS

• is one of the most widely used aqueous dental impression materials. The wide use of alginate results from
  • (1) the ease of mixing and manipulating them;
  • (2) the minimum equipment necessary;
  • (3) the flexibility of the set impression;
  • (4) their accuracy if properly handled; and
  • (5) their low cost. Their principal disadvantages are that they have low tear strength and they do not transfer as much surface detail to gypsum dies as elastomeric impressions do.
Properties

• Mixing and Setting Times Alginates, when properly mixed by hand, should develop a smooth, creamy consistency free of graininess in less than 1 minute for the normal set material and should be suitable for making impressions in the mouth. The setting time of the alginate is indicated as normal or fast by the manufacturer.

• Elastic Recovery Many commercial alginates have actual values of 96% to 98% elastic recovery (2% to 4% permanent deformation). Thus, alginate impression material is flexible but not perfectly elastic.

• Flexibility The relative amounts of water and powder influence the flexibility of the set alginate. Thicker mixes result in lower flexibility.
Strength The tear and compressive strengths at the time the impression is removed increase if the time of removal is delayed. The effect of the consistency of the mix and of the time of removal on the tear strength.

Dimensional Change A problem with alginate impressions is loss of accuracy with increased time of storage.

The set alginate is a hydrocolloid gel that contains large quantities of water. This water evaporates if the impression is stored in air, and the impression shrinks. If the impression is placed in water, it absorbs water and expands. Therefore, storage in either air or water results in serious changes in dimensions and a loss of accuracy.

Reproduction of Detail The impression material must record the detail of the oral tissues, but this detail also must be transferred to the model or die. A number of products have properties that exceed this minimum value.
Taking Alginate Impressions
Elastomeric impression materials are flexible cross-linked polymers when set.

- elastomeric impression materials dominate as a result of their greater accuracy,
- dimensional stability with time,
- and ability to record detail as compared with the hydrocolloid materials.

The first elastomeric impression materials were
- 1- polysulfides, followed by
- 2- condensation silicones,
- 3-polyethers, and
- 4-addition silicones.
CONSENSATION SILICONE

• The materials are supplied as a base paste and a low-viscosity liquid catalyst (or paste catalyst), a two-paste system, or a two-putty system. The putty can be used as the tray material in conjunction with a low-viscosity silicone, that is referred to as the putty-wash technique.
• REPRODUCTION OF ORAL STRUCTURE DETAIL: The clinical significance of the surface reproduction tests is not entirely evident. It is possible that the detail obtained from the elastomeric impression materials under in vitro test conditions might be greater than that obtained in the mouth because of the hydrophobicity exhibited by some of these materials.

• ELASTICITY AND VISCOELASTICITY: An impression with a sufficiently high elastic limit should not sustain permanent deformation. The elastic properties of these elastomeric impression materials improve with an increase in curing time in the mouth. An extra time of 1 or 2 min before removal may be beneficial.
• TEAR STRENGTH: A tear-strength test measures the resistance of an elastomeric material to fracture when subjected to a tensile force acting perpendicular to a surface flaw.

• The amount of force needed to tear a specified test specimen divided by the thickness of the specimen is called the tear strength.

• DIMENSIONAL STABILITY: It is important to distinguish between dimensional accuracy and dimensional stability. The former refers to the lack of dimensional change during curing and shortly after removal from the mouth. The latter refers to the lack of dimensional changes over time. Accuracy is the more important property when impressions are poured up immediately with a die material. This distinction is important because the two do not go hand in hand; materials may be accurate but not stable or inaccurate but stable.
FIGURE 8-14 Representative linear contraction of four elastomeric impression materials.
ADDITION SILICONE IMPRESSION MATERIALS

• The low-, medium-, high-, and very high-viscosity products of one manufacturer’s addition silicone
Properties

• 1- The dimensional change in 24 hours of about 0.1% is very low.

• 2- The elastic recovery at the time of removal from the mouth of about 99.8% (permanent deformation of 0.2%) is the highest of all the impression materials.

• 3- The percentage flow values of the addition silicones are likewise low.

• 4- The working time is short for the addition silicones, and the flexibility is low to moderate.

• 5- Removal of addition silicone impressions from undercut areas may present difficulties because of this stiffness, and extra space should be provided for the impression material when a custom tray is used.

• 6- Tissue culture tests on the base and catalyst pastes have been negative and indicate that addition silicones cause less tissue reaction than the condensation silicones.

• 7- Nearly all addition silicones contain surfactants and are hydrophilic. Hydrophilic silicones wet the oral tissues better than earlier hydrophobic materials and permit gypsum models and dies to be prepared with fewer air bubbles.
Consistencies

• Addition silicones are supplied as low-, medium-, high-, or very high-viscosity (putty) material.

• Originally, the addition silicones were packaged in tubes of base and catalyst for hand mixing.

• Currently, they are supplied in auto-mixing or dual cartridge systems with the base paste in one cartridge and the catalyst paste in the other and a mixing gun. The cartridge is placed in the mixing gun, and ratchet plungers force the pastes through a static mixing tip. During extrusion through the static mixing tip, the two pastes are folded over each other and exit the tip in a mixed condition.
Polyether materials have properties similar to the addition silicones. The polyether polymer is hydrophilic and exhibits good wetting properties, even in a moist field.

Polyethers have the disadvantage of limited dimensional stability over time and older materials had poor taste.

The consistency is listed as medium viscosity but is high compared with that of other medium-viscosity elastomeric impression materials. It is also available as a low- and high-viscosity polyether system.
Properties

1- The elastic recovery of the polyethers is slightly less than that of the addition silicones.

2- The stiffness of the newer polyethers is indicated by a flexibility of 5% and 7%. The low flexibility caused problems in the removal of the impression from the mouth, and a 4-mm rather than a 2-mm thickness of impression material between the tray and the teeth was recommended.

3- The dimensional change of polyethers is higher than that of the addition silicones. The polyether absorbs water and changes dimensions if stored in contact with water until equilibrium is reached.

4- The aromatic sulfonic acid ester catalyst can cause skin irritation, and direct contact with the catalyst should be avoided. Thorough mixing of the catalyst with the base should be accomplished to prevent any irritation of the oral tissues.
Manipulation

- The polyether materials are supplied in two mixing systems:
  - (1) as a cartridge with a mixing gun and
  - (2) as a sausage with a dynamic mechanical mixer (Figure 8-13). A stock or individual tray may be used, but in either instance an adhesive should be used.
- The impression should be pulled slowly to break the seal and then removed in a single stroke; it should be rinsed with cold water, disinfected, and blown dry.
DENTURE SOFT LINERS
Denture soft liners are materials that coat the tissue-bearing surface of a complete or partial denture. As their name implies, these materials are soft or rubbery and are less likely to traumatize the oral soft tissues than the harder acrylic polymer.

A soft liner or also called as resilient liner may be soft elastic and resilient material forming all or part of the impression surface of a denture.

It usually acts as a cushion between the hard acrylic and the soft tissue surface thus providing comfort to the tissues.

Elasticity ensures that the material will regain its original shape following deformation, while resilience is also important because it determines the rate of recovery.
Classification of soft liners

• Classification:
• I. Based on curing:
  • 1- Self cure- eg., soften, viscogel
  • 2- Heat cure- eg., supersoft, molloplast
  • 3- Light cure resins- eg., clearfitLC (polyisoprene based material)
• II. Based on composition: 
  • 1- Silicone elastomers
  • 2- Soft acrylic compounds
• **III. Based on durability**
  1- Temporary/Short term liners-eg., soft comfort
  2- Definitive/long term liners

• **IV. Based on consistency**
  1- Hard denture liners-eg.,Ufigel hard C
  2- Soft denture liners-eg., Silastic 390
  3- Soft denture liners are further classified as
    a) silicone based
    b) Auto cured and heat cured
Ideal Properties

• 1. They should be easily processed using conventional laboratory equipment.
• 2. They should exhibit minimal dimensional change during processing and such change should be the same as that of the denture base materials.
• 3. Water absorption should be minimal.
• 4. The materials should have minimal solubility in saliva. Ideally, the plasticizer (used in some materials) should not leach out with time; however, if leaching does occur, it should be minimal.
• 5. They should retain their resilience. The degree of resilience will depend on the chemical composition of the material and the thickness of the soft lining.
• 6. They should bond sufficiently well to poly (methyl methacrylate) to avoid separation during use. If the strength of the bond between the two materials is weak, separation takes place during use and such localized areas of separation rapidly become unhygienic because of the difficulty of cleaning.
Indications of soft liners

• The application of a soft material is intended to increase the comfort of denture wearers and to support prosthetic treatment.
• 1- Diagnostic relining: A diagnostic relining is indicated in several clinical scenarios. It may be used in conjunction with a diagnostic acrylic resin removable partial denture, also referred to as a temporary or transitional prosthesis.
• 2. Impression material: A number of dentists use tissue conditioner as a border-molding material and as an impression material for edentulous and partially edentulous patients.
• 3. Used in adjunctive to complete dentures in cases where patients are unable bear the hard acrylic dentures bases without which the patient can suffer from mucosal discomfort and ulcerations chronically.
• 4. Can be used with immediate dentures. There is usually a tendency to reline the dentures too soon at the request of the patient.
• 5. Used in patients with abnormal or irregular bony contours like bilateral undercuts, it can also be used when the ridges are severely resorbed.
Short-term vs Long-term Soft Liners
Short term soft liner (tissue conditioners)

**uses**

1- the edentulous tissues are inflamed or swollen, are easily irritated or damaged, or
2- edentulous tissues are likely to change contours significantly over a period of days.
3- are often used after oral surgery or
4- if the patient has a significant oral infection

**composition**

- consist of a polyethylene methacrylate powder and liquid plasticizers.
- When these materials are mixed, there is no polymerization reaction.
- Rather, the plasticizers penetrate and soften the pre polymerized acrylic polymer, providing adhesion to the denture base and a soft texture that serves the purpose of the liner.
Manipulation of short term soft liner

- Short term materials, also known as “treatment” materials, are always applied at chairside, and the liner is replaced frequently (every 3 days or sooner).
- Treatment materials flow under static load but are elastic (do not flow) under intermittent loads produced by chewing.
- As irritated and swollen tissues heal, the liner flows and follows the contour of the tissues.
- They become harder as the oral fluids leach out the plasticizers.
- When the tissue contours are more stable, a longer-term liner may be used before a new denture is constructed.
Long term soft liner

- in edentulous patients with sharp or atrophied alveolar ridges, in patients with thin atrophic mucosa
- in patients in whom the mucosa presents insufficient tolerance to the load transmitted by the dentures
- in cases of the formation of recurrent sore spots under the dentures,
- help to evenly distribute the biting loads transferred onto the soft tissues during chewing
Long-term materials are commonly **methacrylate- or silicone-based polymers.**

- **Methacrylate-based materials** often consist of poly(methyl/ethyl methacrylate) copolymers with plasticizers.
  - Methacrylate-based liners are cured either by heat or chemically at room temperature.
  - Heat-cured formulations are processed in a laboratory, whereas chemical-cure materials may be processed either in the laboratory or at chairside.

- **Silicone soft liners** are either heat cured or chemical cured, but they are processed in a laboratory regardless of the initiation mechanism.
  - Silicone liners do not harden as time passes because they contain no plasticizer. Rather, the soft nature of the liner is from the flexible nature of the polymer network itself.
  - Yet because of their flexible nature, silicone liners are difficult to finish at the periphery, and this makes irritation or yeast infection more likely.
  - The bond strength of silicone liners to acrylic denture base material is not high, but it is adequate to retain the soft liner in service in most cases.
Manipulation of short term soft liner

- **Chairside Reline Materials**
  - the tissue-bearing side of the denture base is roughened to provide a fresh, clean surface for the new material, and
  - the product components are mixed and spread over the freshened denture surface.
  - The denture is placed into the patient’s mouth and held in position until the polymerization process has been completed.
  - Extreme care must be taken because the heat released during the polymerization reaction occurring immediately against the oral mucosa is high enough to cause pain.
  - When polymerized, the excess material flowing out of the denture is removed, and the junction of the old denture to the new is polished.
(A) Temporary lining materials.

(B) a separating agent is added.

(C and D) powder and liquid mixed.
(E) The mixed material is applied to the tissue side of the denture; (F) it is inserted into the patient’s mouth until it gels.
(G) material thinly coats the entire tissue-bearing surface of the denture

(H) Excess is easily trimmed prior to insertion
• Laboratory Reline Materials

• Denture reline materials that are sent to the laboratory for processing polymerize to a higher degree than those that are used chairside.

• For the lab-processed relines, the old denture surface is roughened as before, an impression material is placed directly on the denture base, and the denture is inserted into the patient’s mouth. Thus, the old base is used much as an impression tray would be.

• The denture/impression is then sent to the laboratory, where technicians encase the old denture in stone, much like in the conventional denture-making process.

• The new denture base material is added and polymerized directly against the old base under heat and pressure.