# Crown and bridge Prosthodontics

*Lecture.14* **Dr. Adel F. Ibraheem**

## Dental Porcelain

*Ceramic is derived from GREEK word "KERAMI KOS" meaning Burnt earth. Generally the word ceramic is used to name any material having both metallic and non-metallic ions (usually silicon, boron, oxygen) in its compositional formula which are obtained by the action of heat and whose final structure is partially or completely crystalline examp. cements, gypsum, porcelain and glasses. Dental porcelain are the material from which the most esthetic restoration are made, it is compatible with the soft tissue. a ceramic material formed of infusible elements joined by lower fusing materials. Most dental porcelains are glasses and are used in fabrication of teeth for dentures, pontics & facings, crowns, inlays, onlays and other restorations. Dental porcelain in this domain is superior over polymers and reinforced polymers regarding toothshade reproduction, translucency, biological compatibility, chemical stability and abrasion resistance. Porcelain is very hard material but it is extremely brittle , can fracture easily.*

*In order to overcome this disadvantage, porcelain fused to metal restoration is used to combine the strength and the accuracy of cast metal with the esthetic of porcelain. P.F.M. composed of a metal casting (copping) that fit over the tooth and porcelain fuse on to that copping. This combination is stronger than porcelain alone.*

- *Also aluminium or zirconium oxide have been added to porcelain to increase it strengths, enable it using alone ( without metal substructure) as in all ceramic crowns ,bridges, inlays and onlays.*

**TYPES OF DENTAL CERAMICS**

Three main divisions of ceramics:

1) Predominantly glassy materials,
2) Particle filled glasses---- Glass ceramics
3) Polycrystalline ceramics.

Esthetic dental ceramics : Glassy

Substructure dental ceramics: Crystalline

**1) Predominantly glassy materials**

- *Best mimic the optical properties of enamel and dentine: Glassy material*
- *Glasses: 3D network of atoms having no regular pattern to the spacing between nearest atoms, thus they are amorphous or without form.*
- *Derived principally from a group of minerals called FELDSPAR: based on silica and alumina: Aluminosilicate glasses.*
- *Resistant to crystallization during firing, long firing ranges, biocompatible.*

**2) Particle filled glasses---- Glass ceramics**

- *Filler particles are added to the base glass composition to improve mechanical properties and to control optical effects like Opalescence, Color, and opacity.*
- *This filler was added to create porcelains that could be successfully fired on metal susbstructure.*
- *Adding 17-25% Leucite filler (feldspar forms crystalline mineral Leucite, potassium-aluminum-silicate mineral with large coefficient of thermal expansion, when mixed with metal oxides & fired to high temperature) to base glass creates porcelains that are thermally compatible with dental alloys.*
- *Moderate strength increases can also be achieved with appropriate fillers added and uniformly dispersed: "Dispersion Strengthening"*

### 3) Polycrystalline ceramics

- *No glassy components, atoms are densely packed, regular network: Crack propagation difficult.*
- *Tougher and stronger than glassy ceramics.*
- *Difficult to process, CAD-CAM.*
- *Relatively opaque, core substructure.*
- *E.g. Aluminum oxide, partially stabilized Zirconia.*
- *Procera, Cercon, Lava.*

## Composition

**1) Kaolin 11—12%**

- *It is a white clay like material (hydrated aluminum silicate).*
- *Increases the ability of the porcelain mold before baking*
- *Facilitates mixing with water while maintaining the form during drying and firing.*
- *Make the material workable Reacts with the feldspar and gives rigidity*
- *Being sticky in nature , bind the particles*
- *Material can be carved*
- *Give opacity to the fired porcelain*

**2) Feld Spar 70 – 90% (Alkaline aluminum potassium silicate)**

- *It constitutes the bulk of dental porcelain*
- *Translucent glossy matrix*
- *Bind small particles of Kaolin and Quartz together*
- *Alumina may replace silica –increase strength & opacity – use as core material under a regular translucent porcelain in all ceramic crown ( jacket).*

**Aluminous porcelain**

*The porcelain material contains 40-50% alumina crystals ($Al_2O_3$) in a low-fusing glass matrix. High-Ceram ;The dispersed alumina particles are much stronger with higher modulus of elasticity and coefficient of thermal expansion than those of the glassy matrix. Presence of alumina makes the material opaque. (used only as coping beneath regular porcelain)*

**3) Quartz**

- *Form refractory skeleton about which the other material fuse and flow*
- *A form of silica is used as filler*
- *Form refractory skeleton about which the other material fuse and flow*
- *Help the crown holding itself during firing*
- *Increase the strength of the material*
- *Tissue contacts appear as normal tooth*
- *Constitutes the crystalline face*
- *Hardening of the mass*

**4) Fluxes**

- *Alkalies such as sodium, potassium and calcium*
- *Increase fluidity*
- *Lower firing temperature*
- *Acting as glass modifier (called glass modifiers).*

**5) Pigments**

- *Added to color the porcelain (to provide proper shade)*
- *Involve metal oxide such as titanium oxide – yellowish brown , iron or nickel oxide – brown , copper oxide – green ,manganese oxide (lavender), cobalt oxide (blue), etc*
- *They are fused together with regular feldspar and then reground and blended to produce a variety of colors.*

**6) Opacifiers**

*Since pure feldspathic porcelain is quite colorless, opacifiers are added to increase its opacity in order to simulate natural teeth. Oxides of zirconium, titanium and tin are commonly used opacifiers.*

## *CHARACTERS OF DENTAL PORCELAIN*

**1. Biological Properties:**
- *Inert has no interaction with surrounding soft tissue (biocompatible)*

**2. Interfacial Properties:**
- *Not adhere chemically to dental cements*

**3. Chemical properties:**
- *Not soluble in oral fluids and resist acid attach*
- *Both hydrofluoric acid and stannous fluoride can cause an increase in surface roughness*

**4. Mechanical Properties:**
- *Brittle*
- *Low Dimensional tensile strength and fracture toughness*
- *Hard, can cause wearing of opposing dentition*

**5. Thermal Properties:**
- *Low thermal diffusivity*
- *Coefficient Of thermal expansion similar or slightly higher than to that of enamel and dentine, not exhibit microleakage (acrylic 4 –6 more).*

**6. Esthetic properties:**
- *porcelain exhibit the best (Excellent) esthetic quality, and color matching*
- *Difficult to be stained*
- *differ from acrylic which is esthetically poor because of light absorbent).*

**7. Practicability:**
- *Sensitive manipulation technique, Requiring skilled operator and Special equipments*
- *Firing shrinkage is always, So operator should build up the restoration to a bigger size that allows shrinkage*

**8. Color stability;**
- *Porcelain is the most stable tooth colored restorative material. Glaze porcelain provide smooth glassy non porous surface that is resistant to adherent of exogenous stain ( acrylic is not stable due to water absorption and porosity).*

## Disadvantages of dental porcelain

1) *Abrasive to antagonists.*
2) *Complex techniques need (fabrication).*
3) *Difficult to adjust and polish intra-orally.*
4) *May degrade supporting structure.*
5) *Low fracture resistance.*

## *Techniques of firing*

1. *Pressure technique*
2. *Diffusible gas technique*
3. *Vacum firing technique*

***Vacum firing is one of greatest practical value** to the dental ceramist **because***

1. *It is easy to manipulate*
2. *Porcelain of grater translucence is achieved (decrease in the No. of gas bubbles)*
3. *Strength qualities somewhat more*

❖ ***Porcelain reaction to firing (Phases of maturation)***

**1. Biscuit stag;**

- *Little shrinkage in the body of porcelain*
- *Appear like opaque whit mass with porous surface , no translucency*
- *Contamination of porcelain at this stag is easy (oil and dust)*

### 2. Maturity stage

- *It divide into low , medium and high*
- *Maturation of porcelain is evident at this stag*
- *The amount of translucency and color shin depend on the degree of maturation*
- *At the end of maturation it will appear non porous glaze where the surface reflect light and cluster*

### 3. Coalescence stag

- *If we continue firing we reach this stage in which we loss the form of porcelain*

## ***Classification***

- **According to fusing temperature**

**1) High fusing porcelain 2350 – 2500 F**

Usually used for manufacture of porcelain denture teeth and aluminous cores production

**2) medium fusing porcelain 2000 – 2300 F**

Usually used for porcelain jacket crown & porcelain inlay and onlay

**3) Low fusing porcelain 1600 – 2000 F**

Usually used for porcelain fused to metal restoration

**4)** Ultra-low fusing less than 850 (used with titanium)

- **According to type of restoration**
  - **1)** All ceramic crown
  - **2)** Porcelain fused to metal crown
  - **3)** Inlay
  - **4)** Onlay
- **According to Microstructure**
  - **1)** Glass
  - **2)** Crystalline
  - **3)** Crystal containing glass
- **According to porcelain Type**
  - **1)** Feldspathic or conventional porcelain
  - **2)** Aluminous porcelain
  - **3)** Leucite reinforced
  - **4)** porcelain Glass infiltrated alumina
  - **5)** Glass infiltrated spinell
  - **6)** Glass ceramic
- **According to Processing Method**
  - **1)** Sintered porcelain
  - **2)** Cast porcelain
  - **3)** Machined porcelain.
- **According to their clinical applications**
  1) Core porcelain:
     Used to form the basal layer of jacket crown
  2) Dentine or Body porcelain:
     More translucent, used to build the body of crowns
  3) Enamel porcelain:
     The most translucent, used to form the incisal edges

**Nature of Bond Between Porcelain & Metal**

### 1. Mechanical bond

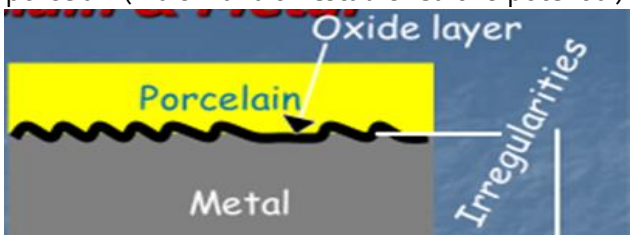
- Achieved by minute irregularities on the surface of the metal (rough surface)
- Mechanical interlocking occur only when wetting is efficient

**2. Vander woals bond**

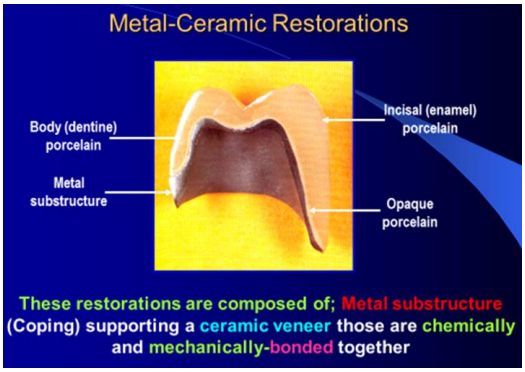
- Represent attraction between atoms or molocules which are not primarily of same chemical nature
- It is more physical in nature
- It represent 1/3 of bonding

**3. Chemical bond**

- It is either covalent or ionic bond
- It mean formation of anew substance between metal and porcelain which is combination of both
- There will be direct electron transfer between the oxygen of the glass and the oxidizable metal in the copping alloy
- It depend on the ability of alloy to form oxide layer between the copping and porcelain (indium and tin established this potential)



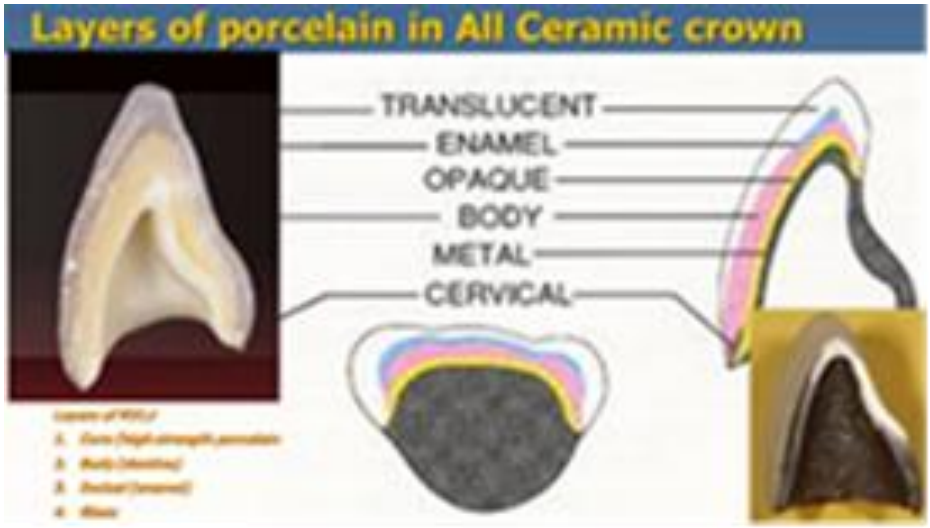

❖ ***Layers of porcelain in P.F.M***




1. ***Opaque porcelain:*** *It is applied as a first porcelain layer, it initiate the development of shade. it perform two major function: it masks the color of the alloy, and it play an important role in the development of the metal porcelain bond.*
2. ***Body porcelain (Dentin):*** *this is fired onto the opaque layer, make up the bulk of the restoration, providing the most of the color or shade of the final restoration. It provide some translucency. Body porcelains are available in a wide selection of shades, to match adjacent natural teeth.*
3. ***Incisal porcelain (Enamel) :*** *A translucent, lightly – pigmented dental ceramic used on a base of dentine ceramic to simulate the natural tooth enamel*
4. ***Glaze:*** *Translucent, low fusing porcelain which may applied to the surface as final stage in the firing cycle*

❖ ***Layers of porcelain in All Ceramic Crown***

1. *Core (high strength porcelain)*
2. *Body (dentine)*
3. *Incisal (enamel)*
4. *Glaze*




❖ ***Requirements of the alloys***

1. *The alloy should have high melting range point to withstand the porcelain firing temperature without melting or creep*
2. *The alloy should be sufficiently rigid and have high modulus of elasticity so that it resist deformation during firing veneer bonded to the metal or during masticatory function where occlusal force acting ( to support a very brittle porcelain veneer) otherwise fractures of the veneer is inevitable.*
3. *The alloy should be capable of forming a bond with the porcelain veneer in order that the latter does not become detached (capable of forming oxide layer).*
4. *The alloy should have a value of coefficient of thermal expansion similar to that for the porcelain to which it is bonded.*
5. *The alloy should have good castibility*
6. *The alloy should have fine grain structure to resist corrosion*

❖ ***available alloy for porcelain bonding***

- *Noble alloys (gold platinum alloy).*
- *Low noble alloys (gold palladium alloy).*
- *Silver-palladium alloys.*
- *Nickel-chromium alloys.*

***Families of all-ceramic restorations***

*ALL CERAMIC SYSTEMS can classified According to fabrication technique into*

1. ***Conventional ceramic jacket crown***

*The restoration fabricate mixing the powder with water to form slurry , which is built upon layer on the die of the prepared tooth to form the contour of the restoration*

2. ***Castable ceramic***

*The restoration fabricate by casting technique, to cast the molten ceramic material ( the product supplied as a solid ceramic block) into previously prepared mold cavity.*

3. **Machinable ceramic**

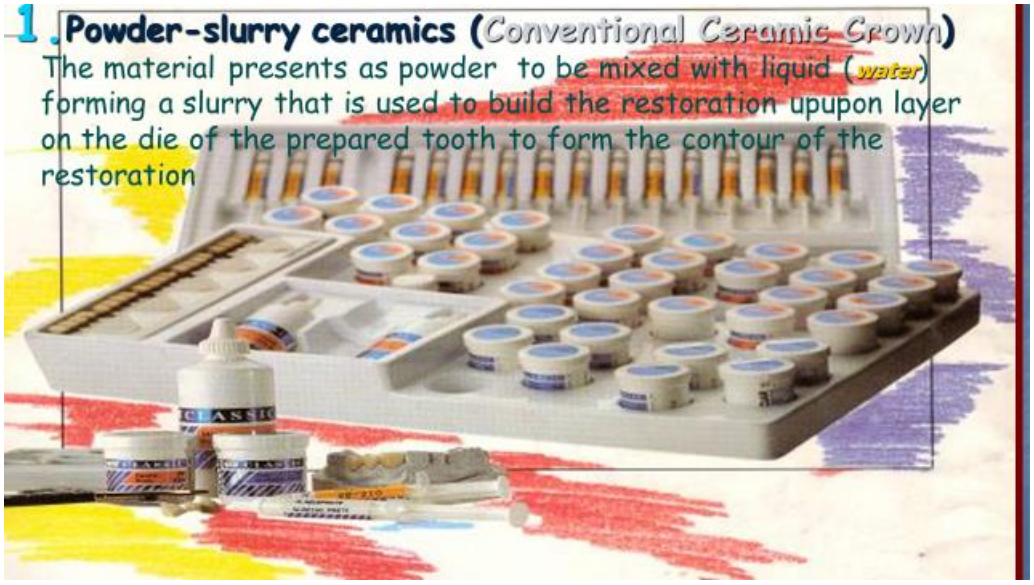
***Either Copy milling technology or CAD/CAM system*** *(computer aid machine / computer aid design ) ------ computer integrate imaging and milling system , with the restoration design on the computer screen ---- copy milling technology*

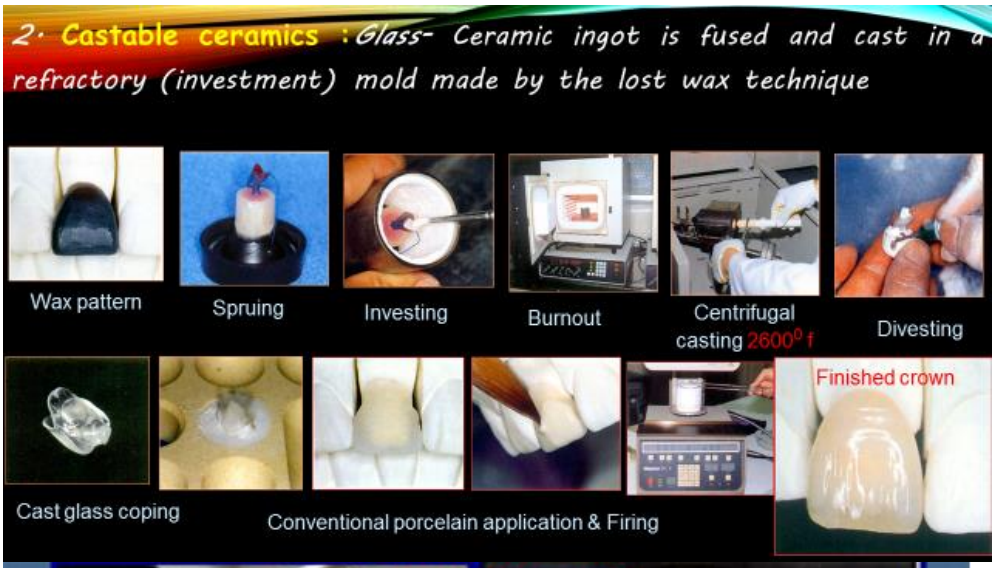
4. ***Pressable ceramic***

*The restoration fabricate by injection or pressing the molten ceramic material into a mold cavity made by lost wax technique ( after waxing and investing).*

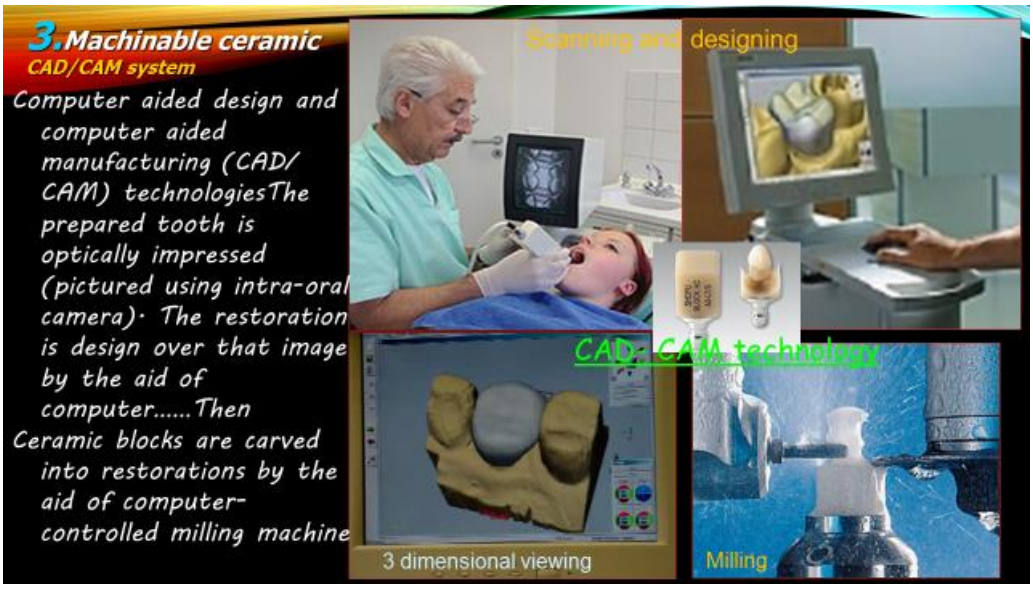
5. ***Infiltrated ceramic***

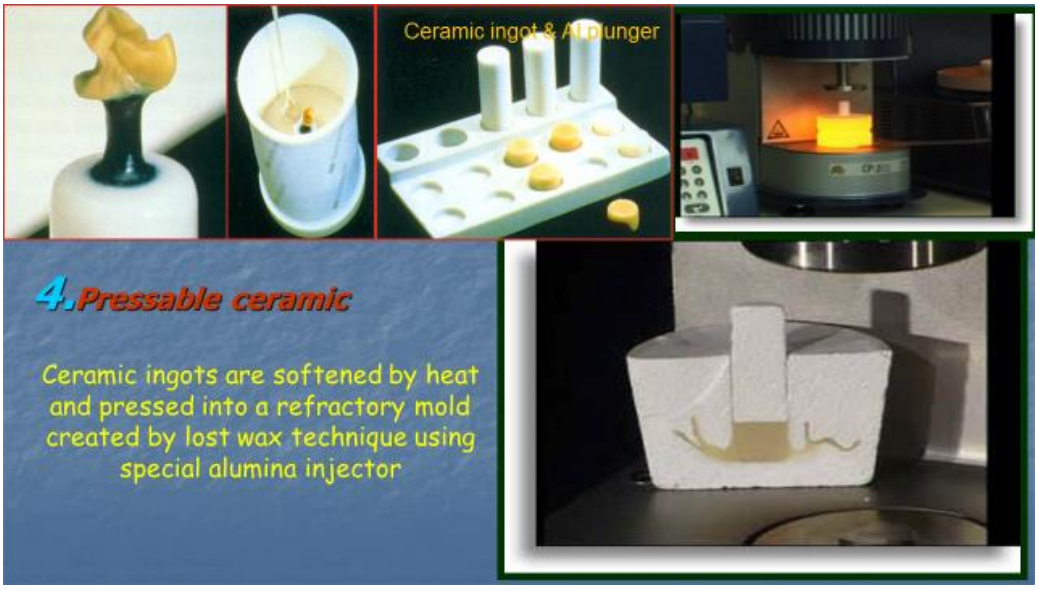
*Powder is used to form a porous core with little shrinkage , then , at high temperature glass infiltrated into that porous substrate to give high strength restoration*

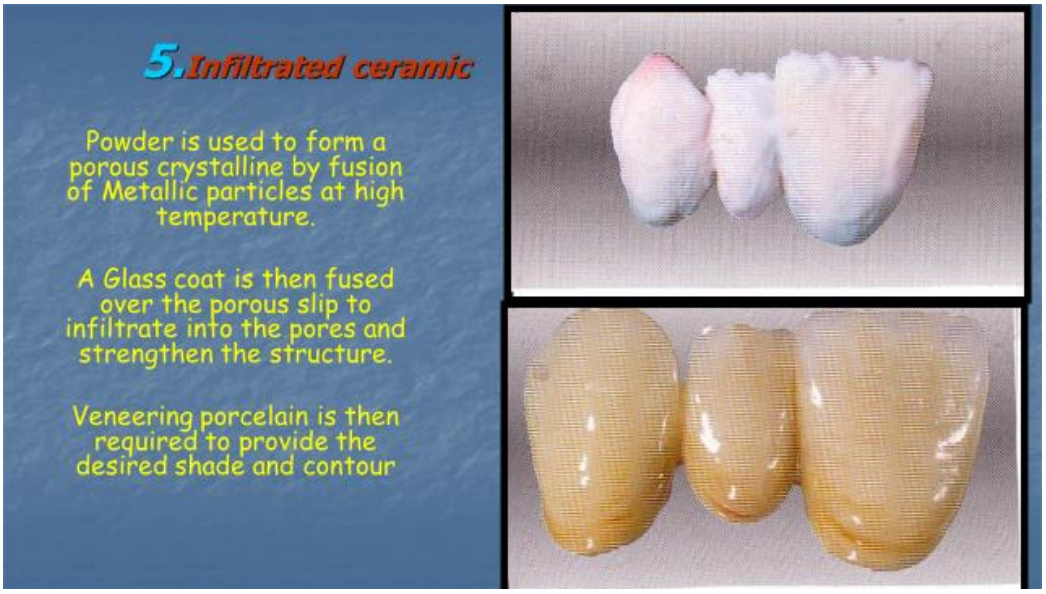

1. Powder-slurry ceramics (Conventional Ceramic Crown)
The material presents as powder to be mixed with liquid (water) forming a slurry that is used to build the restoration upupon layer on the die of the prepared tooth to form the contour of the restoration


2· Castable ceramics : Glass- Ceramic ingot is fused and cast in a refractory (investment) mold made by the lost wax technique
Wax pattern
Spruing
Investing
Burnout
Centrifugal casting 2600° f
Divesting
Finished crown
Cast glass coping
Conventional porcelain application & Firing


3· Machinable ceramic
Copy Milling technology
A resin pattern is directly fabricated on the prepared tooth or on the master die, scanner were then used to scan the pattern , the pattern were then used as a copping guide for the milling machine


3.Machinable ceramic
CAD/CAM system
Computer aided design and computer aided manufacturing (CAD/ CAM) technologiesThe prepared tooth is optically impressed (pictured using intra-oral camera)· The restoration is design over that image by the aid of computer.....Then
Ceramic blocks are carved into restorations by the aid of computer-controlled milling machine
Scanning and designing
CAD- CAM technology
3 dimensional viewing
Milling


Ceramic ingot & Al plunger
4.Pressable ceramic
Ceramic ingots are softened by heat and pressed into a refractory mold created by lost wax technique using special alumina injector


5.Infiltrated ceramic
Powder is used to form a porous crystalline by fusion of Metallic particles at high temperature.
A Glass coat is then fused over the porous slip to infiltrate into the pores and strengthen the structure.
Veneering porcelain is then required to provide the desired shade and contour