CERAMICS

Ceramics..

PART 1

CONTENTS

INTRODUCTION

- The word “Ceramic” derived from Greek word “Keramikos” = Earthen
- Earthy material, usually of silicate nature
- Compounds of one or more metals with a nonmetallic component, usually oxygen (GPT-8)

- Ceramics are formed of chemical and biochemical stable substances that are strong, hard, brittle, and inert nonconductors of thermal and electrical energy

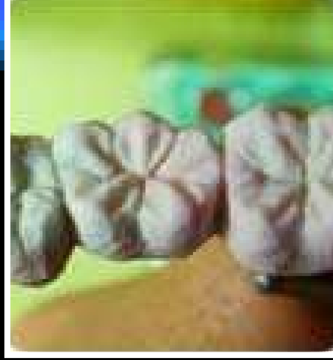
- **PORCELAIN** is ceramic material formed of infusible elements joined by lower fusing materials

- Dental Ceramics contain a glassy matrix reinforced by various disperse phases consisting of crystalline structures such as Leucite, alumina & silica

HISTORICAL BACKGROUND

- During stone age-10,000 years ago ceramics were most important materials
- First porcelain tooth material was patented in 1789 by deChemant and Duchateau
- In 1808, Fonzi, an Italian dentist, invented “terrometallic” porcelain tooth that was held in place by platinum pin or frame

- Dr. Charles Land introduced one of the first ceramic crowns to dentistry in 1903
- First commercial porcelain was developed by vita zahnfabrik in about 1963
- The end of the 20^{th} century saw the introduction of several innovative systems for fabricating all-ceramic dental restorations



COMPOSITION OF DENTAL PORCELAINS

- Ceramics are composed of essentially the same material as porcelain, the principal difference being in the proportioning of the primary ingredients & the firing procedure.
- The ingredients are (Tri-axial composition)

  a) Feldspar

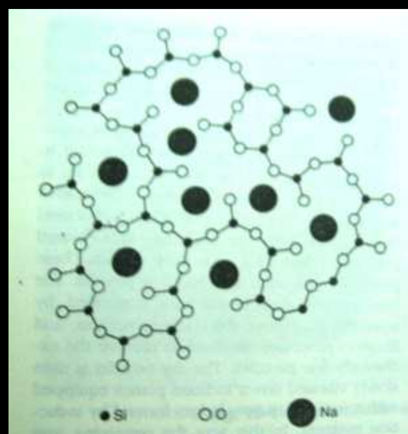
  b) Silica (quartz or flint)

  c) Kaolin

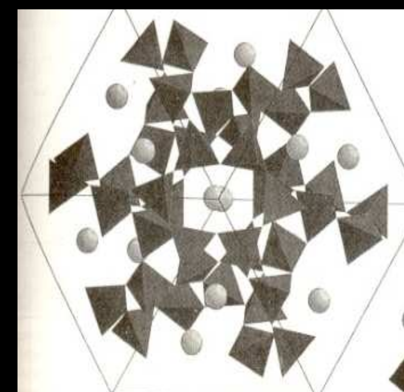
FELDSPAR

- In its mineral state, feldspar is crystalline and opaque with an indefinite color between gray and pink.
- Chemically it is designated as potassium-aluminum silicate, with a composition of K_2O, $Al_2\,O_3\,6SiO_2$.
- Potassium and sodium feldspar are naturally occurring composed of potash (K_2O), Soda (Na_2O), Alumina (Al_2O_3), and Silica (SiO_2).

- Feldspar —heating, 1200^0 c→ Glassy phase with amorphous structure
- Feldspar —heating, 1200^0 c→ Crystalline phase consisting of leucite



2D Structure of SODIUM SILICATE GLASS



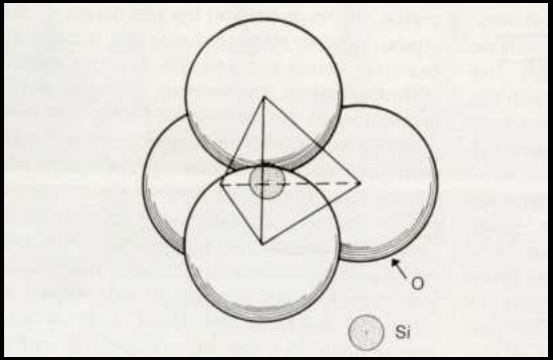
3D structure of LEUCITE

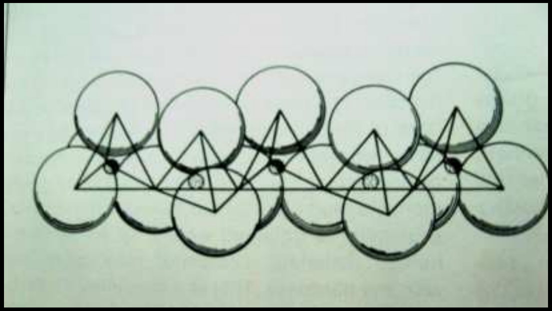
- The softening of this glass phase during porcelain firing, allows the powder particles to coalesce together.

SILICA

- It can exist in four different forms
    - Crystalline quartz
    - Crystalline cristobalite
    - Crystalline tridymite
    - Non-crystalline fused silica

- Silica remains unchanged at high temperature used in firing porcelain and thus contributes stability to the mass during heating by providing a framework for other ingredients.



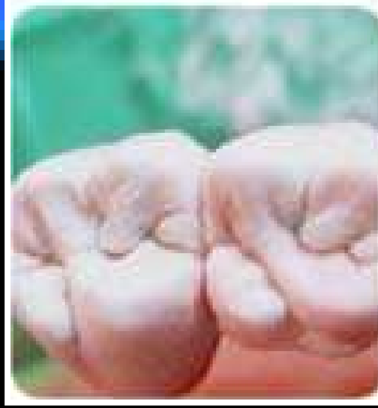


KAOLIN

- It is produced naturally by weathering of feldspar during which the soluble potassium silicate is washed out by acidic water. In this process the residue is deposited at the bottom of the streams in the form of clay.
- Kaolin gives porcelain its property of opaqueness.

COLOUR PIGMENTS

- Added to the porcelain in small quantities to obtain delicate shades necessary to simulate natural teeth.
- Prepared by grinding metallic oxides with fine glass and feldspar, fusing the mixture in a furnace and regrinding to powder.



Metallic Oxides

- Titanium oxide – yellowish brown
- Manganese oxide – lavender
- Iron oxide or Nickel oxide – Brown
- Cobalt oxide – Blue
- Copper oxide – Green

Opacifying Agents

Generally consists of metallic oxide (between 8% to 15%) ground to a very fine particle size (<5 μm) to prevent a speckled appearance in porcelain

- Cerium oxide
- Zirconium oxide
- Titanium oxide
- Tin oxide

STAINS

- Stain is more concentrated than the color modifier
- They can be supplied as pure metal oxides but are sometimes made from lower fusion point glasses.
- Used as surface colorants or to provide enamel check lines, decalcification spots

GLASS MODIFIERS

Crystalline silica

- Decreases viscosity
- Lowers softening temperature
- Increases thermal expansion

Too high a modifier concentration

↓

Reduces chemical durability

Glass may crystallize during porcelain firing

GLAZES AND ADD-ON PORCELAIN

- One purpose of an industrial glaze is to seal the open pores in the surface of fired porcelain.
- Dental glazes consists of low fusing porcelains which can be applied to the surface of a fired crown to produce a glossy surface.
- Thermal expansion of the glaze should be fractionally lower than the ceramic body to which it is applied.
- Add-on porcelain is used for simple corrections of tooth contour or contact points

Other Additions to Dental Porcelains

- Boric oxide (B_2O_3)

  Glass modifier

- It decreases viscosity
- lowers the softening temperature
- forms its own glass network
- Alumina (Al_2O_3)
- It takes part in the formation of glass network
- alter the softening point and viscosity
- Lithium Oxide
- Added as an additional flux agent
- Magnesium Oxide
- present but in minute quantities
- It can replace calcium oxide

DEVITRIFICATION AND THERMAL EXPANSION

"**Vitrification**" in ceramic terms is development of a liquid phase by reaction or melting, which on cooling forms glassy phase.
This structure is termed 'Vitreous'

- When too many glass forming silica tetrahydra are disrupted in dental porcelain, the glass may crystallize or **devitrify**
- The regular aluminous porcelains are less susceptible to **devitrification** due to their higher silica to alkali ratio
- The aluminous porcelains contain much less soda and their thermal expansions are too lower

FRITTING

- The mixture of leucite and glassy phase is cooled very rapidly i.e. quenched in water
- This causes the mass to shatter in small fragments and the product obtained is called frit which is ball-milled
- The process of blending, melting and quenching the glass components it termed fritting

Thank you

END OF PART 1

Ceramics..

PART 2

CLASSIFICATION

Dental ceramics are classified according to their;

- Firing temperature
- Type of porcelain
- According to the use
- Processing methods
- Substructure material
- Methods of fabricating ceramic restorations
- Methods of firing
- According to application

✦ According to Firing Temperatures

- High Fusing 1300^{0}C

  denture teeth

  Superior strength, insolubility and translucency
- Medium fusing 1100^0-1300^{0}C

  denture teeth, metal-ceramic restoration
- Low fusing 850^{0}C-1100^{0}C

  metal-ceramic restorations
- Ultra low fusing <850^{0}C

- **According to Firing Methods**

  Air fired – Firing at atmospheric pressure

  Vacuum fired – Firing at reduced pressure

- **According to the Type of Porcelain**

  Feldspathic porcelain

  Leucite reinforced porcelain

  Aluminous porcelain

  Glass infiltrated alumina

  Glass infiltrated spinel

  Glass infiltrated zirconia

  Glass ceramic

☯ According to the Use

Denture teeth

Metal ceramics

Laminate and veneers

Inlays, onlays

Crown and bridge

☯ According to Processing Methods:

Sintering

Casting

Machining

- ***According to the method of Applications***

  All porcelain

  Porcelain fused to metal

- **According to the Substructure Material**

  Cast metal

  Glass ceramic

  Sintered glass ceramic

  CAD/ CAM Porcelain

  Sintered ceramic core

According to Fabrication Technique (CRAIG)

	Fabrication	***Crystalline Phase***
All Ceramic	Machined	Alumina – Al_2O_3 Feldspar – AKAl Si_3 O_8 Mica – KMg_{25} Sio_4 F_2
	Slip Cast	Alumina – Al_2O_3 Spinel – Mg Al_2 O_4
	Heat Pressed	Leucite – Kal Si_2 O_6 Lithium disilicate Li_2 Si_2 O_5
	Sintered	Alumina – Al_2O_6 Leucite – Kal Si_2O_6
Ceramic Metal	Sintered	Leusite – $KA1Si_2O_6$
Denture teeth	Manufactured	Feldspar

PROCESSING OF PORCELAIN

Condensation of Dental Porcelain

- The process of packing the particles together and removing the liquid binder is known as condensation
- Distilled water-most commonly used liquid binder
- Other binders: Glycerin, propylene glycol or alcohol
- Dense packing of powder particles
  - -lower firing shrinkage
  - -less porosity in fired porcelain
- Condensing methods
  - Vibration
  - Spatulation
  - Brush techniques

Vibration method

- ★Manual or ultrasonic
- ★Mild vibration is used to pack the wet powder densely on the underlying framework
- ★Excess water is blotted or wiped away with clean tissueor fine brush, and condensation occurs toward blotted or brushed area

Ultrasonic vibration

- ★The restoration is placed on vibrator
- ★Low amplitude along with very high rate of vibrations/sec pulls the liquid to surface with almost no disturbance to the porcelain contour

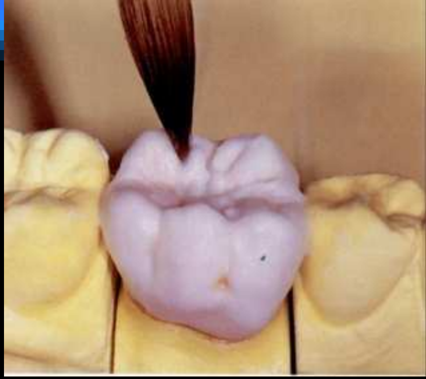
whipping

★ No.10 sable hair brush is used in whipping motion, producing gentle vibration

Spatulation method

★Spatula is used to apply and smoothen wet porcelain

★The smoothing action brings excess water to the surface, where it is removed

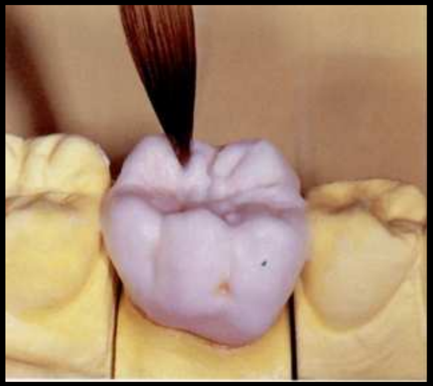


BRUSH APPLICATION METHOD

- ✧Capillary attraction method
- ✧Dry powder is placed by a brush to the side opposite from an increment of wet porcelain
- ✧As the water is drawn toward the dry powder, the wet particles are pulled together
- ✧ Not recommended because the control of the powder can be difficult and time consuming
- ✧This will enhance the risk of the porcelain drying out

Wet brush technique

- Condensation is done by using brush to flow the wet porcelain around the framework
- A gentle pushing or tapping motion will agitate porcelain particles into position and brush will keep porcelain moist
- Water is withdrawn with paper tissue, surface tension will automatically cause the particles to settle closer together



Modeling Brush

Constant humidity box

CONDENSATION

Flat Brush

FIRING/ SINTERING OF PORCELAIN

- Porcelain restorations are fired either by temperature control alone or temperature and time control

- Sintering is defined as a process of heating without melting closely packed particles to form a coherant mass by inter-particle bonding and sufficient diffusion to decrease the surface area and increase the density of the structure

AIR FIRING

During firing, partial fusion of particles at their point of contact

↓

Temp ↑ sintered glass gradually flows to fill up air spaces

↓

Air becomes trapped in form of voids because fused mass is too viscous to allow all the air to escape

↓

porosity reduces translucency and strength

- Very slow maturation period is ideal
- 30-40^{0}c below maximum firing temperature is recommended

How vacuum firing works?

After porcelain is placed in the furnace

↓

Air pressure in furnace muffle is reduced to 0.1atm

↓

Temp ↑ until firing temperature is reached

↓

Vacuum is then released and furnace pressure returns 1atm

↓

Increase in pressure from 0.1-1atm compresses residual pores

↓

Marked reduction in porosity in vacuum sintered porcelain

ADVANTAGES OF VACUUM FIRING

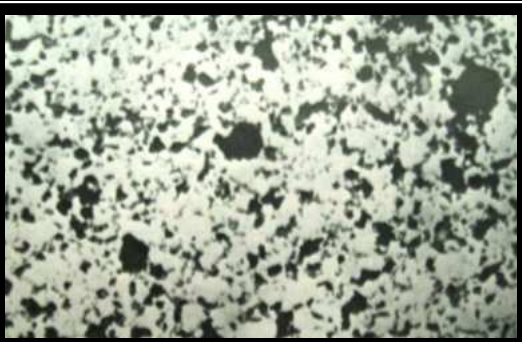
- Improves translucency and decreases surface roughness
- Increases impact strength approximately 50%
- Reduces the amount of porosity to 0.56% (from 5.6%) in air fired dental porcelain

DIFFUSIBLE GAS FIRING

- It is an alternate method which uses the principle of diffusion to secure improved density in fused porcelain
- A diffusible gas such as helium may be introduced to furnace at low pressure during sintering stage
- The helium gas is entrapped instead of air in interstitial spaces
- Since its molecular diameter is smaller than porcelain lattice, its diffuses outward under pressure of shrinking porcelain

STAGES IN FIRING

Low Bisque	Medium Bisque	High Bisque
Surface very porous	Less porous	Completely sealed and smooth
Grains start to soften and "lense"	Entrapped air becomes sphere shaped	A slight shine appears on the surface
Shrinkage is minimal	Definite shrinkage	
Body extremely weak and friable		Body is strong



GLAZING OF PORCELAIN

- After porcelain is cleaned and any necessary stains are applied, it is returned to the furnace for final glaze firing
- Usually, the glazing step is very short
- When glazing temperature is reached, a thin glassy film (glaze) is formed by viscous flow on the porcelain surface
- Natural glaze enhances transverse strength, esthetics and reduces crack propagation
- Over glazing should be avoided

Advantages

- Good esthetics
- Long term color stability
- High hardness & compressive strength
- Chemical inertness
- Excellent biocompatibility
- Excellent thermal and electrical insulators

Disadvantages

- Brittleness
- Low fracture toughness
- Low tensile strength.

METAL CERAMICS

Requirements for metal-ceramic system

- High fusion temperature of alloy
- Fusion temperature of ceramic should be low
- Ceramic must wet the alloy
- Good bond between ceramic and metal is essential
- Compatible coefficients of thermal expansion of ceramic and metal is necessary
- Adequate stiffness and strength of alloy core
- High sag resistance of alloy is essential
- An accurate metal coping is required
- Adequate design of restoration is critical

INDICATIONS

- ✓Teeth that require complete coverage
- ✓Fixed partial denture retainer
- ✓Cases of extensive tooth destruction
- ✓Need of superior retention and strength
- ✓Restoration of teeth with multiple deflective axial surfaces
- ✓An endodontically treated tooth in conjunction with suitable supporting structure
- ✓Correction of minor inclinations

CONTRA-INDICATIONS

- Patients with active caries
- Untreated periodontal disease
- In young patients with large pulp chambers due to high risk of pulp exposure
- When a more conservative retainer is feasible

METAL-CERAMIC RESTORATION

- Metal-ceramic restoration is composed of metal casting or coping, Which fits over the prepared tooth and ceramic is fused to coping

- The metal coping in a metal-ceramic restoration is covered with three layers of porcelain

OPAQUE PORCELAIN

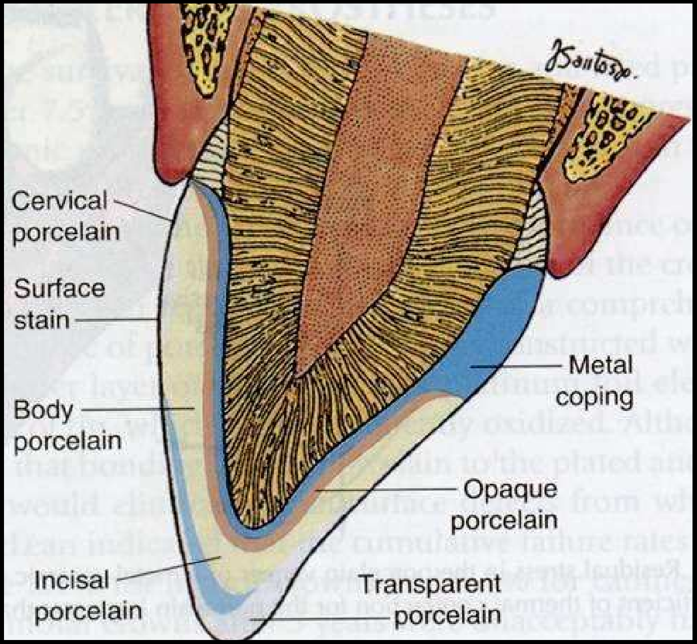
- Conceals the metal underneath
- Initiates the development of shade
- Plays an important role in development of bond between ceramic and metal

DENTIN OR BODY PORCELAIN

- Makes up the bulk of the restoration, providing most of the colour or shade

ENAMEL OR INCISAL PORCELAIN

- Imparts translucency to the restoration



Functions of Metal Substructure

Primary Functions

- The casting provides the fit of the restoration on the prepared tooth
- The metal forms oxides that bond chemically to dental porcelain
- The coping serves as a rigid foundation to which the brittle porcelain can be attached for increased strength and support
- The substructure restores the proper emergence profile of the tooth

Secondary functions

- Metal occlusal and lingual articulating surfaces can be less destructive to the enamel of opposing natural teeth
- The occluding surfaces can be easily adjusted and repolished intra orally
- Fabrication of a restoration with minimal occlusal clearance has more potential for success with a metal substructure than all-ceramic materials

FARICATION OF METAL-CERAMIC RESTORATION

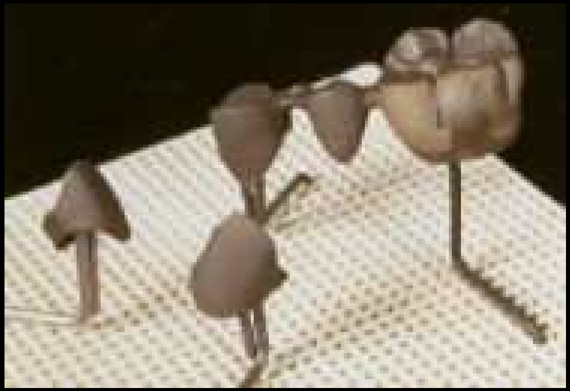
Stage I

- The metal coping is cleaned by sand blasting or steam cleaning and then placed in an ultra-sonic cleaning bath

- The roughened surface produced by sandblasting provides wettable surface and will assist in mechanical retention of the porcelain

Stage II

- The metal is de-gassed by heating to 1000^{0}C in vacuum for about 10 minutes and then slowly air-cooled in normal atmosphere
- This procedure also produces some age hardening in the alloy
- At the same time, base metal atoms will diffuse to the surface of the metal and form an oxide film



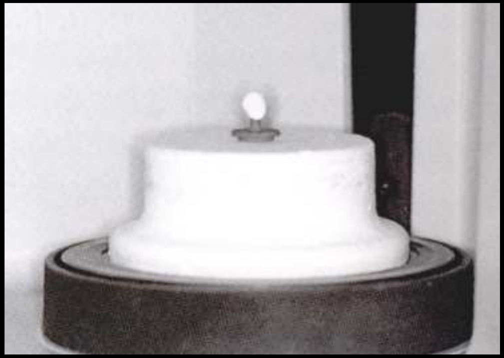
Stage III

- An opaque porcelain slurry is applied to the surface of the casting so that an even and thin layer is formed

- The metal and opaque porcelain are then slowly oven-dried and opaque porcelain will shrink onto the metal surface

Stage IV

The opaque porcelain on the metal is introduced into the hot zone of the furnace and initial sintering of the grains of porcelain will occur.



Stage V

The opaque porcelain is then raised to its final maturing temperature of around 930^0C to 960^0C. At this stage the porcelain will continue to shrink through sintering and pore elimination.

Stage VI

The enamel and dentin porcelain are applied and sintered

Thank you

End of part 2

Ceramics..

Part 3

DEGASSING

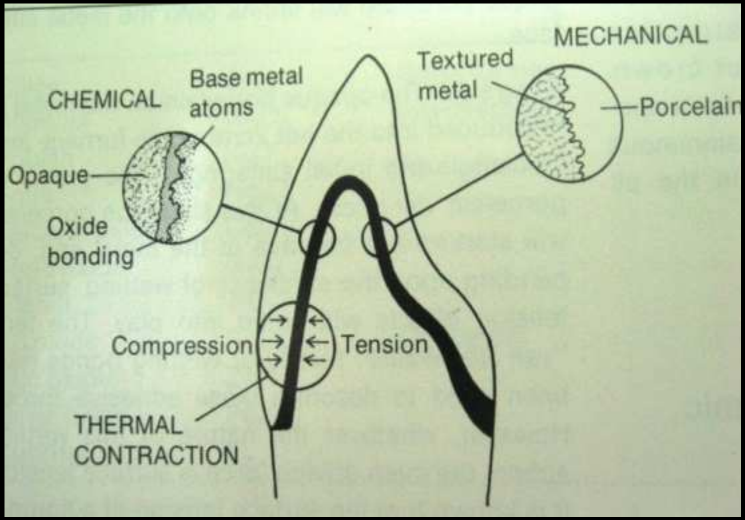
- The term degassing refers to a procedure recommended to clean the metal to remove entrapped surface gases such as hydrogen
- The procedure is important for removal of volatile contaminants that might not otherwise be eliminated either by metal finishing, steam cleaning, or air abrading
- This process also allows specific oxides to form on the metal surface which responsible for the chemical bond

METAL-CERAMIC BONDING

Strong bond between metal and porcelain is essential

Types of bond

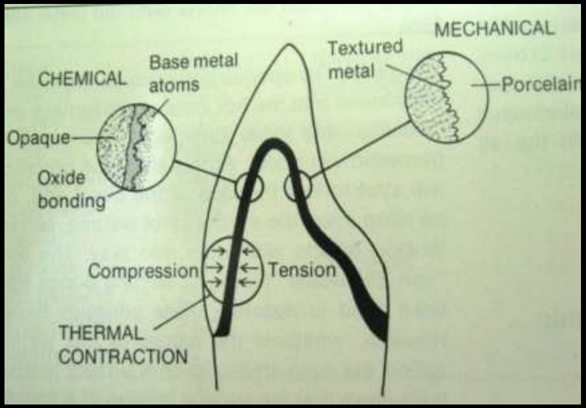
- Mechanical entrapment
- Compressive forces
- Van der waal's forces
- Chemical bonding



Mechanical Entrapment

Mechanical inter locking of the ceramic with micro abrasions created on the surface of the metal coping by,

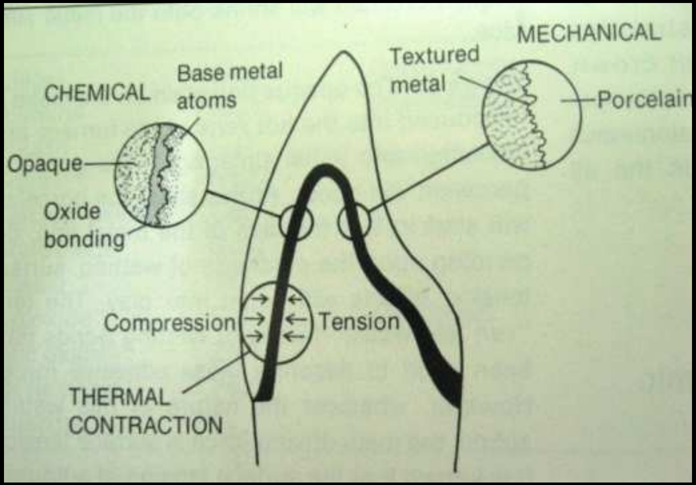
- Finishing the metal with non-contaminated stones or discs
- Air abrasion
- The use of a bonding agent such as platinum spheres
- Electrochemical corrosion of the metal surface
- Selective oxidation of grain boundaries



Compressive Forces

- Compressive forces are developed within ceramic system by properly designed coping with slightly higher co-efficient of thermal expansion than the porcelain veneered over it

- Sintering shrinkage and thermal contraction of porcelain will be resisted by the metal and compressive stresses will be set up in porcelain resulting in firm bonding of porcelain with the metal



Van der waals forces

- These forces comprise of an affinity based on mutual attraction of charged molecules
- They are minor force and not as significant as once thought however they play a major role in initiation of the most important bonding mechanism – the chemical bond
- The better the wetting of the metal surface, the greater the Van der Waals forces

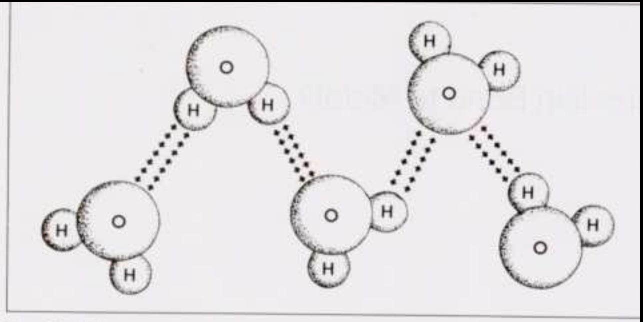


Fig 6-1 The attraction between the positively charged hydrogen *(H)* portion of one molecule and the negatively charged oxygen *(O)* of an adjacent molecule is one of the best examples of van der Waals forces.

Chemical Bonding

- Chemical bonding is generally accepted as the **primary** mechanism in the porcelain metal attachment process.
- Two mechanisms may exist with the chemical bonding theory. According to one hypothesis, the oxide layer is permanently bonded to the metal substructure on one side while the dental porcelain remains on the other.
- The oxide layer itself is sandwiched in between the metal substructure and the opaque porcelain.

- The second theory which is more accepted, suggests that the surface oxides dissolves or dissolved by the opaque layer of the porcelain
- The porcelain is then brought into atomic contact with the metal surface for enhanced wetting and direct chemical bonding so that metal and porcelain share electron
- Both covalent and ionic bonds are thought to form but only a monomolecular layer of oxide is believed to be required for chemical bonding to occur.

METAL-CERAMIC ALLOYS

System	Group
Noble metal alloys	
i) Gold-platinum-palladium	
ii) Gold-palladium-silver	High silver; Lower silver
iii) Gold-palladium	
iv) Palladium – silver	
v) High palladium	Copper; Silver-gold
Base Metal Alloys	
i) Nickel-Chromium	Beryllium; Beryllium-free
ii) Cobalt-Chromium	
iii) Other systems	

Alloy	Advantages	Disadvantages
Gold Platinum Palladium	- Excellent bonding to porcelain - Good castability - Easily finished and polished - Corrosion resistant and non-toxic - Excellent for producing occlusal surfaces	- Low sag or creep resistance, can distort at fine margins or warp on long span bridges - High cost
Gold Palladium Silver	- High melting range giving better creep resistance - Yield strength can be higher than some Au-Pt Pd alloys - Good castability - Easily finished and polished - Non-toxic - Low cost	- Silver content may cause greening of porcelain - High palladium content can increase risk of H2 gas absorption during casting - Bonding to porcelain not yet proven clinically or experimentally

Alloy	Advantages	Disadvantages
Palladium Silver Alloys	- High yield strength and modulus of elasticity - Suitable for long span bridges -Non-toxic -Low cost	- Difficult to cast - Does not reproduce fine margins like the high gold alloys - High silver content can interfere with bonding and cause discoloration of porcelain - High palladium content increases gas absorption - Poor color
Nickel Chromium alloys	- High modulus of elasticity and yield strength allows use in thinner section - Low cost	- Very difficult to cast accurately - Margins may be short or rough - Permanence of bond yet to be established - Can be toxic in nickel sensitive patients - Very difficult to remove from teeth in event of repair

Methods of Strengthening Ceramics

- Predictable strength of a substance is based on the strength of the individual bonds between the atoms in the material.
- However, the measured strength of most materials are 100 times lower than this theoretical value.
- **Reasons for low strength:**

- Minute scratches and other defects present on all the material, behave as sharp notches whose tips may be as narrow as the spacing between atoms.

- A phenomenon known as "**Stress concentration**" at the tips of these minute scratches or flaws causes the localized stress to increase to the theoretical strength of the material even though a relatively low average stress exists throughout the bulk of the structure.

METHODS OF STRENGTHENING CERAMICS

- Development of residual compressive stresses within the surface of the material
- Interruption of crack propagation
- Minimize the effect of stress raisers
- Minimize the number of firing cycles
- Minimize tensile stress through optimal design of ceramic prosthesis

Development of residual compressive stresses within the surface of the material.

- The metal and porcelain should be selected with slight mismatch in their thermal contraction coefficients
- This mismatch leave porcelain in residual compression and provides additional strength to prosthesis

Methods of introducing these residual compressive stresses are:

a) ***Ion exchange or chemical tempering*** is a process involving the exchange of larger potassium ions (K) for the smaller sodium ions (Na), a common constituent of a variety of glasses.

b) ***Thermal tempering*** is a common method. It creates residual surface compressive stresses by rapidly cooling (quenching) the surface of the object while it is hot and in the softened (molten) state.

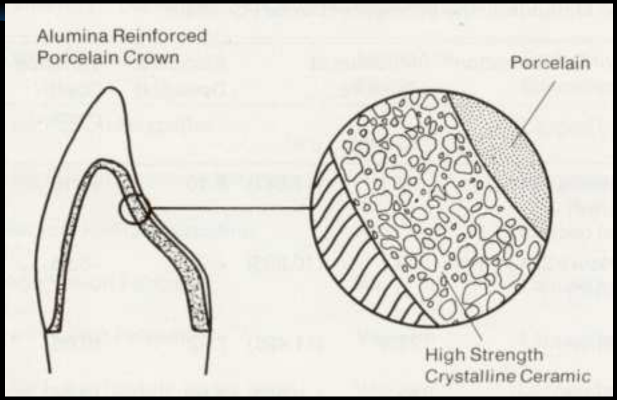
DISPERSION STRENGTHENING

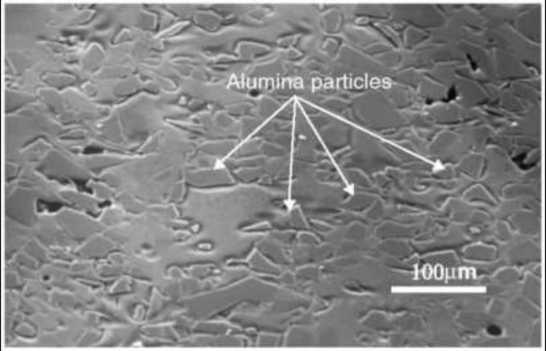
Reinforcing with dispersed phase of different material that is capable of hindering crack from propagating through the material is known…

Dental ceramics containing primarily glass phase can be strengthened by increasing the crystal content

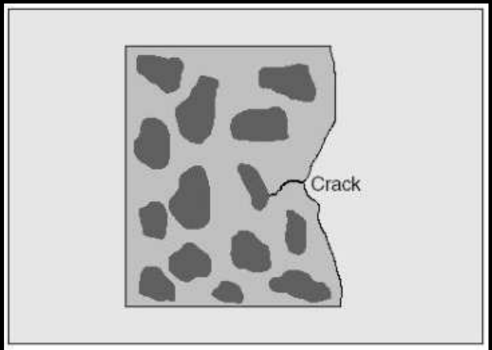
- Leucite
- Lithia disilicate
- Alumina
- Magnesia-alumina spinel
- Zirconia

Dispersion strengthening





Alumina Particles Acting as Crack Stoppers



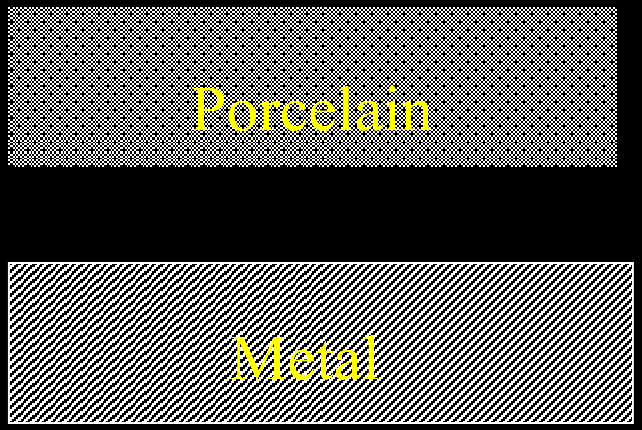
SEM of Alumina Reinforced Core showing the alumina particles embedded in a glassy matrix composed of feldspar

TRANSFORMATION TOUGHENING

- This technique involves the incorporation of a crystalline material that is capable of undergoing a change in crystal structure when placed under stress
- The crystal material usually used is termed partially stabilized zirconia (PSZ)

TYPES OF METAL-PORCELAIN BOND FAILURE (O'Brien-1977)

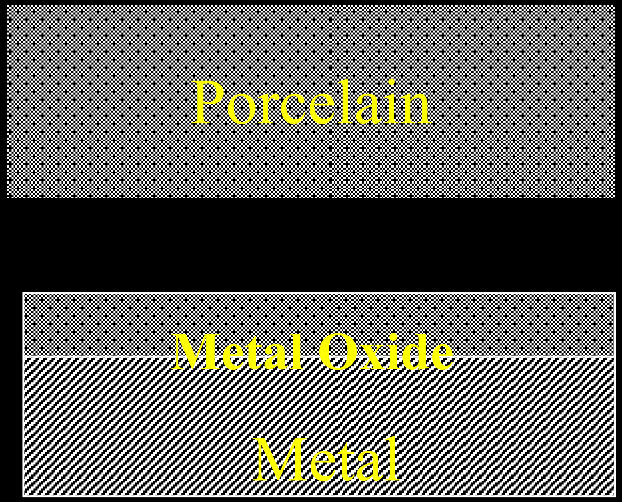
- The interfacial fracture occurs leaving a clean surface of metal
- It is generally seen when metal surface is totally depleted of oxide
- Contaminated or porous metal surface



METAL –PORCELAIN

Classification of bond failures in Metal-Ceramics (O'Brien-1977)

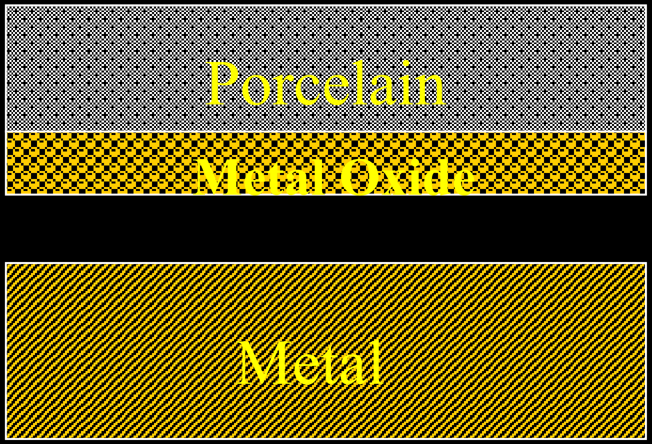
- Porcelain fractures at metal oxide surface, leaving the oxide firmly attached to the metal
- Common type of failure in base metal alloy system



METAL OXIDE - PORCELAIN

TYPES OF METAL-PORCELAIN BOND FAILURE (O'Brien-1977)

- In this type metal oxide breaks away from the metal substrate and is left attached to the porcelain
- Common cause of failure in base metal system when there is over production of chromium and nickel oxide at the interface

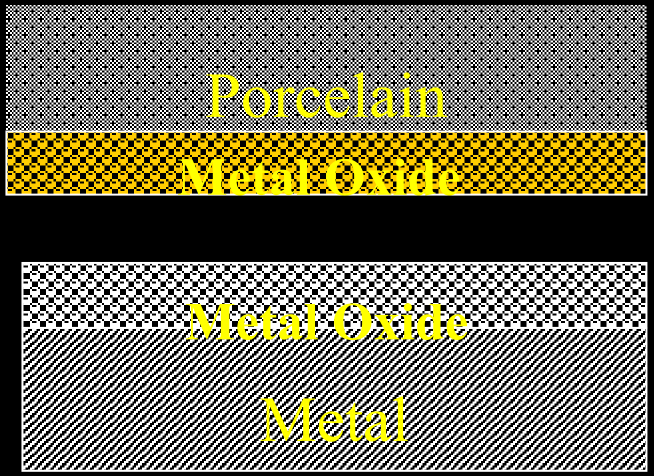


METAL - METAL OXIDE

TYPES OF METAL-PORCELAIN BOND FAILURE

(O'Brien-1977)

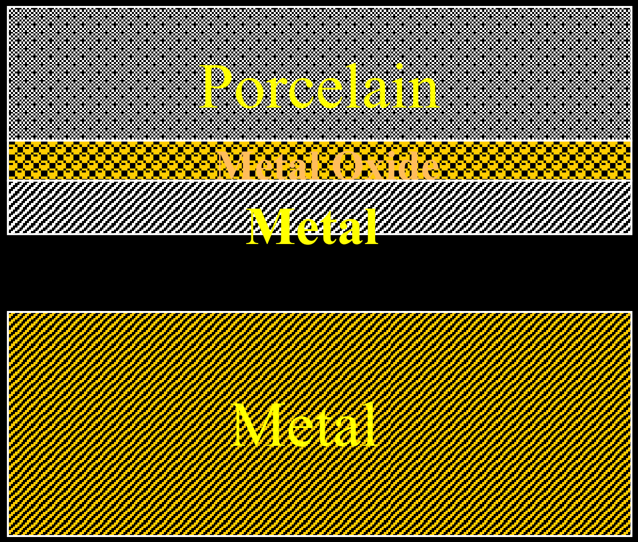
- Fracture occurs through the metal oxide at the interface and results from an over-production of oxide causing a sandwich effect between metal and porcelain



METALOXIDE - METAL OXIDE

TYPES OF METAL-PORCELAIN BOND FAILURE (O'Brien-1977)

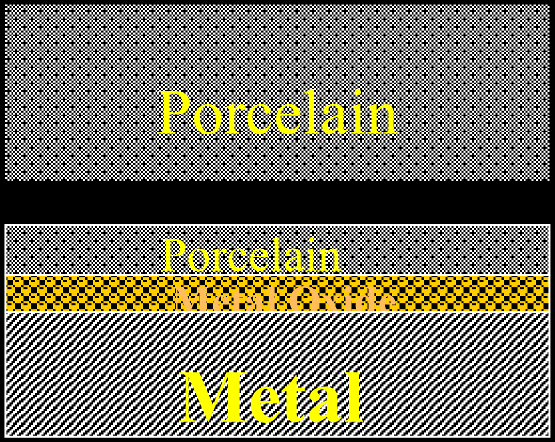
This type would only occur in cases e.g. where joint area in bridges break



COHESIVE WITHIN METAL

TYPES OF METAL-PORCELAIN BOND FAILURE (O'Brien-1977)

- In this type tensile failure occurs within the porcelain
- Bond strength exceeds strength of the porcelain
- Most common in high gold content alloys



COHESIVE WITHIN PORCELAIN

BENEFITS

- Fracture resistant
- Esthetic fixed partial denture
- Maximum retention
- Easy correction of the axial form
- superior marginal fit
- Close simulation of natural appearance.

DRAWBACKS

- Increased potential of gingival problems
- More tooth reduction
- Possible abrasive damage to opposing dentition
- Inhalation of silicon dust
- Difficult in accurate shade selection
- Chemical degradation
- Plaque accumulation
- Difficulty to obtain accurate occlusion in glazed porcelain
- Inferior esthetics compare to all-ceramic material

Thank you

End of part 3

Ceramics…

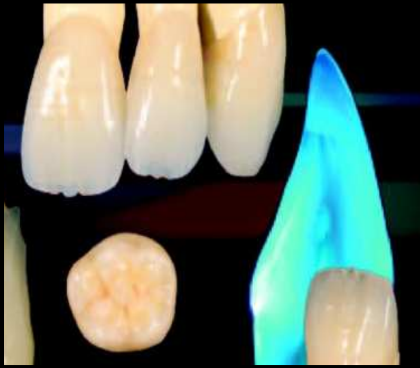
Part 4

METAL FREE CERAMICS

CONTENTS

- Introduction
- Classification
- Conventional/powder slurry systems
- Castable ceramics
- Pressable ceramics
- Infiltrable ceramics
- Machinable ceramics
- Conclusion
- Bibliography






INTRODUCTION

"The rewards are many but must not be taken for granted as many advances have been made in the field of metal free ceramics, they should be used with caution and only in those patients who demand ultimate esthetics or who have developed allergy to specific metal elements.

INTRODUCTION

- The metal base in metal ceramic restoration can affect the esthetics by decreasing the light transmission through the ceramic and by creating metal ion discolorations.
- In addition some patients have allergic reaction or sensitivity to various metals.
- These drawbacks have prompted the development of *All ceramic* system that do not require metal, yet have high strength and precision fit of ceramo-metal systems.

DEFINITION

The term "*All-Ceramic*" refers to – *Any restorative material composed exclusively of ceramic, such as feldspathic porcelain, glass-ceramic, alumina core systems and certain combination of these materials*. (J. Esth Dent 1997, 9 (2): 86).

ADVANTAGES OF ALL-CERAMIC RESTORATIONS

- Increased translucency
- Improved fluorescence
- Greater contribution of color from underlying tooth structure
- Inertness
- Biocompatibility
- Resistance to corrosion
- Low thermal or electrical conductivity


All Ceramic and Metal Bond Porcelain
Hideki Kawahara D.D.S.

CLASSIFICATION

- CONVENTIONAL / POWDER SLURRY SYSTEMS
- CASTABLE CERAMICS
- PRESSABLE CERAMICS
- INFILTRATED CERAMICS
- MACHINABLE CERAMICS




CONVENTIONAL / POWDER SLURRY CERAMICS

- ***Alumina – Reinforced porcelain (Aluminous Porcelain)***

  Eg: Hi-Ceram

  Vitadur – N core

- ***Magnesia–Reinforced porcelain(magnesia core ceramics)***

- ***Leucite Reinforced (Non-pressed)***

  Eg: Optec HSP

  Optec VP

  Fortress

  Cerinate

- ***Low fusing ceramics***

  Hydrothermal low fusing ceramic

  Eg: Duceram LFC

  Finesse

- ***Zirconia whisker- fibre reinforced***

  Eg: Mirage II

ALUMINA-REINFORCED PORCELAIN (ALUMINOUS PORCELAINS)

- **McLean & Hughes(1965)** introduced Alumina – reinforced porcelain containing up to 50wt% Al_2O_3.
- These were developed with the object of improving the strength of PJC without sacrificing esthetics.
- 40% stronger than feldspathic porcelain
- Flexural strength-120mpa

PLATINUM FOIL TECHNIQUE

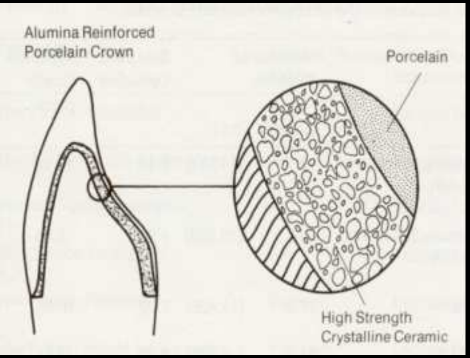
- A core of aluminous porcelain is applied and fired on substrate of platinum foil
- Layers (veneers) of more translucent but weaker porcelain is then applied and fired until the crown form is completed
- The platinum foil is removed from inside the crown after the completion of the firing process

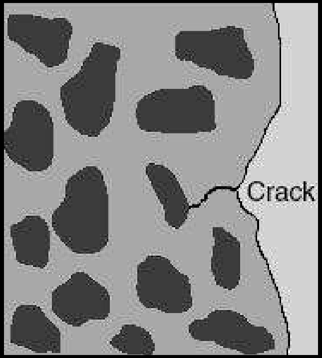
TWIN FOIL TECHNIQUE

- Two platinum foils are placed in close approximation to each other.
- Inner foil of 0.025mm provides matrix for the baking of porcelain.
- Outer foil which forms the inner skin of crown is tin plated and oxidized to achieve chemical bond with porcelain.
- The outer or bonded foil remains in position on internal fit surface of the crown and will eliminate surface micro cracks in the porcelain.

ALUMINOUS CORE PORCELAIN

- Contains 40-50wt% fused alumina crystals
- Alumina particles dispersed in the glass matrix have very high tensile strength… interrupts crack propagation
- Incorporation of alumina produces dull/ opaque porcelain with lack of translucency…
- Although improved in strength, it is still insufficient to bear high stresses





DISADVANTAGES

- Requires specially formulated and compatible enamel and dentin porcelains for veneering.
- Improvement in strength is insufficient to bear high stresses.
- Fracture resistance in the aluminous PJC was improved by a technique in which the platinum matrix was left in the completed restoration.
- The platinum foil matrix not only provided additional support to the porcelain; it also allowed a chemical bond with the tin-plated foil… decreases esthetics

MODIFICATIONS

HI-CERAM

- It is a dispersion strengthened core crown fabricated utilizing a refractory die.
- It is similar in chemistry to the traditional alumina core, but has a higher alumina content.
- When fired directly on the refractory die a naturally rough surface finish is obtained which contributes to the retention of the restoration.
- Flexural strength is approximately – 155 MPa

MAGNESIA – REINFORCED PORCELAIN

- **O'Brien** in **1984**
- ***Magnesia core ceramics-***high expansion ceramic used as core material for metal ceramic veneer porcelain
- These are dispersion strengthened core ceramics made by fine dispersion of crystalline magnesia (40-60%) i.e.; precipitation of fine '*Forsterite*' crystals into the glass matrix surrounding the unreacted magnesia
- magnesia crystals strengthen the glass matrix by both dispersion strengthening and crystallization within the matrix.

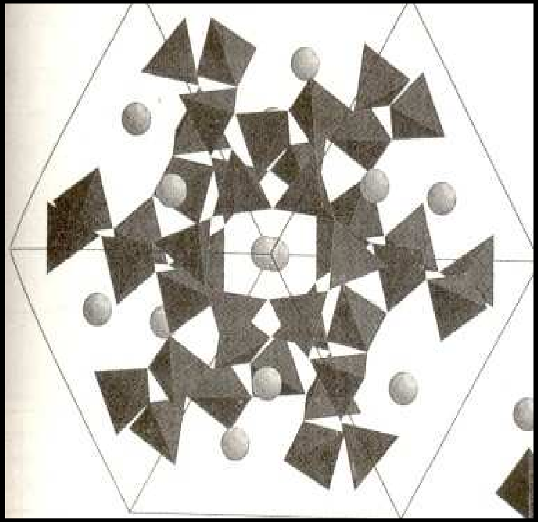
ADVANTAGES

- Increased coefficient of thermal expansion ($14.5x10^{-6}/^{0}C$) improves its compatibility with conventional feldspathic metal veneering porcelains (CTE: 12 to $15x10^{-6}/^{0}C$

- Improved strength and a high expansion property compared to conventional feldspathic porcelain makes it suitable for use as a core material , thus substituting for a metallic core as substructure

LEUCITE – REINFORCED PORCELAINS

Leucite-reinforced glass ceramics are feldspathic porcelains, dispersion strengthened by crystallization of leucite crystals in the glass matrix.



OPTEC HSP (HIGH STRENGTH PORCELAIN)

- *It* is leucite reinforced feldspathic porcelain that is condensed and sintered like aluminous and traditional feldspathic porcelain on a refractory die instead of a platinum foil .

- Despite the increase in crystallization, the material retains its translucency because of closeness of the refractive index of leucite with that of the glass matrix .

- The flexural strength is 140 MPa.

ADVANTAGES

- Despite lack of metal or opaque substructure, it has high strength by leucite reinforcement, hence can be used as a core material.
- Good translucency
- Moderate flexural strength
- No special laboratory equipment needed.

DISADVANTAGES

- Potential marginal inaccuracy caused by porcelain sintering shrinkage.
- Potential to fracture in posterior teeth.
- Increased leucite content may contribute to high abrasive effect on opposing teeth.

PRIMARY USES

Inlays , onlays, crowns and veneers

HYDROTHERMAL CERAMICS

- New category of ceramics…hydroxyl groups introduced into the ceramic structure under heat and steam from which the term '*hyrdothermal*' ceramic is derived.
- The hydroxyl addition which Bertschetein and Stepanov…"*a palstified layer*" increases chemical resistance; generates a "smoother" surface profile, and possesses the unique capacity of "healing" surface flaws through the ion exchange process.

SELF HEALING EFFECT OF HYDROXYL SURFACE LAYER

- Conventional porcelains containing surface micro flaws can result in surface discoloration and reduction in flexural strength.

- In hydrothermal ceramics an ionic exchange occurs between alkali and hydroxyl groups at the surface layer.

- This ionic exchange is suggestive of an effect of "*healing*" surface flaws, thereby contributing to an increase in strength

DUCERAM LFC

- Low fusing hydrothermal ceramic composed of an amorphous glass containing hydroxyl (-OH) ions.

FABRICATION

- Duceram MC is condensed on a refractory die using conventional power slurry technique and sintered at 930^0C.
- Over this base layer, Duceram LFC is condensed and sintered at 660^0C.
- Being highly polish able they do not require glazing.

ADVANTAGES OVER FELDSPATHIC PORCELAIN

- Greater density
- Higher flexural strength attributed to -OH ion exchange and sealing of surface micro cracks
- Greater fracture resistance
- Lower abrasion than feldspathic porcelain (wear rate equal to that of natural teeth)
- Surface resistant to chemical attack by fluoride containing agents
- Highly polish able, not requiring re-glazing during adjustment

DISADVANTAGES

Cannot be directly sintered on the metallic substructure because of the low coefficient of expansion. Thus, an inner lining of conventional high-fusing ceramic is required on the metal substructure because of the low coefficient of expansion.

CASTABLE CERAMICS

CASTABLE GLASS CERAMICS

Glass-ceramics are polycrystalline materials developed for application by casting procedures using the lost wax technique, hence referred to as **"castable ceramic"**.

Glass ceramics in general are partially crystallized glass and show properties of both crystalline and amorphous (glassy) materials.

CASTABLE GLASS CERAMIC

FLUROMICAS

eg: Dicor

APATITE GLASS CERAMICS

eg: Cerapearl

OTHER GLASS CERAMICS

- Lithia based
- Calcium phosphate based

DICOR

- Dentsply International and Corning Glass
- First commercially available castable glass-ceramic.
- It is a castable polycrystalline fluorine containing tetrasilicic mica glass-ceramic (55 vol%) initially cast as glass by lost-wax technique and subsequently heat treated resulting in a controlled crystallization to produce glass ceramic material.

FABRICATION OF CASTABLE GLASS CERAMIC

CASTING   CERAMMING

Equipment

- DICOR Casting Machine
- DICOR Ceramming Furnace with Ceramming Trays

CASTING

The glass liquefies at 1370°C to such a degree that it can be cast into a mold using lost wax and centrifugal casting techniques

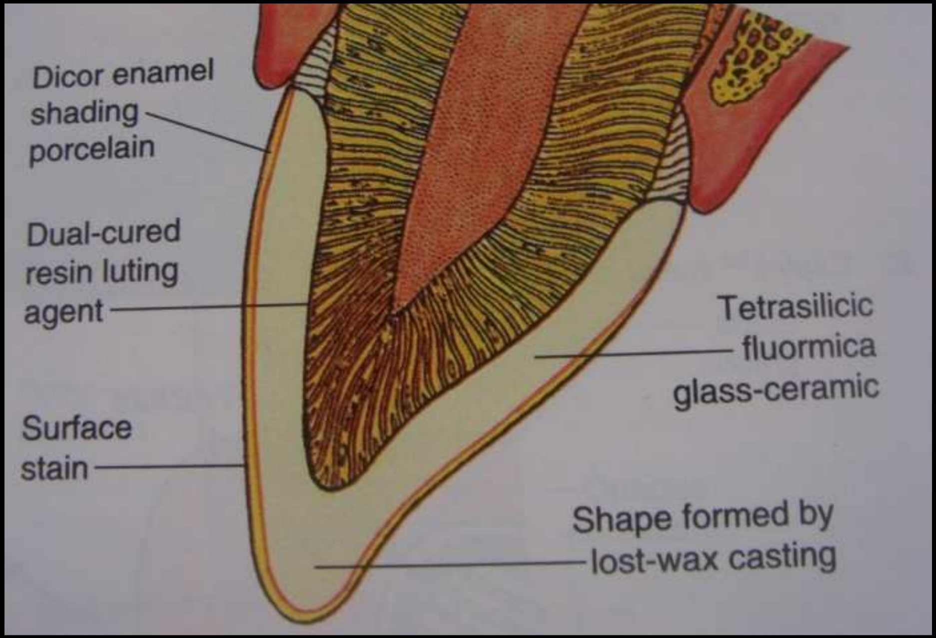
CERAMMING

- The cast glass material is subject to a single-step heat treatment called as '***Ceramming***' to produce controlled crystallization.

- It gives glass ceramic the special physical and mechanical properties of DICOR.

- ***Ceramming cycle :*** 650-1075°C for 1 and1/2 hr and sustained up to 6 hours.

- Following ceramming process a "*Ceram layer*" or '*skin*' of 25-100µm thickness is formed on the surface of DICOR restoration.
- It contains '*whiskers*' crystals that are oriented perpendicular to the external surface which increases opacity.
- The outer 'skin' may or may not be removed following ceramming process, depending on the level of translucency desired in the final restoration



CHAMELEON EFFECT OF DICOR

- The transparent crystals scatter the incoming light.
- Light is disbursed as if it is bouncing off large number of small mirrors that reflect the light and spread it over the entire glass ceramic.
- Dicor change color according to its surroundings, which enhances its esthetic properties.

ADVANTAGES

- Chemical and physical uniformity.
- Excellent marginal adaptation (fit).
- Compatibility with lost-wax casting process.
- Uncomplicated fabrication procedure
- Excellent esthetics.
- Relatively high strength (152 MPa), surface hardness and occlusal wear similar to enamel.
- Inherent resistance to bacterial plaque and biocompatible
- Low thermal conductivity.
- Radiographic density is similar to that of enamel.

DISADVANTAGES

- Requires special and expensive equipments-Dicor casting machine, ceramming furnace
- Failure rates as high as 8% in the posterior region
- Dicor must be shaded/ stained with low fusing feldspathic porcelain to achieve acceptable esthetics, however the entire stain may be lost during occlusal adjustment and during routine dental prophylaxis or through the use of acidulated fluoride gels.

DICOR PLUS

- Consists of a cast cerammed core (Dicor substrate) and shaded feldspathic porcelain veneer.
- As, it is a feldspathic porcelain that contains leucite, abrasiveness is expected to be similar to other feldspathic porcelains

WILLIS GLASS

- Consists of a Dicor cast cerammed core and a Vitadur-N porcelain veneer similar in nature to that used for Dicor Plus

ADVANTAGES OF CASTABLE GLASS CERAMICS

- High strength because of controlled particle size reinforcement.
- Excellent esthetics resulting from light transmission similar to that of natural teeth and convenient procedures for imparting the required color.
- Accurate form for occlusion, proximal contacts, and marginal adaptation.
- Uniformity and purity of the material.

CASTABLE APATITE GLASS CERAMIC

- **1985 -Sumiya Hobo & Iwata**
- Available as CERA PEARL.
- **Chemistry**: Apatite glass-ceramic melts (1460°C) and flows like molten glass and when cast (1510°C) it has an amorphous microstructure
- Cerapearl is similar to natural enamel in composition, density, refractive index, coefficient of thermal expansion and hardness
- Bonding to tooth structure

- Favorable soft tissue response.
- X-ray density allowing examination by radiograph
- Hardness and wear properties closely matched to those of natural enamel
- Similar thermal conductivity and thermal expansion to natural enamel
- Dimensional stability regardless of any porcelain corrective procedure and subsequent firings

PRESSABLE CERAMICS

PRESSABLE CERAMICS

Shrink-free Ceramics

Cerestore
AI Ceram

Leucite reinforced Glass ceramics

IPS Empress
OPC

Shrink Free Alumina Ceramics

- The shortcomings of the traditional ceramic like failures related to poor functional strength and firing shrinkage limited use of "all-ceramic" for jacket crowns.
- The development of non-shrinking ceramics directed towards providing an alternate treatment.

CERESTORE

Shrink free ceramic with crystallized magnesium alumina spinel fabricated by injection molded technique to form dispersion strengthened core.

ADVANTAGES

- Good dimensional stability
- Better accuracy of fit and marginal integrity
- Esthetics enhanced due to the lack of metal coping
- Biocompatible
- Low thermal conductivity
- Low coefficient of thermal expansion

DISADVANTAGES

- Complexity of the fabrication process.
- Need for specialized laboratory equipment
- Inadequate flexural strength (89MPa)
- Poor abrasion resistance, hence not recommended in patients with heavy bruxism or inadequate clearance.
- Limitations and high clinical failure rates led to its withdrawal from the market. It underwent further improvement with a 70 to 90% higher flexural strength and was marketed under the commercial name Al Ceram

AL CERAM

- Recrystallization of residual glass – Fracture toughness 22.5 MN/m² (32,000psi)
- High polycrystalline content
- Same relative thermal conductivity of core and veneer porcelain
- Low coefficient of thermal expansion - Thermal shock resistance.
- High modulus of elasticity - Low stress on cement.

LEUCITE REINFORCED PORCELAINS (TRANSFER-MOLDED)

PRESSED

- IPS Empress & IPS Empress 2
- Optec Pressable Ceramic / OPC

NON-PRESSED

- Optec HSP
- Optec VP
- Fortress

IPS EMPRESS

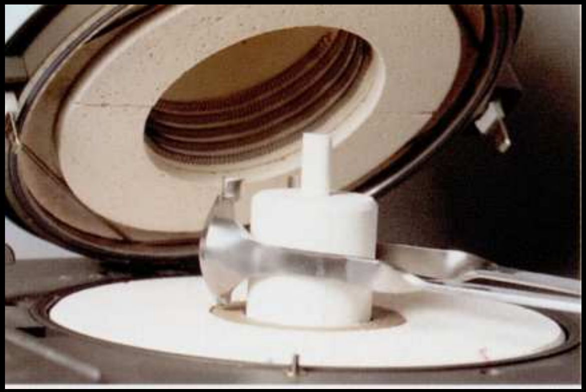
- Precerammed glass ceramic having a high concentration of leucite crystals ie.35 vol%($KAlSi_2O_6$).
- It increases the resistance to crack propagation.
- Leucite reinforced ceramic powder is pressed into ingots and sintered.
- The ingots are heated in the pressing furnace until molten and then injected into the investment mold.

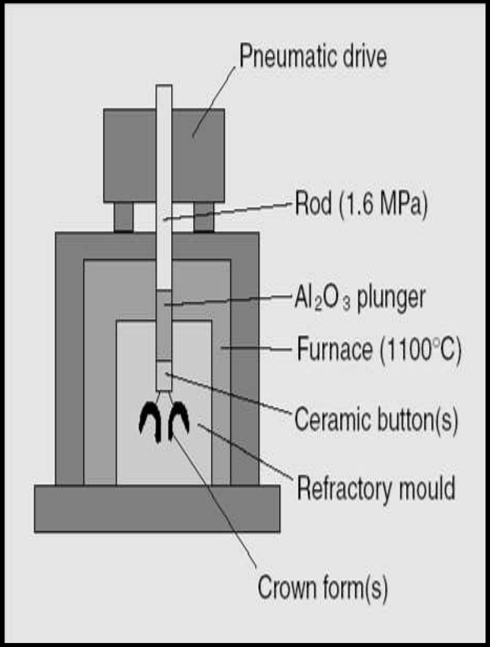
FABRICATION

Lost-wax technique: wax pattern is invested in a special flask using IPS Empress special investment material (phosphate bonded).

PRESSING PROCEDURE

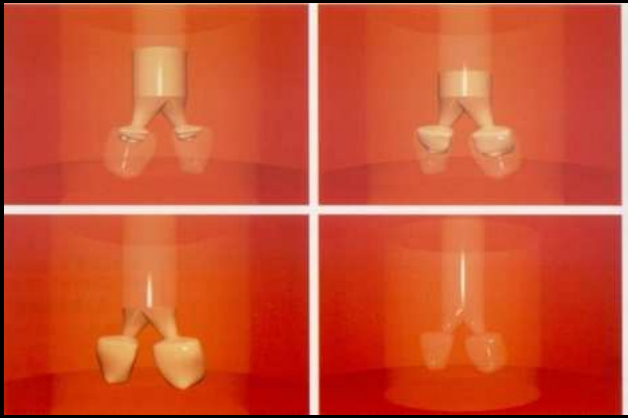
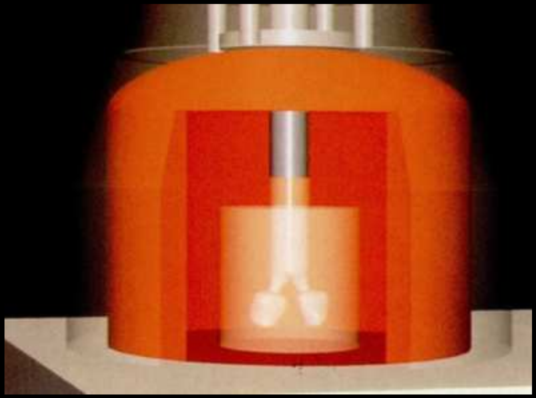
- Following burnout (at 850°C) the crucible former is placed into a specialized automated furnace that has an alumina plunger.





PRESSING PROCEDURE

- The ceramic ingot is placed under plunger and the entire assembly is preheated to 1,100ºC .
- When the temperature reaches 1150ºC after a 20 minute holding time the plunger presses the ceramic under vacuum (0.3-0.4 MPa) into the mold, in which it is held under pneumatic pressure (for a 45-minute period) to allow complete and accurate fill of the mold.

PROPERTIES

- Reported flexural strengths are in the range of 160 to I80MPa.
- Increase in strength has been attributed to the pressing step which increases the density of leucite crystals.
- Subsequent heat treatments which initiate growth of additional leucite crystals.

USES

- Laminate veneers and full crowns for anterior teeth
- Inlays, Onlays and partial coverage crowns
- Complete crowns on posterior teeth.

ADVANTAGES

- Lack of metal or an opaque ceramic core
- Moderate flexural strength (120-180MPa range)
- Excellent fit (low-shrinkage ceramic)
- Improved esthetics (translucent, fluorescence)
- Etchable
- Less susceptible to fatigue and stress failure
- Less abrasive to opposing tooth
- Biocompatible material
- Unlike previous glass-ceramic systems IPS Empress does not require ceramming to initiate the crystalline phase of leucite crystals

DISADVANTAGES

- Potential to fracture in posterior areas
- Need for special laboratory equipment such as pressing furnace and die material
- Inability to cover the colour of a darkened tooth preparation or post and core since the crowns are relatively translucent.
- Difficulty in removing the crown and cementing medium during replacement.
- Compressive strength and flexural strength lesser than metal-ceramic or glass-infiltrated (In-Ceram) crowns.

OPTEC (OPTIMAL PRESSABLE CERAMIC/OPC)

- Optec stands for Optimal Technology.
- Crystalline leucite particle size has been reduced with a more homogenous distribution without reducing the crystalline content and increased leucite content has resulted in an overall increase in flexural strength of OPC
- However, because of its high leucite content, its abrasion against natural teeth is higher than that of conventional feldspathic porcelain.
- Fabrication is similar to IPS Empress

IPS EMPRESS 2

- Second generation of pressable materials for all-ceramic bridges.
- It is made from a lithium disilicate framework with an apatite layered ceramic.
- The apatite crystals incorporated are responsible for the improved optical properties (translucency, light scattering) which contribute to the unique chameleon effect of leucite glass-ceramic materials.

	IPS Empress	**IPS Empress 2 (frame work)**
Flexural strength	Upto 150 MPa	> 400 Mpa

INFILTERATED CERAMICS

INFILTRATED CERAMICS

- IN-CERAM
  - IN-CERAM ALUMINA
  - IN-CERAM SPINELL
  - IN-CERAM ZIRCONIA

INCERAM

- An improved high aluminous porcelain system termed **In-Ceram** was developed by **Dr. Michael Sadoun** in 1980

COMPOSITION

- Alumina/ Al203 crystalline 99.56 wt%
- Lanthanum aluminosilicate with small amounts of Na and Ca
- Lanthanum-decreases the viscosity of the glass to assist infiltration and increases its refractive index to improve translucency

USES

- Single anterior & posterior crowns
- Anterior 3-unit FPD's

In-Ceram Crown process involves three basic steps :

- Dense core is made by slip casting of fine grained alumina particles and sintered.
- The sintered alumina core is infiltrated with molten glass to yield a ceramic coping of high density and strength.
- The infiltrated core is veneered with feldspathic porcelain and fired.

ADVANTAGES

- Minimal firing shrinkage, hence an accurate fit.
- High flexure strength (almost 3 times of ordinary porcelain) makes the material suitable even for multiple-unit bridges
- Aluminous core being opaque can be used to cover darkened teeth or post/ core.
- Wear of opposing teeth is lesser than with conventional porcelains.
- Improved esthetics due to lack of metal as substructure.
- Biocompatible, diminished plaque accumulation,

  biochemical stability.

DISADVANTAGES

- Requires specialized equipment
- Poor optical properties.
- Incapability of being etched with HF acid.
- Slip casting is a complex technique and requires considerable practice.
- Requires considerable reduction of tooth surface all over for adequate thickness of restoration.

IN-CERAM SPINELL

- Due to the comparatively high opacity of the alumina core, this material was introduced.
- Incorporating magnesium aluminate (spinel) results in improved optical properties characterized by increased translucency with about 25% reduction in flexural strength.

DISADVANTAGES

- Lower strength and toughness.

USES

- Anterior inlay, onlay ,veneers and anterior crowns.

IN-CERAM ZIRCONIA

- The In-Ceram technique was expanded to include its modified form with zirconia.
- A mixture of zirconium oxide and aluminum oxide is used as a framework material, the physical properties were improved without altering the proven working procedure.
- The final core of ICZ consists of 30 wt% zirconia and 70 wt% alumina.

ADVANTAGES

- High flexural strength 700 MPa (2 to 3 times the impact capacity as the ln-Ceram Alumina), excellent marginal accuracy and biocompatibility.

DISADVANTAGES

- Poor esthetics due to increased opacity.
- Inability to etch.

USES

- Posterior crowns and FPD’s.

MACHINABLE CERAMICS

- Until 1988, indirect ceramic dental restorations were fabricated by conventional methods (sintering, casting and pressing) and neither were pore-free.
- The tremendous advances in computers and robotics could also be applied to dentistry and provide both precision and reduce time consumption.
- With the combination of optoelectronics, computer techniques and sinter-technology, the morphologic shape of crowns can be sculpted in an automated way.

MACHINING CERAMIC SYSTEM

CAD-CAM (DIGITAL)

DIRECT	INDIRECT
Cerec 1	Automill
Cerec 2	Denti CAD

COPYING SYSTEMS (ANALOGOUS)

1. MANUAL
   eg: Celay
2. AUTOMATIC
   eg: Ceramatic

1. SONOEROSION
   eg: DFE Erosonic
2. SPARK EROSION
   eg: DFE Procera

TRIAD OF FABRICATION

Traditional technique	High technology
Data acquisition or information by impressions and translated into articulated stone casts	**Data acquisition** or information is captured electronically, either by a specialized camera, laser system, or a miniature contact digitizer.
Restoration design is the process of creating the wax pattern	**Restoration design** is done by the computer – either with interactive help from the user or automatically.
Restoration fabrication includes all the procedures from dewaxing upto the final casting (lost wax technique)	**Restoration fabrication** includes machining with computer controlled milling machines, electrical discharge machining and sintering

CAD CAM

- Uses digital information about the tooth preparation or a pattern of the restoration to provide a computer-aided design (CAD) on the video monitor for inspection and modification.
- The image is the reference for designing restoration on video monitor.
- Once the 3-D image for the restoration design is accepted, computer translates the image into a set of instructions to guide a milling tool (computer-assisted manufacturing [CAM]) in cutting the restoration from block of material.

STAGES OF FABRICATION

All systems ideally involve 5 basic stages:

1. Computerized surface digitization
2. Computer - aided design
3. Computer - assisted manufacturing
4. Computer - aided esthetics
5. Computer - aided finishing

SEQUENTIAL EVENTS OCCURING DURING CAD – CAM TECHNIQUE IN FABRICATING CERAMIC RESTORATION :

The cavity preparation is scanned stereo-photogram metrically, using a three-dimensional miniature video camera

↓

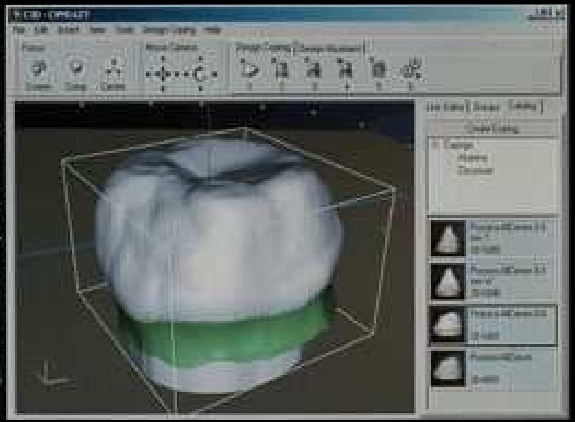
The small microprocessor unit stores the three dimensional pattern depicted on the screen

↓

The video display serves as a format for the necessary manual construction via an electric signal

↓

The microprocessor develops the final three-dimensional restoration from the two dimensional construction



SEQUENTIAL EVENTS OCCURING DURING CAD–CAM TECHNIQUE OF FABRICATING CERAMIC RESTORATION

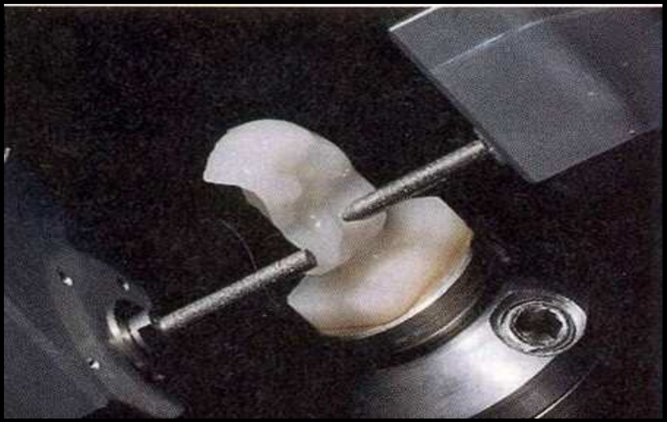
The processing unit automatically deletes data beyond the margins of the preparation

↓

The electronic information is transferred numerically to the miniature three-axis milling device

↓

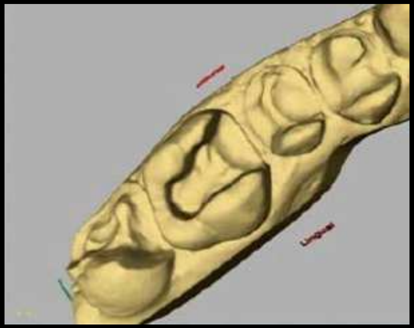
Driven by a water turbine unit, the milling device generates a precision fitting restoration from a standard ceramic block



UNESTHETIC AMALGAM

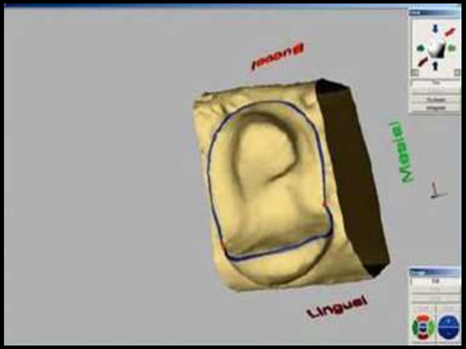
RESTORATION REMOVED AND REFINED

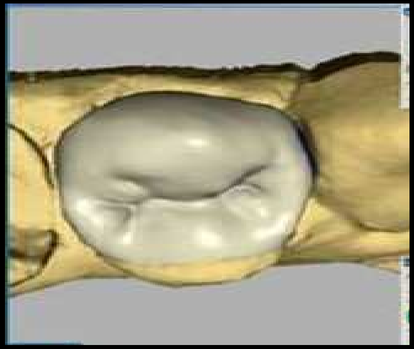
COAT WITH TiO_2 FOR OPTICAL SCANNING



PREPARATION OF VIRTUAL MODEL

MARGINS OUTLINED FOR RESTORATIION DESIGN





RESTORATION READY FOR MILLING

CEREC SYSTEM

The CEREC (Ceramic Reconstruction) was originally developed by Brains AG in Switzerland. Identified as CEREC CAD/CAM system, it was manufactured in West Germany

Cerec System consists of :

- 3-D video camera (scan head)
- Electronic image processor (video processor) with memory unit (contour memory)
- Digital processor (computer)
- Miniature milling machine (3-axis machine)

CEREC 1

The main change or revolution in the hardware of Cerec 1 machine was the introduction of an electrically driven milling machine with a more efficient cutting disc.

Clinical shortcomings of Cerec 1 system

- Although the CEREC system generated all internal and external aspects of the restoration, the occlusal anatomy had to be developed by the clinician.
- Inaccuracy of fit or large interfacial gaps.
- Clinical fracture related to insufficient depth of preparation.
- Relatively poor esthetics due to the uniform colour and lack of characterization in the materials

CEREC 2

The introduction of Cerec 2 unit at the end of 1994 addressed virtually all of the limitations of Cerec 1

MAJOR CHANGES INCLUDE

- Upgrading of the software with more sophisticated technology which allows machining of occlusal surfaces and the complex machining of the floor parts.
- The new camera provides more data with greater accuracy resolving down to 25 μ.
- The milling machine was replaced with multihead version incorporating two cutting heads with a total of 120^0 of freedom
- Enlargement of the grinding unit from 3 axes to 6 axes.

CEREC 3

- Milling chamber is separate from the imaging/designing unit.
- The system is now Windows based.
- CEREC 3 can be used in conjunction with a CEREC 2 by using the 'Link' software.
- Two burs (one is tapered) do the cutting instead of one bur and one diamond wheel.
- No 'adjust' process (time savings).
- Faster milling times (5 min savings).
- Greater occlusal anatomy.
- All design windows can be opened at once.

CEREC PROCEDURE

BENEFITS OF CEREC SYSTEM

Benefits for the patient:

- Esthetics
- Biocompatible
- Cost-effective
- Quick turn-around time (1 day laboratory time)
- In case of in-office procedure, only one visit required
- Perfect occlusion
- High marginal integrity
- No metal in mouth

BENEFITS FOR THE DENTIST

- Economic production in the laboratory
- Increased precision
- Better interproximal integrity
- No polishing needed
- Contacts optimized in the laboratory
- Negligible porosity levels
- Freedom from making an impression
- Need for only single patient appointment
- Good patient acceptance

DISADVANTAGES

- Limitations in the fabrication of multiple units.
- Inability to characterize shades and translucency.
- Inability to image in a wet environment
- Incompatibility with other imaging system.
- Extremely expensive and limited availability.
- Few long-term studies on the durability of the restorations.
- Lack of computer-controlled processing support for occlusal adjustment.
- Technique sensitive

MACHINABLE CERAMICS

The industrially prefabricated ceramic ingots/ blank used are practically pore-free which do not require high temperature processing and glazing, hence have consistently high quality.

Two classes of machinable ceramics available are:

- Fine-scale feldspathic porcelain
- Glass-ceramics

CEREC VITABLOC MARK I

This feldspathic porcelain was the first composition used with the Cerec system with a large particle size (10 - 50µm). It is similar in composition, strength, and wear properties to feldspathic porcelain used for metal-ceramic restorations.

CEREC VITABLOC MARK II

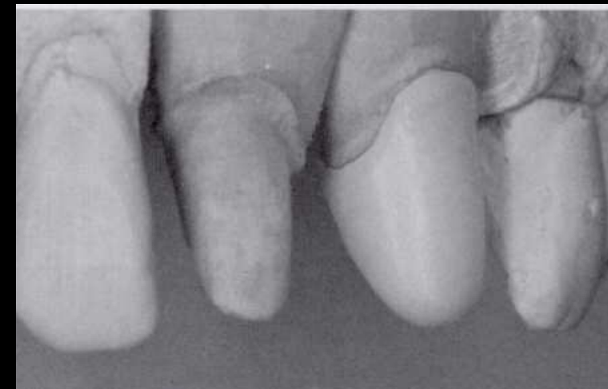
This is also a feldspathic porcelain reinforced with aluminum oxide (20-30%) for increased strength and has a finer grain size (4µm) than the Mark I composition to reduce abrasive wear of opposing tooth.

DICOR MGC

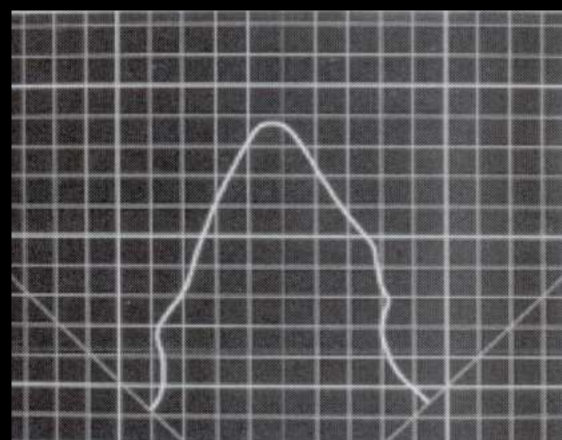
- Composed of fluorosilica mica crystals in a glass matrix.
- Mica plates are smaller (average diameter 2 um) than in conventional Dicor
- Greater flexural strength than castable Dicor
- Softer than conventional feldspathic porcelain.
- Less abrasive to opposing tooth than Cerec Mark I, and more than Cerec Mark II

PROCERA ALLCERAM

- It is composed of densely sintered, high purity aluminum oxide core combined with a compatible all ceram veneering porcelain
- A unique feature of the procera system is the ability of the procera scanner to scan the surface of the prepared tooth and transmit the data to the milling unit to produce an enlarged die through a CAD-CAM processor.
- The core ceramic is dry pressed on to the die, sintered and veneered.



CONTACT SCANNER



MILLING UNIT

OTHER MACHINABLE CERAMICS

- Bioglass
- Empress / Vivadent
- MGC -F
- Pro CAD
- Celay

OTHER DIGITAL SYSTEMS

- The COMET SYSTEM
- The Duret System
- The Denti CAD svstem
- The SOPHA System
- The REKOW Svstem
- The DUX system/The Titan System
- CICERO System (Computer Integrated Crown Reconstruction)

ANALOGOUS SYSTEMS

(COPYING / PANTOGRAPHY METHODS)

COPY MILLING

- Mechanical shaping of an industrially prefabricated ceramic material, which is consistent in quality and its mechanical properties.
- It includes fabrication of a prototype (pro-inlay or crown) usually via impression making and model preparation.
- Based on the model, a replica of inlay/ crown is made and fixed in the copying device and transferred 1:1 into the chosen material such as ceramic.

COPY MILLING

The pattern is placed in the machine

↓

Tracing tool passes over the pattern and guides a milling tool which grinds a copy of the pattern from a block of ceramic

EROSION METHODS

- It needs a copy-suitable pre-version (e.g.: pro-inlay) in the form of a negative model of the interior and exterior contour of the restoration for its fabrication.
- The (metal-based) negative form is prepared either by wax molding and casting or by intensive copper plating of the impression.

  Sono erosion - for ceramic restoration

  Spark erosion - for metal restorations

SONO EROSION

- Based on ultrasonic methods. The ceramic blank is surrounded by an abrasive suspension of hard particles, such as boron carbide, which are accelerated by ultrasonics, and thus erode the restoration out of the ceramic blank.

SPARK EROSION

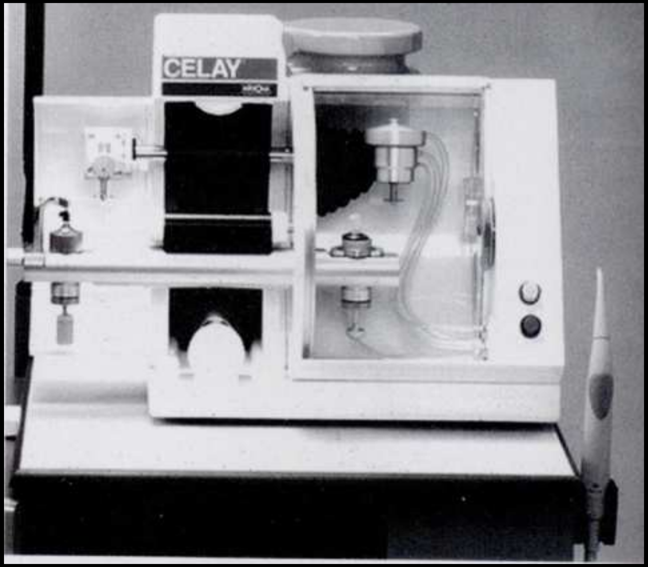
- 'Electrical Discharge Machining' (EDM).
- Defined as a metal removal process using a series of sparks to erode material from a work piece in a liquid medium under carefully controlled conditions. The liquid medium usually, is a light oil called the dielectric fluid.

CELAY SYSTEM

- Celay System became first commercially available in 1992.
- It is a high precision, manually operated copy milling machine

Advantages of Celay system over the Cerec system

- Celay could recreate all surfaces of restoration whereas Cerec I could not make the occlusal surface.
- Celay has the potential to fabricate crowns and short-span bridges with In-Ceram system



CERCON AND LAVA ZIRCONIA CORE CERAMICS

Tooth preparation → Impression made → Wax pattern (0.8 mm) is anchored on to the Cercon Brain

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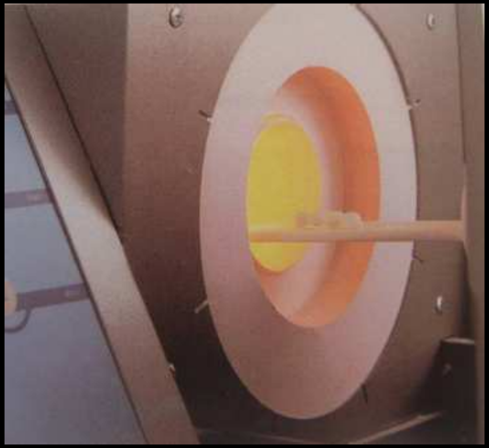
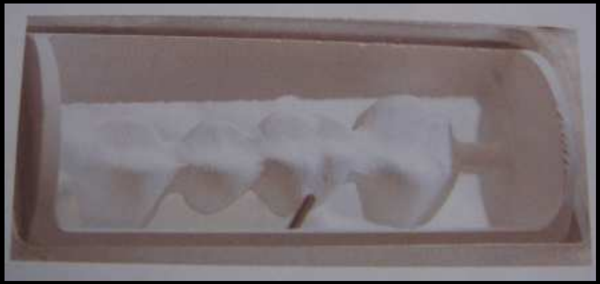
A presintered zirconia blank is attached on to the other side of the brain unit → Unit activated, pattern scanned

CERCON FURNACE





BLANK

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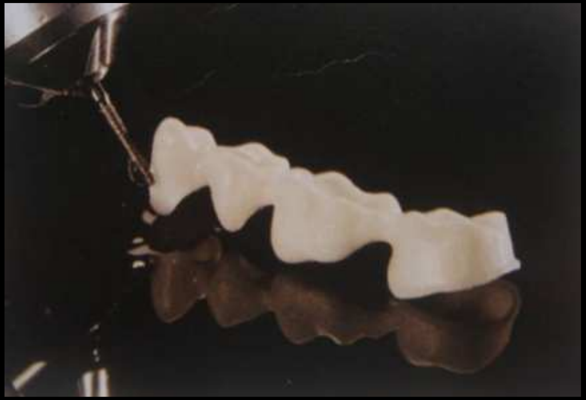

EXTENDED & INNOVATIVE APPLICATIONS OF CERAMICS IN DENTISTRY

- Posterior esthetic restorations (Inlay & Onlays)
- All-Ceramic Post & Core systems (Zirconia ceramics)
- Ceramic coating for dental implants
- Implant supported ceramic restorations
- Ceramic Orthodontic Brackets
- Ceramics for Oral Mucosal Stimulation
- Silanized ceramic fibres in Ceromers (Eg: Targis)
- As fillers

CERAMIC COATING FOR DENTAL IMPLANTS

BIOACTIVE CERAMICS

- Calcium phosphate ceramics (CPC)
  - hydroxyapatite (HA)
  - tricalcium phosphate (TCP)
- Glass ceramics

BIOINERT CERAMICS

- Aluminum oxide
- Titanium oxide
- Zirconium oxide

IMPLANT SUPPORTED CERAMIC RESTORATIONS

CERA ONE ABUTMENT

- **It** is a special implant device for single-tooth implants in the Branemark system.
- It is a pre-fabricated pure-titanium abutment cylinder designed to provide a cement-retained single-tooth porcelain restoration with subgingival margins.

CER ADAPT

- It is a tooth coloured, biocompatible all-ceramic abutment for single-tooth replacement.
- It allows both cement-over and screw-retained restorations, especially for an anterior single tooth implant.

CERAMICS FOR ORAL MUCOSAL STIMULATION

Surgical correction of certain localized deficiencies of the alveolar ridge and periodontal tissues can be adequately performed in the preprosthetic phase of treatment.

However, periodontal surgery is not always the corrective treatment of choice and maybe contraindicated by biologic factors, costs, time and patients medical and emotional status.

GINGIVAL-TONED CERAMICS developed from conventional feldspathic porcelain have been shown to be suitable for replacing periodontal structures in either tooth or implant supported fixed prosthesis.

ORMOCERS(ORGANICALLY MODIFIED CERAMICS)

- Represents a novel inorganic-organic copolymers in the formulation that allows for modification of its mechanical parameters
- Inorganic-Si-O-Si network
- Organic-methacrylate
- The inorganic poly condensation and organic polymerization result in formation of inorganic-organic co-polymer

ADVANTAGES

- Biocompatibility
- Reduced polymerization shrinkage
- Lasting esthetics
- Anticariogenic property

CEROMERS
(CERAMIC OPTIMIZED POLYMER)

- Composed of specially developed and conditioned fine particle ceramic fillers of submicron size (0.04, 1µm) which are closely packed and embedded in an advanced temper able organic polymer matrix.

Uses

- Veneers, inlay/onlay without metal frame work
- Can be used with fiber reinforced composite framework for inlays or onlay, crowns and bridges (3 unit) including implant restorations on metal framework

ADVANTAGES

- Durable esthetics
- High abrasion resistance
- High stability
- Ease of final adjustment
- Excellent polish ability
- Effective bonding with luting composite
- Low degree of brittleness
- Conservation of tooth structure

PORCELAIN LAMINATES

- Thin facing of about 0.5-0.7mm thick, covering labial aspects of anterior teeth and buccal aspects of premolar teeth
- Fabricated from feldspathic porcelain or castable or machinable ceramic
- They may restore the strength of natural teeth up to 96%.

INDICATIONS

- Discoloration: Teeth discolored by tetracycline staining, devitalization and fluorosis and even teeth darkened with aging
- Enamel defects: Such as hypoplasia and malformation can be masked.
- Diastema closure
- Malpositioned teeth

CONTRAINDICATIONS

- Available enamel
- Ability to etch fluoridated enamel
- Oral habits

ADVANTAGES

- Color stability and lifelike appearance
- Bond strength
- Resistance to abrasion and staining
- Inherent porcelain strength
- Resistance to fluid absorption

DISADVANTAGES

- Cannot be easily repaired
- Technique sensitive
- Extremely fragile and difficult to manipulate

CONCLUSION

- Dental ceramic technology is one of the fastest growing areas of dental material research and development.
- The unsurpassed esthetics and biocompatible qualities of ceramic material still provide the stimulus to seek to overcome their limitations.
- Much of the materials research has been directed towards producing stronger, reinforced restorations, with improved marginal accuracy
- The advantages and limitations of each material and technique must be considered prior to use.

BIBILIOGRAPHY

- **John. W. McLean -** The Science & Art of Dental Ceramics, Vol. I; Quintessence - 1979.
- **John W. McLean** - Science and Art of Dental Ceramics (Bridge Design & Lab procedures), Vol II. Quintessence – 1980
- **R. G. Craig** - Restorative Dental Materials 9th ed. - 1993.
- **Ralph W. Phillips** - Skinner's Science of Dental Materials 9th ed. - 1994.
- **Rosenstiel S.F., Land M.F, Fujimoto. J -** Contemporary Fixed Prosthodontics 2nd ed., Mosby: 1995.
- **Kenneth J. Anusavice -** Phillips Science of Dental Materials, 10th ed., Philadelphia, W.B.Saunders – 1996 : 583-618.
- **H. T. Shillingberg** - Fundamentals of Fixed Prosthodontics ; 3rd edition - 1997.

- Heat pressed ceramics:technology and strength: IJP 1999;5
- Procera All ceramic crowns: BDJ 1999;186:430
- Porcelain esthetics for 21 st century: JADA 2000;131:47
- Relative flexural strength of 6 new ceramic materials: IJP 1995;8:239
- Cast glass ceramic: DCNA 1985;29:725
- Recent advances in ceramic materials and systems: Dental update 1999;26:65
- Dental CAD-CAM:A millstone or a milestone: Dental update 1995;22:200
- Machinable glass ceramics and conventional lab restorations: Quint Int 1994;25:773
- Ceramics in dentistry:Historical roots and current perspective: JPD 1996;75

THANK YOU