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Ceramic restorations in dentistry (A simplified compilation)

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Introduction

Word 'ceramic' derived from the Greek word 'keramos' means 'pots and other articles made from clay , hardened by heat . So it basically implies a material that is produced by firing or burning. During the Stone Age, more than 10,000 years ago, ceramics were necessary materials and have retained importance in human societies ever since. In 700 BC - Teeth of ivory and bone that were held in place by a gold framework were used. Animal bone and ivory from hippotamus or elephant were used for many years thereafter. Later human teeth sold by the poor and teeth obtained from dead were used to make dentures and replace missing teeth. It is interesting to note that the U. S President George Washington, in his lifetime wore two sets of spring retained dentures ; the first one was made from extracted teeth and the second one was made from hippopotamus ivory by the dentist John Greenwood.

Definitions:

Ceramic is an inorganic compound with non-metallic properties typically composed of metallic (or semi metallic) and non-metallic elements (example CaO, Al2O3) [Kenneth J Anusavice]

Compounds of one or more metals with a nonmetallic element, usually oxygen. They are formed of chemical and biochemical stable substances that are brittle, strong, hard, and inert nonconductors of thermal and electrical energy [GPT 8]

The term "All ceramic" refers to any restorative material composed excessively of ceramic, such as feldspathic porcelain, glass ceramic, alumina core systems and certain combination of these materials [J. Esthetic Dent 1997, 9(2):86]

Composition of Porcelains

Composition	Percentage	Use
Feldspar	60-80%	Basic glass former
Quartz	15-25%	Filler
Oxide	9-15%	Fluxes
Alumina	8-20%	Glass former & fluxes
Metallic pigments	1%	Color matching
Kaolin	3-5%	Binder

Indications and uses

1. Esthetic alternative to
   - Discolored teeth
   - Grossly decayed teeth
   - Congenital anomalies
2. Inlays & Onlays
3. Abutment retainers
4. Denture teeth
5. Ceramic brackets
6. Implants (Zirconia Implants)

Definitions:

1. Contraindications:
2. Young permanent teeth
3. Small, short or thin crowns
4. Teeth round in cross section/More axially tapered
5. High lip line patients - PFM
6. Patient's lifestyle susceptible to trauma

Properties of ceramics

Compressive strength	330 MPa
Diametral tensile strength	34 MPa
Transverse strength	62 - 90 MPa
Shear strength	110 MPa
MOE	69 GPa
Surface hardness	460 KHN
Specific gravity	2.2-2.3 gm/cm^3
Thermal conductivity	0.0030 Cal/Sec/cm^2
Thermal diffusivity	0.64 mm^2/sec
Coefficient of Thermal expansion	12 × 10-6/°C

Why are ceramics weak?

- Aim: To pack the particles as close as possible in order to reduce the amount of porosity and shrinkage during firing.
- They are supplied as fine powder that is designed to be mixed with water or another vehicle and condensed into desired form
- Liquid binder:

o Distilled water.

o Propylene glycol

o Alcohol or formaldehyde based liquids

- • Benefits of Dense packing:

o Lower firing shrinkage

o Less porosity

- Techniques:

1. Vibration: Mild vibration to densely pack the wet powder upon the underlying matrix. The excess water: blotted with a tissue.
2. Spatulation: Smoothening action brings the excess water to the surface , where it is removed
3. Brush technique: Employs the addition of dry porcelain powder to the surface to absorb the water.

- Principle: Surface tension of water is the driving force of condensation, hence porcelain must not dry out until condensation is completed, irrespective of the method of condensation.

Classification of ceramics:

1. According to Uses

a) Anterior

e) Posterior

f) Crowns

g) Veneers

h) Post & cores

i) Fpd's

j) Stain ceramic

k) Glaze ceramics

2. According to Composition

a) Feldspathic Porcelains

b) Leucite Reinforced Glass Ceramics

c) Tetrasilicic fluormica based glass ceramics

d) Lithia disilicate based ceramics

e) Alumina reinforced ceramics

f) Spinel reinforced ceramics

g) Zirconia reinforced ceramics

3. According to Firing Temperature

Porcelain type	Firing temperature range	Clinical recommendations
High fusing	>1300°	Denture teeth, sintered alumina and zirconia core ceramics
Medium fusing	1000°-1300°	Denture teeth, presintered zirconia
Low fusing	850°-1000°	Crown and bridge veneer ceramic
Ultra low fusing	<850°	Crown and bridge veneer ceramic

4. According to Method of firing

a) Under Atmospheric Pressure (Air)

b) Under Reduced Pressure (Vaccum)

5. According to Microstructure

a) Glass

b) Crystalline

C) Crystal containing glass

6. According to its Function within the Restorations

a) Core ceramics–Supports and reinforces the restoration in all-ceramic restorations

b) Opaquer ceramics – Masks or hides the metal or underlying core ceramic. Bonds ceramic to underlying metal

c) Veneering ceramics

- Body or dentin – Simulates the dentin portion of natural teeth
- Incisal – Simulates the enamel portion of natural teeth
- Gingival – Simulates the darker gingival portion of teeth
- Translucent – Simulates translucent incisal enamel seen some times in natural teeth

d) Stains – Used to color ceramics to improve esthetics

e) Glaze – Imparts a smooth glossy surface to the restoration

7. According to Translucency

a) Opaque

b) Transparent

C) Translucent

8. According to Application

TABLE 18-1 Classification of Dental C[illegible]

	Fabrication	Crystalline Phase
ALL-CERAMIC	Machined	Alumina (Al_2O_3) Feldspar ($KAlSi_3O_8$) Mica ($KMg_{2.5}Si_4O_{10}F_2$)
	Slip-cast	Alumina (Al_2O_3) Spinel ($MgAl_2O_4$)
	Heat-pressed	Leucite ($KAlSi_2O_6$) Lithium disilicate ($Li_2Si_2O_5$)
	Sintered	Alumina (Al_2O_3) Leucite ($KAlSi_2O_6$)
CERAMIC-METAL	Sintered	Leucite ($KAlSi_2O_6$)
DENTURE TEETH	Manufactured	Feldspar

9. According to Method of Fabrication

a) Sintered Glass ceramics

i. Porcelain jacket crown (traditional).

ii. Porcelain jacket crown with aluminous core.

iii. Porcelain jacket crown with leucite reinforced core.

b)Castable Glass Ceramics

i. Dicor : first commercially available castable glass-ceramic

c) Injection Moulded / Heat Pressed / Hot Isostatically Pressed/ Shrinkfree Ceramics

i. Cerestore – 1st commercially available shrink free ceramic

ii. Leucite Reinforced

iii. Lithium Disilicate Reinforced

d. Glass Infiltrated / Slip Cast Ceramics

i. Glass infiltrated alumina core (In-Ceram Alumina).

ii. Glass infiltrated spinell core (In-Ceram Spinell).

iii. Glass infiltrated zirconia core (In-Ceram Zirconia).

e) Machinable glass ceramics

i. CAD/CAM systems

ii. Copy milled systems

Material name	Material type	Laboratory fabrication technique/procedure	Clinical recommendations
Vitablocs Mark II	Feldspathic ceramic	CAD/CAM	Inlays, onlays, veneers, anterior and posterior crowns
Cerec	Feldspathic ceramic	CAD/CAM	Inlays, onlays, veneers, anterior and posterior crowns
Techceram	Aluminous ceramic	Flame spraying	Inlays, anterior and posterior crowns
IPS Empress	Leucite re-enforced glass-ceramic	Pressable	Inlays, onlays, veneers, anterior crowns
IPS Empress CAD/CAM	Leucite re-enforced glass-ceramic	CAD/CAM	Inlays, onlays, veneers, anterior and posterior crowns
IPS E.Max	Lithium disilicate glass-ceramic	Pressable	Inlays, onlays, veneers, anterior and posterior crowns
IPS E.Max CAD/CAM	Lithium disilicate glass-ceramic	CAD/CAM	Inlays, onlays, veneers, anterior and posterior crowns, anterior fixed partial dentures
In-ceram Alumina	Glass infiltrated alumina	CAD/CAM	Onlays, anterior and posterior crowns, anterior fixed partial dentures
In-ceram Zirconia	Glass infiltrated alumina (ZrO added)	CAD/CAM	Onlays, posterior crowns and posterior fixed partial dentures
Procera	Polycrystalline alumina	CAD/CAM	Anterior and posterior crowns
Lava Zirconia	Polycrystalline zirconia (Y-TZP)	CAD/CAM	Anterior crowns, posterior crowns, anterior and posterior fixed partial dentures

CAD: Computer-aided design, CAM: Computer-aided manufacturing

Recent Advances: A few of the recent advances include

Lithium silicate with Zirconia (VITA Suprinty) - 2013

Enamic -Hybrid of ceramics & Composites (VITA Zahnfabrik) – 2013 To Summarize:

To Summarize:

TABLE 18-4 Methods of Processing the Ceramic Core Component of a Ceramic Prosthesis

Initial Forming Method	Examples	Initial Material Form	Second Processing Step	Subsequent Form	Final Steps
Condensation	Ceramco, VITA VMK, Duceram LFC, IPS d.Sign	Powder and mixing liquid	Sintering of core ceramic	Dense core ceramic with less than 5 vol% porosity	Veneer, glaze
Hot pressing	IPS Empress 2, OPC 3G, Finesse Pressable	High-quality ceramic ingot	Stain only or stain and glaze (inlays), or veneering ceramic	Stained/glazed inlay or veneered core	Stain and/or glaze for crowns and FPDs
Casting	Dicor (obsolete)	Glass core	Crystallization heat treatment (ceramming)	Glass-ceramic core containing a glass phase and tetrasilicic fluormica crystals	Shading porcelain (obsolete)
Slip casting	In-Ceram Alumina In-Ceram Spinell, In-Ceram Zirconia	Powder and mixing liquid	Partial sintering	Partially sintered core	Glass infiltration, trimming of excess glass, veneer, glaze
Computer-aided milling (CAM) of fully sintered form	Cerec VITABLOCS In-Denzir BruxZir	High-quality ceramic ingot	Margin repair (if necessary)	High-quality core possibly with repaired margin	Veneer, glaze (except for BruxZir)
Computer-aided milling (CAM) of partially sintered form	Cercon Lava e.max ZirCAD	Partially sintered ceramic block	Final sintering of machined/ground core and margin repair (if necessary)	Fully sintered core possibly with repaired margin	Veneer, glaze
Copy milling	Variety of ceramic products	High-quality ceramic block	Margin repair (if necessary	High-quality core possibly with repaired margin	Veneer, glaze
Machining, grinding of dry-pressed powder on enlarged die	Procera AllCeram	Dry pressed and machined alumina block	Sintering	High-quality core containing 99.9% alumina	Veneer, glaze

Conclusion: Ceramics have a great past in dentistry. The unsurpassed aesthetic and biocompatible qualities of 'All-ceramics' have positioned them in the high -end segment of restorative dentistry and provide the stimulus to seek to overcome their limitations and continue laboratory and clinical research .The future of ceramics is even greater since they offer great potential for improvement, especially in manufacturing technology . Each system has its own merits, but may also have shortcomings. Combinations of techniques and materials are beginning to emerge which aim to exploit the best features of each. Glass-ceramic and glass-infiltrated alumina blocks for CAD-CAM restoration production are examples of these and it is anticipated that this trend is likely to continue.

Important historical events:

- 1708: First scientific laboratory experiments on ceramic material
- 1728: Pierre Fauchard: Use of porcelain in dentistry
- 1774: de Chemant: First porcelain tooth material was patented
- 1825: Samuel Stockton: Produced first porcelain teeth in the US
- 1839: Invention of Vulcanized rubber
- 1870: Charles H Land: Porcelain jacket crown with Platinum foil technique.
- 1903: Charles H Land: First ceramic crowns to dentistry
- 1965: Mc lean and Hughes: Aluminous porcelain
- 1968: Mc Culloch: Glass ceramic in dentistry
- 1983: O' Brien : High expansion magnesia core
- 1983: Sozio and Riley: Cerestore
- 1984: Adair and Grossman : First commercial glass ceramic (DICOR)
- 1988: Mormann and Brandestini: CAD-CAM.
- 1988: CEREC I
- 1989: Wohlwend and Scharer : Pressable ceramic systems (IPS Empress)
- 1990's: IPS Empress 2
- 1991: Celay copy milling system.
- 1992: Ducera LFC
- 1993: Procera
- 1994: CEREC II
- 1999: Fluorapatite glass ceramic system for use in metal ceramic
- 2000: CEREC III