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REVIEW

Dental ceramics used in dentistry

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ABSTRACT

The metal-ceramic restorations successfully used in the past to the present day after tooth extraction. However, more esthetic restorative materials are most popular than metal-ceramic restorations, with the increase of interest in patients' esthetic restorative materials, Full ceramic restorations are most aesthetic than metal-ceramic restorations. However, because of its high biocompatibility, low plaque retention, creating less irritation of gums and creating less risk of allergies properties full ceramic restorations are often used. The article of dental ceramics, history, structure, classification and properties are discussed.

HISTORY OF DENTAL CERAMICS

Porcelain artificial teeth was first used in dentistry by Alexis Duchateau, a French dentist, and Nicholas Dubois de Chemant, a French apothecary working together with him, in 1774. These materials' aesthetic and mechanical features got a great advantage in prosthetic dentistry. All-ceramic restorations, called 'jacket kuron', were made by baking feldspathic ceramic material on residual limbs, that prepared by platinum leaf, in the late 19th century.[1] Despite its aesthetic benefits, the restoration lost its popularity gradually due to poor marginal sealing, low resistance and a high risk of fracture.[2] Developments in restorations without metal support, got started by McLean ve Hughes' adding alümina (Al2O3) in porcelain to strengthen it in 1965. This procedure made ceramic attain a structure stronger and more resistant to thermal shocks. The production of more durable porcelain and the development of techniques for fusing, have made it possible to produce full porcelain crowns that were more convenient and break-resistant, especially since 1960.[3]

Adair and Grossman developed the technique that provided controlled crystallization of glass (Dicor) in 1984. Also Brugges developed the system, that was a new refractory die (heat-resistant die) method included 70% Alumina (Al_2O_3).

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In the late 1990's, glass ceramic (IPS Empres 2) system with high fracture resistance, which can be shaped by pressure, made production of fixed partial restorations extending to second premolars, possible.[4]

One of the latest materials, that added into ceramic structure for strengthening all-ceramic restorations, is zirconium oxide. A sub-structure ceramic with a higher hardness and resistance was obtained by adding 35% partially stabilized zirconia (In-Ceram Zirconia) into glass-infiltrated alumina. The last point on ideal infrastructure material for all-ceramic restorations is using yttria tetragonal zirconia polycrystal (Y-TZP) based ceramics.[5]

STRUCTURE OF DENTAL CERAMICS

Dental porcelain is consisted of 3-5% kaolin (clay), 12-22% quartz (silica, sand) and 75-85% feldspar.[6] Kaolin (Al_2O_3. $2SiO_2$. $2H_2O$) is hydrated alumina silicate. It gives porcelain opacity and makes porcelain dough take shape. Silica is SiO_2 and it makes porcelain mass stable.[7] Feldspar is a mixture of potassium alumina silicate ($K_2OAl_2O_26SiO_2$) and sodium alumina silicate ($Na_2OAl_2O_36SiO_2$). It is the basic material that makes dental ceramics transparent. It dissolves during baking and wraps kaolin and quartz by its unifying feature. So it ensures the integrity of the mass. It makes porcelain restorations hold their structure during baking procedure, due to the feature. Feldspar contains carbonated water (Na_2O) and potas (K_2O) in different proportions. Carbonated water form lowers the melting point, potas form reduces leakage during baking by increasing the viscosity of molten material.[1] Metal and metal oxide pigments, which added into porcelain powders, provides coloration that is needed for obtaining a natural tooth appearance.[6]

CLASSIFICATION OF ALL-CERAMICS

There are different classifications in the literature. Infrastructure materials can be divided into 3 basic groups according to the classification made by Conrad et al.[8]

GLASS CERAMICS

1) Leucite-reinforced ceramics
    - IPS Empress (Ivoclar Vivadent, Schaan, Liechtenstein)
    - Optimal Pressable Ceramic /Optec OPC (Jeneric Pentron, Wallingford, Conn)
    - IPS ProCAD (Ivoclar Vivadent Schaan, Liechtenstein)
    - Mirage (Chameleon Dental Products)
2) Ceramics powered by Lithium disilicate
    - IPS Empress 2 (Ivoclar Vivadent, Schaan, Liechtenstein)
    - IPS e.max Press (Ivoclar Vivadent, Schaan, Liechtenstein)
3) Feldspathic ceramics
    - Vitablocks Mark II (Vita Zahnfabrik, Bad Sackingen, Germany)
    - Vita TriLuxe Bloc (Vita Zahnfabrik, Bad Sackingen, Germany)
    - Vitablocks Esthetic Line (Vita Zahnfabrik, Bad Sackingen, Germany).

ALUMINA-BASED CERAMICS

- In-Ceram Alumina (Vita Zahnfabrik, Bad Sackingen, Germany)
- In-Ceram Spinell (Vita Zahnfabrik, Bad Sackingen, Germany)
- In-Ceram Zirconia (Vita Zahnfabrik, Bad Sackingen, Germany)
- Synthoceram (CICERO Dental Systems, Hoom, Netherlands)

- Procera (Nobel Biocare AB, Goteborg, Sweeden).

ZIRCONIA-BASED CERAMICS

- Lava System (3EM ESPE, St. Paul, Minn)
- Cercon System (Dentsply DeguDent, Germany)
- DC Zirconia System (DCS Dental AG, Allschwil, Switzerland)
- Denzir System (Decim AB, Skelleftea, Sweeden)
- Celay System (Mikrona Technologie AG, Spreitenbach, Switzerland)
- Cerec In Lab System (Sirona Bensheim, Germany)
- Everest System (Kavo Dental, Biberach, Germany)
- Zeno Tec System (Wieland, Pforzheim, Germany)
- Zirkonzahn System (Steger, Ahrntal, Italy).

GLASS CERAMICS

Leucite-reinforced Ceramics

Leucite crystals are used to strengthen the structure of glass ceramic. It has a semi-transparent appearance. Because of this, it is possible to produce restorations which have high aesthetic feature.[9] IPS Empress system was released in 1983. It can be produced by the compression technique using heat and pressure or **C**omputer **A**ided **D**esign/**C**omputer **A**ided **M**anufacturing (CAD/CAM) technology. Its average resistance to bending forces is 120-160 MPa. It can be increased up to 200 MPa by the development of the surface properties.[10] Its fracture resistance is 1,5-1,7 MPa $m^{1/2}$. The success of restoration is provided by the adhesive cementation to dental tissue. Weakness of durability limits its being used to a single tooth restorations in the front region.[11]

Ceramics powered by Lithium disilicate

IPS Empress II is in this group. Ceramic ingots consist of lithium disilicate glass ceramics, which generates more than 60% of the crystal component by volume. Infrastructures can be prepared by removal of candle, heat-pressing or milling prefabricated blocks. Bending resistance of the infrastructure material is about 300-400 MPa. This rate is nearly three-fold of IPS Empres I. Fracture resistance is 2,8-3,5 MPa $m^{1/2}$.[12] IPS Empresss II system lets production of aesthetic restorations to be done visually. Roughening restorations and cementing them adhesive increase resistance of restorations and extend the duration of the service. This type of restorations can be performed from incisor teeth to second premolars. Minimal critical size for binders is 4-5 mm for occlusal-gingival, and 3-4 mm for bukko-lingual.[13]

Feldspathic Ceramics

Vitablocks Mark I and Vitablocks Mark II are examples for feldspathic ceramics. Vitablocks Mark II was produced for Cerec I system in 1991. Its durability is more than Vitablocks Mark I, and it has small particle size. It contains 60-64% SiO_2 and 20-23% Al_2O_3. It can be roughen to provide micromechanical retention and can be cemented with composite resin cement.[14]

ALÜMINA-BASED CERAMICS

In-Ceram Alumina

In-Ceram Alumina (Vita Zahnfabrik) system, that was introduced in the market in 1989, is the first all-ceramic system which allows the construction of fixed prosthesis with a three-member in the anterior region.[15] The mixture, which is 70-80% of its weight Al_2O_3, is performed on 'refractory die'. It is baked at 1120°C for

10 hours. Water passes through refractory die by capillary pressure, alumina particles gather on day. The technique is called 'slip casting'. Lanthanum glass is spread on infrastructure as a thin layer to make the alumina skeleton become more resistant and to reduce porous structure. It is baked at 1100°C for 4 hours again. Compressive stresses occur due to the difference in thermal expansion coefficients of alumina and glass, and these stresses make it more durable[16] Spaces in the material is filled with glass thanks to capillary action. After baking porcelain superstructure, the restoration is finished.[17]

In-Ceram Spinell

It was produced as an alternative to In-Ceram Alumina, that has opaque infrastructure, in 1994. Magnesium and aluminum oxide (Mg Al_2O_4) mixture is used to increase light transmission in infrastructure, instead of aluminum oxide used in In-Ceram technique.[9] Its bending resistance's being lower than In-Ceram Alumina, limits its using to single-tooth restorations in the front region.[18] Magnesium aluminum oxide (Mg Al_2O_4), in other words spinel, is a natural mineral. Spinel crystals are opaque crystals, that are colored or colorless, and have glassy structure, transparant or cubic symmetry. Its production technique is like In-Ceram Alumina's, such as slip casting or milling porcelain block. In-Ceram spinel is the most aesthetic one among the Vita In-Ceram products.[17]

In-Ceram Zirconia

It is a modification of In-Ceram Alumina system, and is obtained by adding 35% partial stabilized zirconium oxide into In-Ceram Alumina system, in order to improve the mechanical properties of ceramics.[19,20] Milling semi-sinterize prefabricated blocks or classic slip-casting technique can be used in production of infrastructure, then veneer process is performed with feldspathic porcelain.[20] Its bendin resistance is about 421-800 MPa, and breaking strength is 68 MPa $m^{1/2}$.[21] After adding zirconium oxide, infrastructure becomes more durable, but increase in opacity causes to use the material in sub-structure of the crown or bridge prosthesis in posterior region.[9,21]

Synthoceram (CICERO Dental Systems, Hoom, Netherlands)

It is an infrastructure ceramic, that is produced by Computer Integrated CEramic RecOnstructions (CICERO) technology and is strengthen with infiltrated aluminum oxide.[22] The production of ceramic restoration by CICERO procedure is obtained by laser optical imaging, sintering and computer-aided milling. Models of tooth preparation and counter-occlusion is imaged by using a three-dimensional laser scanner on computer. The infrastructure, designed on computer, is frozen on ceramic blocks, that are strengthen with aluminum oxide, and the infrastructure is obtained by sintering.[23] Final restoration is obtained after veneering infrastructure by using Syntagon (CICERO, Hoorn, Neatherlands), leucite-free glass ceramic.[24]

Procera (Nobel Biocare AB, Goteborg, Sweeden)

It contains 99,9% Al_2O_3 crystal as an infrastructure material for all-ceramic restorations. İt is used by sinterize intensively (Procera AllCeram sistem).[25] It has three compositions such as Procera AllCeram, Procera AllTitan, and Procera AllZircon. The diffrence of the names come from the blocks that system works. Procera AllCeram system was developed in 1993, Procera AllZircon was developed in 2001.

In Procera system, day model is scanned by mechanical reader, three-dimensional design of coping is planned on computer, and infrastructure is frozen on alumina or zirconia blocks. Zirconium oxide-based Procera AllZircon blocks is preferred as an infrastructure of fixed prostheses.[26]

ZIRCONIA-BASED CERAMICS

Lava System (3M ESPE, St. Paul, Minn)

Lava system use CAD/CAM technology to produce high-strength infrastructure, which contains zirconia polycrystal, that partially stabilized by 3% mol yttrium. System consists of optical scanner (Lava Scan), computer-aided milling machine (CAM) (Lava Form), an oven to sinterize (Lava Term), and CAD/CAM software. Model is obtained in laboratory, and is scanned by optical scanner. İnfrastructure is generated wider to compansate 20-25% linear polymerization shrinkage, and is sinterized for 8 hours. Then sinterized infrastructure is covered by veneer ceramic (Lava Ceram). It can be used both in the anterior and posterior region due to its good mechanical and optical features.[27,28]

Cercon System (Dentsply Ceramco, Burlington, NJ)

Cercon system has two different infrastructure options. These are: classical CAM and CAD/CAM. Infrastructure candle modelation is performed on prepared tooth model by technician. The candle modelation is put into basic section of Cercon device (Cercon brain), and is scanned by laser system of the device. The data is sent to milling unit, and infrastructure is frozen on the blocks called 'Cercon base'. 'Cercon eye' unit is added into CAD/CAM option. Design and production of infrastructure is done computer-aided. Sinterize process is performed at 1350°C for 6 hours at the oven called 'Cercon heat'. Sinterized infrastructures are covered by porcelain superstructure (Cercon Ceram Kiss), that is suitable for the system, and restoration gets its last shape.[1,29]

DC–Zirkon System (Digitizing Computer System, Precident, DCS Dental AG, Allscwill, Switzerland)

Preparation of infrastructure is done by computer-aided designing and computer-aided production.[30] System consists of 3 units, such as Preciscan (optical scanner that works with a fully automatic laser projection), DCS (Dentform software), and precimill (milling machine). Intensively sinterized DC Zirkon ceramic blocks are pressed by hot isostatic pressing procedure, and thanks to this, resistance to enlarging micro-cracks in ceramic can be strengthened.[31] Fully sinterized Y-TZP blocks (DC Zirkon) are used to prepare infrastructure. So, the infrastructure is frozen at intended final size.[32] There is no baking procedure or sintering shrinkage after milling procedure.[33]

Denzir System (Decim AB, Skelleftea, Sweden)

Denzir System is firstly introduced for inlay restorations in 1995. Fully sinterized blocks are used in the system, and are got by hot isostatic pressing procedure. The procedure is performed under high pressure at 1400-1500°C for intensifying particle density in the zirconium ceramic.[34]

Celay System (Vita, Bad Sackingen, Germany)

It was produced as an alternative to computer-aided production methods. Vita, the manufacturer, developed its own blocks. Four different blocks are used. These are: feldspathic blocks (Vitablocks for CELAY), alumina blocks (Vita In-Ceram Alumina for CELAY), spinell blocks (Vita

In-Ceram Spinell for CELAY), and zirconia blocks (Vita In-Ceram Zirconia for CELAY). Dental technician performs infrastructure modelation with special composite material on the model obtained after preparation procedure. The infrastructure is put into the left section of the device. Here there are non-corrosive browser tips, that recognize infrastructure by only circulating on the composite modelation. The block, that is intended to be erode, is put into the right section of the device. The infrastructure is sinterized after milling procedure, and the restoration gets its last shape by using suitable porcelain superstructure for the infrastructure.[35]

Cerec System (Sirona, Bensheim, Germany)

Cerec system removes classical measure up procedure, and do this procedure with intra-oral camera of the device. Preparation model, that is obtained after measurement, can be imaged by the help of in-EOS as an alternative to the procedure. Design of the infrastructure is done on the image, thanks to computer software that the device has. The block is put into the milling unit after selection of the designed infstructure material on the computer software.[36] The infrastructure is get 20% greater than the final size, because zirconia block shrinks nearly 20% after sinterize procedure.[37] The frozen zirconia block is sinterized at the system's oven (InFire HTC), and gets its last shape by using suitable porcelain superstructure.

Everest System (Kavo Dental, Biberach, Germany)

The system consists of 3 units. These are: Everest Scan, that scans and designs model, Everest Engine, abrasion unit, and Everest Therm, sinterize oven. Abrasion unit has 5 axle technologies, as different from other systems. By this way, precise alignment can be get. The model is scanned, designed on computer, and then milling procedure is performed. System has both fully sinterized zirconia blocks and the zirconia blocks that are not sinterized. The infrastructures that are got from the blocks, that are not sinterized, are sinterized at Everest Therm oven at 1500°C. If the zirconia blocks, that are not sinterized, are used in infrastructure, the infrastructure can be colored by Ivoclar IPS e.max or Vita coloring liquids to obtain suitable color.[38]

ZENO Tec System (Wieland, Pforzheim, Germany)

Zeno Tec system is a CAD/CAM system that consists of 3 units. Plaster model is scanned by 3 Shape D 700 laser scanner. Design of prosthetic is got by moving the data in three dimensions on ZENO Cad computer software. Ceramic blocks are handled in ZENO milling machines. Sinterize procedure is performed at ZENO Fire sinterize oven. If zirconia blocks are used, coloring ZENO Color Zr and color stabilizer ZENO Color Fix can be used to produce the infrastructure with an intended color.[39]

Zirkonzahn System (Steger, Ahrntal, Italy)

Zirkonzahn system lets us produce materials by using both CAD/CAM system and mechanical methods. The infrastructure model for tooth or teeth, that are restorated on plaster model, is prepared by the composite resin, that hardens by the light which the company produced, and mechanical technic that uses Zircograph. After corrections, the infrastructure, which is prepared by composite resin, is put into the section Zircograph's reader tip exists. The zirconia block, that belongs to the system (ICE Zirconia or Prettau), is put into the other compartment of the device, that containing abrasive bur. Cutter bur gives the restoration shape on the zirconia block in dehydrated atmosphere, when reader bur is moved manually on the composite infrastructure. The infrastructure model, that will be restorated, is scanned optically by Optical Scanner S 600 in CAD/CAM system, and the design of infrastructure is done by computer software. The infrastructure is milled from zirconia block by using CAD/CAM M5. The infrastructure is sinterized by using sinterize oven of the system, after coloring the infrastructure, that is got 25% larger, with coloring liquids for obtaining intended colour.[40]

CONCLUSION

All-ceramic restorations' using increases, due to its outstanding features, in dentistry, comparing to metal-ceramic restorations. New techniques, as an alternative to the restorative techniques, that have proven to be successful, are being developed each day. Metal infrastructure, that is used in metal-ceramic restorations, gives its place to strengthen ceramic in all-ceramic restorations for restorating physical and mechanical features. Zirconium oxide reinforced ceramics have an important role among the oxide ceramics. Zirconium is started to be used in porcelain material in dentistry due to its low grain diameter and high tensile strength. There are many studies, that evaluate physical and mechanical features of all-ceramic restorations, and intend to strengthen the connection between infrastructure material and porcelain superstructure in the literature, but further studies are needed to support the issue.

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