Ceramic materials in prosthetics

Ceramic materials are the starting material for the production of aesthetically perfect substitutes. The basic material is porcelain = a mass characterized by low penetration (infiltration), usually white color and transparency – the basic components of *porcelain* are *feldspar*, *quartz* and *kaolin*. The term ceramics includes materials in whose processing technology burning is used. In dentistry, these are materials where the kaolin content is minimal or where kaolin does not occur at all.

Složení keramiky		
	Classic porcelain	**Dental porcelain**
feldspar	15 %	72–75 %
quartz	3–5 %	12–22 %
Kaolin	70 %	3–5 %

Feldspar – potassium aluminum silicate, it is a crystalline opaque mass of gray-pink color, which acts as a flux connecting other components and conditions strength.

Quartz – ensures the stability and shape of the mass when firing and forms a kind of internal structure for other components; Its content is the cause of translucency (translucency) of materials.

Kaolin – aluminum hydrosilicate, in porcelain provides opacity; When mixed with water, it is sticky and allows the mass to form.

Colour pigments

Substance	**Color**
titanium dioxide	yellow
iron oxide	Brown
uranium oxide	orange-yellow
manganese oxide	Brown
copper oxide	greenish yellow
nickel oxide	Brown
tin oxide	increases opacity
gold oxide	creates some effects

For the correct distribution of color layers, organic dyes are added, which burn completely when burned.

Cutting of ceramic material

By use

1. for faceting;
2. for the fabrication of structures.

According to the method of processing

1. Ceramic materials containing glass.
2. Ceramic materials containing alumina.
3. Materials based on leucine ceramic dispersions or based on zircon.

Grinding, milling, casting, layering

Materials that we prepare by grinding, milling, casting, layering and that form structures, inlays, onlays, facets and crowns. The construction for an all-ceramic crown or bridge can be obtained by pressure and pressing – e.g. *Empress 2 (Ivoclar), Vitapress (Vita)*; the construction can be prepared by machining – milling – grinding ceramic blocks; we can obtain it by grinding on a Celey copier (*Mikrona technology)* or milling in a CAD/CAM system *(CEREK Sirona, DCS Dental, Procera, Nobel Biocare).* The basis of the pads or reinforcements is glass ceramics, infiltration ceramics, Al2O3 or ZrO2; bending strength in metal-free structures is mostly above 100 MPa.

Sintering

Products in the form of powder or liquid (modification is paste consistency), where ceramics are formed by sintering (= saintering is a method of making objects from powder materials by heating them to a high temperature, but below their melting point, whereby powder particles merge with each other). During this process,

which takes place in a vacuum furnace, the shaped parts are transformed (divided into 8 classes: basic enamel masses, dentine masses 1–3, neck masses, intensive glazes, class 4–8 glazes).

According to melting temperature

1. Refractory – above 1300 °C
2. Medium meltable – 1100–1250 °C
3. Low meltable – 870-1050 °C

Faceting materials

In classical ceramic materials for faceting, the basic type of crystals is leucite, in the form of silicate or alkaline aluminosilicate glass; bending strength is mostly above 80 MPa.

Ceramics for matalo-ceramic structures

The main component of ceramics for metal-ceramic structures is feldspar *orthoclase*, to which smaller proportions of albite, boron oxide and oxides of selected metals are added in the amount necessary to achieve the desired color and translucency. The orthoclase is stable up to 1170 °C. After exceeding it, it turns into leucite and liquid phase; with the addition of albite, quartz and other components, the temperature of formation of leucite and the liquid phase decreases; The presence of leucite crystals in the liquid phase greatly increases the viscosity of this mixture. This makes it difficult for the ceramics to flow at the highest firing temperatures and reduces the possibility of changing the thickness of the ceramic layer applied to the surface of the metal crown. After solidification, the structure of the ceramic layer consists of a glassy matrix in which leucite crystals and pores are deposited.

Alloy-ceramic bindings

Ceramic materials offer the possibility of a strong bond with metal alloys. To achieve this bond, it is necessary to ensure: metal alloys intended for firing must show high thermal stability and the ability to form a thin layer of oxides to bond with ceramic materials. The wet ceramic material adheres to the clean, degassed surface of the metal so that the oxide layer is partially dissolved in the glassy substance during the firing of ceramics. Part of the oxides remains free and provides an additional bond to the oxygen bridge base of base metals. The character of the metal bond is uniform – each atom is enveloped by a layer of electrons that act as an adhesive and ensure high strength and resistance to fractures

The process of firing ceramics

- When firing ceramics, we distinguish 5 stages:
  1. **Drying**:
     - During drying, the modelling liquids evaporate and the added organic dyes are annealed.
  2. **Heating**:
     - The heating stage is the process of increasing the temperature from the level of drying up to the maximum firing temperature, it takes several minutes.
  3. **Sintering**:
     - When sintering (see above), as the temperature in the ceramic kiln increases, sharp tips and edges of particles begin to stretch, which become rounded and connect to each other by forming quasi-liquid bridges. Individual particles grow together into a compact whole; as the temperature increases, the process of particle joining intensifies; At the beginning of the process, there is a tight arrangement of equally large spherical particles of material, the particles have the same chemical composition. During sintering, their centers approach each other, gradually melting and merging into one homogeneous whole.
     - In dentistry, liquid sintering is used, when a liquid phase is present, which allows reactions to progress faster. In the liquid phase, cohesive forces directed to the center act on the surface molecules and thus the material thickens and hardens; the process is logically accompanied by contraction; Color transfer at this stage occurs by diffusion or creep.
  4. **Melting**:
     - Melting increases the intensity of coloration and further melts the amorphous mass.
  5. **Cooling**:
     - The stage of gradual cooling prevents the formation of internal stress and subsequent cracking of the ceramic mass – the greater the proportion of the glass phase, the slower the cooling must be, because glass is a worse conductor of heat than metal.
     - By firing in dental ceramics, the sintered, molten (glass) and crystalline phases coexist. The sintered phase forms the precursor to melting, the crystalline phase forms during cooling.

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Indication of ceramic materials

- Ceramic materials can be used in conjunction with a metal structure as metal-ceramic substitutes, or separately as all-ceramic restorations.

Metal-ceramic dentures

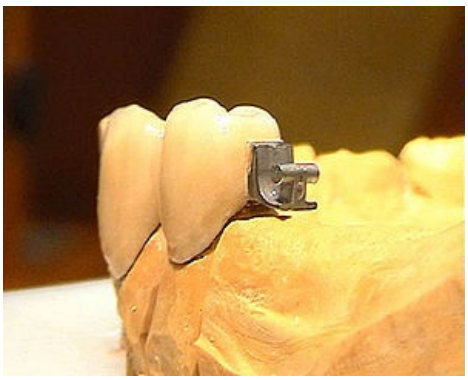
Indication of metal-ceramic dentures

- Crowns
- Classic fixed bridges
  - the extent of fixed bridges made of metal ceramics allows the reconstruction of very extensive defects of teeth of the first class according to Voldřich; They are particularly suitable where high mechanical resistance is required, e.g. adverse interjaw relationships, parafunctions, massive orthognathic system, a combination of fixed and removable restoration, anchoring by a buckle and non-buckle system
  - metal-ceramic structures are also preferred for the reconstruction of dental defects using dental implants – then they are cemented or conditionally removable structures
- Adhesive bridges
- Ceramic veneers for removable dentures

Contraindications of metal-ceramic dentures

- Metal intolerance of basic metal construction
- Other contraindications are based on general contraindications of fixed substitutes
- The use of ceramics in teeth with weakened periodontal and in persons with impaired composition of hard tooth tissues is the subject of discussion, as well as the combination of these materials with enamel or an alloy of noble metals in the opposite jaw
- The key factors leading to harmful effects of metals are their accumulation and increasing concentration in a living organism, the duration of exposure and the genetic sensitivity of the organism. Many so-called harmless metals become allergens or toxic during chronic exposure. The trend of modern dentistry is to create a mechanically resistant ceramic prosthesis without metal construction.

Workflow – metal-ceramic substitutes



Metal-ceramic bridge.

Metal-ceramic bridge. The metal structure is machined before sandblasting by fine carbide cutters with cross edges. *Sandblasting* takes place under pressure of 2 bar with grain size Al2O3125 micrometers; the structure oxidizes at a temperature of 900 °C. Subsequently, the powder and liquid of the appropriate *repeater* are mixed, which is applied to the structure. The repeater is also applied to the structure by spraying (spray-on-technique), or a paste repeater is used – it condenses in a thin layer. The repeater layer is burned out. In layers, another opaque compound is applied and fired. This is followed by a thin layer of opposing dentin, a layer of dentin, from which the full anatomical shape of the replacement is modeled, then a reduction is made in the incisal <>/<> to apply the enamel mass. The shape of the replacement is modeled in a surplus that corresponds to the contraction of the ceramic material. The baked crown is adjusted to the optimal shape, individual coloring is applied using paints to the ceramics and the glaze is fired in a vacuum-free program.

During individual modelling, the layer of the repeater in the area of the neck and incisal edge is coloured, the step area can be supplemented *with translucent shades*; The layer of opposing dentin and the incisal edge can be colored in the same way.

All-ceramic prostheses

Indication of all-ceramic dentures

- Inlays;
- Onlay;
- Overlays;
- Aesthetic facets;
- Root inlays;
- Single crowns;
- Three-member bridges – maximum one intermediate coupler.

These designs are best suited for patients who want to achieve maximum aesthetic quality of treatments, who are proven to be allergic to metals or who believe they have a reaction to metal alloys in dentistry.

Contraindications of all-ceramic substitutes

- Scope of fixed compensation of two or more intermediate members.
- Lack of space to ensure a minimum thickness of the shell.
- A relative contraindication remains the price.

Workflow - all-ceramic construction

The basis is an exact preparation on *a wide stable step* – this prevents springing and torsion of the replacement under load; occlusion is reduced by 1.5–2 mm. It is insulated with 2-3 layers of varnish about 45 micrometers thick. The model is doubled with silicone. A working model is made of a special mass whose composition is close to the forming materials. The boundary of the preparation is marked with a special contour pencil. The mechanically resistant supporting structure is made by gradual layering of ceramic material – a mixed mass of powder and liquid from ceramic oxide with a minimum thickness of 0.5–1 mm is applied, or by pouring the ceramic mass into a split form. At the 2nd stage, layers of ceramic material of the desired shape are applied to the structure.

Constructions can be of three types:

- infiltration *(InCeram Vita)*;
- pressurized *(Empress 2, Ivoclar)*;
- milling *(Procera AllCeram).*

Links

External links

- - Sintering

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