



Zirconia – Polycrystalline Dental Ceramics

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Zirconium oxide ceramics are widely used in dental medicine due to their mechanical properties and biocompatibility [1]. Due to the increasing improvement and development of digital technologies, intraoral scanners and CAD/CAM systems, the digital fabrication of restorations is becoming simpler, faster, and the design and fabrication has high accuracy [2]. There are three phases of zirconium oxide ceramics, namely the monoclinic, tetragonal and cubic phases [3]. Each phase has its own crystal structure or lattice. Various oxide such as yttrium (Y), cerium (Ce), calcium (Ca) and magnesium (Mg) is often added to zirconia to make it stable at room temperature. The monoclinic phase is stable at room temperature by adding oxides (MgO, CaO, Y₂O₃). At a higher temperature (1170 °C), it changes to the tetragonal phase. It enters the cubic phase at a temperature of 2370 °C [4,5]. Tetragonal zirconia polycrystal (TZP) are of various types based on the yttria content: 3Y-TZP (3 mole % Y-TZP), 4Y-TZP (4 mole % Y-TZP), 5Y-TZP (5 mole % Y-TZP), and 6Y-TZP (6 mole % Y-TZP) [6].

Dental zirconia ceramic 3Y-TZP contains 3 mole % yttrium oxide. It consists of 100% tetragonal phase, which makes it a fully stabilized zirconia ceramic. The flexural strength is 1300 MPa. After sintering, it gradually decreases to 800 MPa [7].

Zirconia oxide 4Y-TZP dental ceramic contains 4 mole % yttrium oxide. It is a partially stabilized zirconia ceramic and

consists of 75 % tetragonal and 25 % cubic phases. The flexural strength of 4Y-TZP is lower than that of zirconia ceramic 3Y TZP and is approximately 600-900 MPa. Adding more yttrium oxide improves the aesthetic properties and thus the acceptability for manufacturing of monolithic restorations in the anterior teeth area, but the mechanical properties, i.e. flexural strength, are reduced. Zirconium oxide 5Y-TZP dental ceramic contains 5 mole % of yttrium oxide. It is also partially stabilized but has 50% tetragonal and 50% cubic zirconia phases, which gives it even more beautiful aesthetic properties but further reduces the strength of the material. The flexural strength of 5Y-TZP is 400 - 600 MPa [8,9].

Multilayer blocks of zirconium oxide ceramics have a gradational transition of color and translucency from the cervical to the incisal part and consist of 4Y-TZP and 5Y-TZP dental ceramics. Gradation of the block starts with 4Y-TZP, which located in the lowest part of the block. Then there are the interlayers made of mixing 4Y-TZP and highly transparent 5Y-TZP which located in the middle of the block. This achieves increased transparency in the transition to the incisal area. On top of the block itself there is a layer of 5Y-TZP that completely optically imitates enamel. The possibility of clinical application of multilayer zirconia ceramic blocks is large. Multilayer blocks of zirconium oxide ceramics can be used to produce crowns as well as implant-supported crowns in the frontal and lateral areas. From the same material it can be also manufactured frontal bridges.

If 4Y-TZP zirconium oxide ceramic is used to create a bridge in the lateral part, 2 pontic elements can be created. If 5Y-TZP zirconium oxide ceramic is used to create a bridge in the lateral part, only one pontic can be created and it must not be a molar.

The processing of multilayer zirconium oxide ceramic blocks is digital using a CAD/CAM system. When making a restoration, it is very important to virtually position the desired object (crown or bridge) in block correctly, precisely because of the layers in the block, which have different mechanical and aesthetic properties. It is necessary to place the cervical part of the restoration in the 4Y-TZP layer, because it has the highest flexural strength. The incisal part of the restoration should be placed in the 5Y-TZP layer, which provides the best aesthetic properties, i.e. optical properties similar to enamel [10].

The use of multilayer zirconium oxide ceramic blocks has resulted in improved aesthetic properties but reduced mechanical properties. Increased translucency, which provides better optical properties and achieves the optical properties of enamel, has impaired mechanical properties, which, especially in areas under high load (lateral areas), require caution when setting an indication for the fabrication of restorations. For this reason, the choice of using multilayer zirconium oxide ceramic blocks should be based on clinical indications, forces in the patient's mouth, and placement within the dental arch.

Multilayer zirconium oxide ceramic blocks have a wide range of applications in dental medicine. With good indication selection, digital manufacturing, improved aesthetics and mechanical properties, the possibilities of use and indications for use are expanding. It is also necessary to emphasize that the desired object must be well positioned inside block during milling because of the layers that have different flexural strengths.

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