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The evolution of dental zirconia

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Dental zirconia has evolved considerably over the last 20 years. It has evolved from a material with a single composition to a complex material with variations in yttria and alumina content, grain size and number of layers. These changes have resulted in a wide range of zirconia products with different mechanical and optical properties.

First generation zirconia 3Y-TZP

The first zirconia to be introduced in dentistry was yttrium-stabilised tetragonal zirconia polycrystals (Y-TZP), which consist mainly of the tetragonal phase and are stabilised with 3 mol% yttrium oxide (3Y-TZP). This material, also known as first generation zirconia, has the highest mechanical properties of all zirconia variations. However, it is very opaque and is therefore mainly used as a framework material, which must also be veneered with ceramic to achieve a natural-looking restoration. However, its high opacity can be used to cover dark surfaces (Figs.1-3).

Figs. 1-2: The high opacity of 3Y-TZP (1st generation) can neutralise dark surfaces.

Fig. 3: Further aesthetics are achieved with veneering ceramic GC Initial Zr-FS.

Further development of 3Y-TZP

In order to improve the opaque appearance of zirconia, the alumina-oxide content (Al_2O_3) in 3Y-TZP was first reduced and the porosity eliminated by sintering at higher temperatures. The result was monolithic 3Y-TZP, also known as second-generation zirconia, with improved optical properties (Figs. 4-5). However, this increase in translucency is accompanied by a reduction in flexural strength and fracture toughness.

Figs. 4-5: Second generation zirconia from 2007, glazed with the first version of GC's Lustre Pastes: GC Initial IQ Lustre Pastes NF.

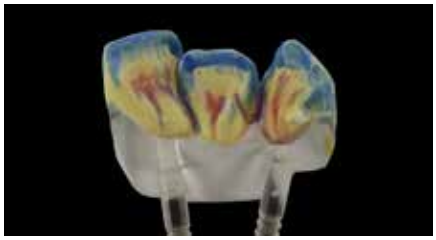
Increasing the cubic phase - 5Y-TZP

Although these modifications improved the translucency of 3Y-TZP, clinicians wanted an even higher translucency for monolithic restorations. This led to the development of the third generation of partially stabilised zirconia with a higher yttria content, 5Y-TZP (Figs. 6-7). This variant has a higher cubic phase content, which leads to increased translucency but reduced mechanical properties (600-800 MPa). With 4Y-TZP, an extension of the possibilities was created to optimise the compromise between translucency and stability for long-span bridge indications.

Figs. 6-7: GC Initial Zirconia Disk UHT (5Y-TZP) exhibits increased translucency due to the higher proportion of yttrium oxide. Colour customisation and glazing with GC Initial IQ Lustre Pastes ONE.

Colour customisation of zirconia

In addition to the option of glazing zirconia with glazing pastes (GC Initial IQ Lustre Pastes), colouring liquids can also be used for pigmentation before the sintering process. GC Initial Zirconia Coloring Liquid contains metallic oxides such as iron, chromium and manganese oxides, which are applied before sintering to enable the natural colour gradient (Figs. 8-10).



Figs. 8-10: Colour individualisation of GC Initial Zirconia Disk HT (3Y-TZP) with GC Initial Zirconia Coloring Liquid.

Zirconia trend: Multi-generations zirconia

The market trend is now moving towards multi-generation zirconia (3Y-TZP/5Y-TZP), in which CAD/CAM discs have a fracture-resistant zirconia generation with a lower yttrium content at the bottom and a more translucent generation with a higher yttrium oxide content at the top. Newer generations of zirconia include multi-layered and polychromatic materials where colour gradients are achieved by adding pigments to different layers to mimic the colour and translucency of natural teeth (Figs. 11-13).

Figs. 11-13: Multi-generation zirconia is more translucent in the incisal area and has a colour gradient from cervical to incisal to mimic the colour and translucency of natural teeth. GC Initial Zirconia Disk Multilayer Elite.

Micro-layering

Zirconia continues to be combined with veneering ceramics to raise it to the highest standards. Micro-layering has established itself as the new standard for achieving the desired aesthetics, particularly when using highly stable types of zirconia. This has also led to new material developments in the field of veneering ceramics. The new so-called SQIN ceramics have a very high degree of homogeneity. This minimises sintering shrinkage and eliminates the need for multiple firing cycles (Figs. 14-15).

Conclusion

The development of dental zirconia in its composition and properties over the last two decades has resulted in a variety of zirconia types. Early generations, particularly 3Y-TZP, offer high strength but are not translucent, so veneering is required. In subsequent generations, modifications were made to improve optical properties, although this was often at the expense of mechanical strength. Current trends include multi-layered zirconia with varying levels of yttria to mimic natural tooth colour and translucency, often combined with innovative veneering techniques for improved aesthetics. The use of colouring liquids and glazing pastes also helps to create natural-looking restorations.

Figs. 14-15: Highly stable 3Y-TZP, 1200 MPa (GC Initial Zirconia Disk HT), customised with GC Zirconia Coloring Liquid and minimally veneered with 0.3 mm GC Initial IQ ONE SQIN.