3M ESPE

Espertise
Scientific Facts

Zirconia is not alike!

CAD/CAM technology had made it possible to prepare restorations out of high strength ceramics like Alumina and Zirconia. Previously, ceramic restorations in the posterior region were limited to single units. Now with the introduction of Zirconia as a dental material, clinicians are able to place all ceramic restorations in the anterior and posterior regions. This is due in part to the high flexural strength (almost two times higher compared to Alumina) and high fracture toughness of the Zirconia ceramic material.

Several companies are offering Zirconia materials in dentistry. These materials are chemically similar, consisting of 3% Yttrium oxide treated Tetragonal Zirconia Polycrystals. In many cases they are also treated with a very small concentration of Alumina (< 0,25 %) to prevent leaching of the Yttrium oxide. This combination ensures the safety and longevity of Zirconia restorations.

Even though Zirconia can be chemically similar it is not necessarily the same.

Bread is often chemically similar, however the colour, consistency and taste can be very different. Many other factors outside of chemistry influence the final result including the order in which ingredients are mixed, the grain size or consistency of the flour, and time and temperature used for incubating the dough. In addition, breads can be baked at different temperatures. Aside from the ingredients and baking process, other differences such as the skill of the baker can lead to a substantial difference in the final product.

Although the Zirconia ceramic is chemically similar, once processed, it can exhibit different mechanical and optical characteristics. Working with Zirconia, one can experience the differences in machinability (e.g. wet milling and dry milling) and in sintering (e.g. temperature for Vita™ YZ-Cube ➔ 1530°C; temperature for Lava™ frameworks ➔ 1500°C; temperature for Cercon™ ➔ 1350°C).

What can be different?

In principle, there is pre-sintered Zirconia and HIP (hot isostatic pressing) Zirconia available on the market. The pre-sintered Zirconia is milled, when the material still has a soft, chalk-like consistency. For full density, it is sintered again after milling. HIP material is milled in the fully sintered state. This sheet describes the differences of pre-sintered Zirconia. For more information on HIP Zirconia see 3M ESPE's respective information sheet.

Processing parameters for pre-sintered Zirconia effect performance attributes

Process Step	Processing Parameters	Performance Attributes
Powder	• CO-Precipitated (most powders) • Mixed Oxide Process (cheaper) • Grain Size (0.07–0,3µm) • Spray Drying & Organic additives	• Translucency • Strength • Longevity • Hydrolytic Stability • Sinter Behavior
Pressing	• Axial Compacting • Isostatic Compacting • Pressure (800–3000 bar) • Clean Room (no imperfections by airborne impurities)	• Marginal Fit • Translucency • Strength
Pre-sintering	• Temperature • Time	• Marginal Fit • Machinability
Machining		
Coloring	• Pigments (part of the powder processing) • Liquids	• Marginal Fit • Translucency • Strength • Longevity
Final sintering	• Temperature (1360°C–1530°C) • Time	• Translucency • Strength • Longevity • Hydrolytic Stability

Fig. 1 Main steps in the production process of pre-sintered Zirconia and the important parameters with their influence on clinical aspects.

Zirconia is not alike! (continued)

Pre-sintered Zirconia is prepared by three main steps (see Fig. 1). The Zirconia powder is pressed and pre-sintered. This usually occurs by the manufacturer. The dental lab mills the pre-sintered blank and then sinters the coping or framework to achieve full density.

The preparation of the pre-sintered blanks by the manufacturer differs depending on the Zirconia powder source and both the pressing and the pre-sintering conditions selected.

1.) Powder

The available Zirconia powders can have different grain sizes, different distributions of the various grain sizes, and different additives (e.g. binder for the pressing step). The additives Yttrium oxide and Alumina can be distributed within the material in a variety of ways such as a homogeneous distribution throughout the whole material, higher concentration at grain borders, etc. The grain size has an effect on strength and transformation toughening, a special and key mechanical characteristic of Zirconia. Variations in grain size distribution affects the resulting porosity and hence the translucency of the material. The distribution of additives can affect the hydrothermal stability of the sintered material.

Differences in the zirconia powder effects the strength/ long-term stability and translucency of the restoration.

Lava Zirconia has five years of clinical performance, optimal translucency and high strength. You can find more clinical studies about these topics in the 3M ESPE publications shown above

2.) Pressing conditions:

The powder is first pressed, which can be accomplished by different procedures (e.g. isostatically or axially). The pressing conditions are adjusted to get an optimized blank for the pre-sintering step. The pressing methodology influences the homogeneity and the density distribution of the material and hence the marginal fit. The pressing conditions can lead to differences in strength, translucency and affect the final sintering temperature of the Zirconia.

The pressing condition and pressing method affect the marginal fit, strength and translucency of the restoration.

Lava Zirconia has shown an excellent marginal fit and optimal translucency. You can find more clinical studies about these topics in the 3M ESPE publication shown above.

3.) Pre-sintering:

The pressed Zirconia powder is then pre-sintered in a furnace with an optimized temperature profile to generate a blank with suitable strength and millability.

Pre-sintering conditions affect the strength of the pre-sintered material and its millability.

4.) Colouring:

Some Zirconia materials can be coloured in the pre-sintered state by immersing copings and frameworks in a dyeing liquid. This enables the absorption of colouring agents in the Zirconia material. Colouring can be achieved either by pigments (grains) or non-pigmented (ions) agents. It is important to control the effect of the dying liquid on the mechanical characteristics of the Zirconia material.

Colouring of the Zirconia can affect the marginal fit, strength and translucency of the material.

Dyed Lava Zirconia shows high strength, excellent marginal fit and translucency. You can find more clinical studies about these topics in the 3M ESPE publications shown above.

In summary, Zirconia in dentistry is chemically similar, but not necessarily alike.

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