RENISHAW
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inciseTM zirconia
Taking a closer look

All-ceramic restorations are soaring in popularity amongst dentists and patients. Their aesthetic properties are ideal for anterior work, but discerning technicians have tended to avoid them for larger posterior restorations.

With progress of the materials and processing technology, these concerns have been dispelled. The primary reason for these improvements lies in the use of zirconia ceramic as a substructure material. Restorations made using zirconia frameworks are the strongest and toughest all-ceramic units available. The benefits to the patient are obvious, and the resilience and damage resistance during handling is a major advantage in the laboratory.

Zirconia ceramics do not stimulate allergic responses. This is clearly of benefit to those people who are allergic to certain metals, and also instils confidence in patients who may have no existing restorative work or may not be aware of any allergies.

What is zirconia Y-TZP?

Zirconia ($ZrO2$) is the oxide of the metal zirconium. The ceramic can be made in many different forms, with a corresponding vast range of properties. Y-TZP (yttria-stabilised tetragonal zirconia polycrystal) is the strongest and toughest of the forms, and is used in Renishaw's inciseTM CAD/CAM process. It is composed of an ultra-dense arrangement of sub-micron crystalline grains, each of which exhibit the tetragonal crystal structure.

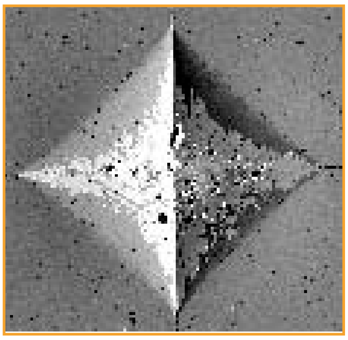


Figure 1a. SEM microscope image indentation in zirconia, created by pressing a pyramidal diamond into the surface.

Y-TZP possesses a toughening mechanism that is key to its high performance as a dental material. Any minute cracks that form in the ceramic have a stress field associated with them,

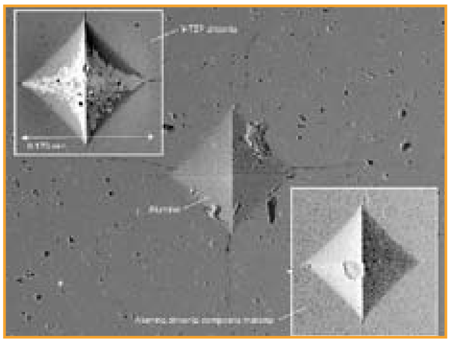


Figure 1b. A pyramid shaped diamond is pressed into each material under a 20kg load. The size of the resulting impression is realted to the hardness of the material, and toughness is demonstrated by the severity of the corner cracks.

which causes the surrounding tetragonal material to transform into a stable monoclinic crystalline structure. This phase of zirconia has a higher volume than the tetragonal bulk, which compresses the crack faces together and drastically impedes its growth.

This 'transformation toughening' is unique to zirconia and its effect is most marked in the TZP material. This explains why its strength and toughness are both over twice that of alumina ceramics.

The electron microscope images above show indentations that have been made in three different ceramic materials. In these examples, the alumina-zirconia composite material shows the smallest impression (it is the hardest), followed by the alumina and lastly Y-TZP. It is important not to confuse hardness with strength.

Super-high hardness is not a desirable property for dental cores as it generally implies greater brittleness and can make the material more difficult to machine. Needless to say, all of these ceramics are far harder than natural dental tissues.

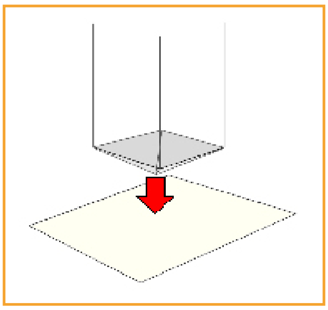


Figure 1c. The identification process

The porosity of the alumina can be seen as well as the lack of toughness, with a considerable amount of inter-granular cracking that is not seen in the other materials.

Pressable and slip-cast ceramics differ from the structural materials shown in figure 1b. These have a glassy matrix binding ceramic particles, and do not possess the fracture resistance of modern engineering ceramics.

Why choose fully-sintered zirconia?

Machining hard-state zirconia places high demands on the tools, causing relatively fast wear rates. The resulting framework will suffer from poor accuracy if these tools are not accurately monitored. The incise™ process measures tool wear during the manufacturing cycle and compensates for changes in the tool shape, delivering a framework to a measurable degree of accuracy. A certificate of conformance is supplied with each job that confirms how well the framework fits the master model.

There are also strength benefits from working with fully sintered Y-TZP. The blanks used are industrially produced, and because of their simple shape and large size, extremely uniform material properties are realised. If the final sintering is done after the material has been milled to a complex shape, such uniformity will not be reached and the likely occurrence of weak spots is increased.

Doesn't zirconia get damaged if it is machined in the hard state?

Conventional milling techniques, as used to machine soft and pre-sintered ceramics, can cause damage to zirconia. This is true of any sintered ceramic being machined in this way. The incise™ process uses a novel technique specifically developed by Renishaw for machining hard-state Y-TZP zirconia. As a result, no damage is caused to the material and an extremely strong framework is the result.

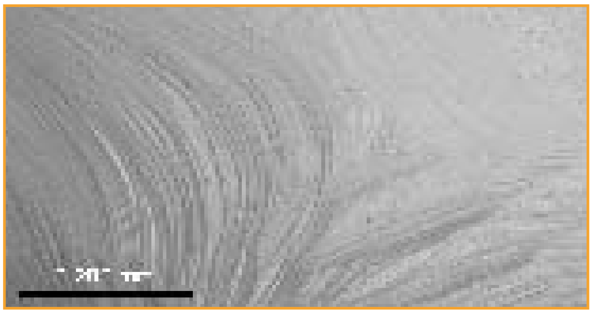
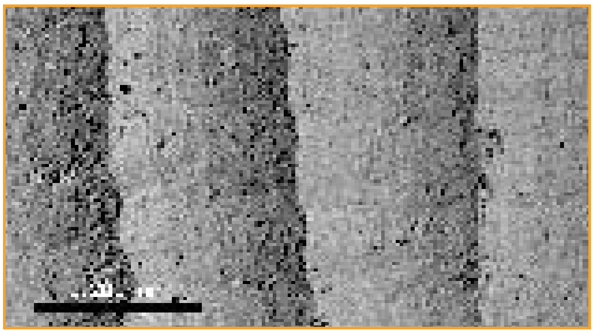


Figure 2. Image (x80) showing machined incise zirconia above and much more coarser, rough and more porous suirface of zirconia framework machined prior to sintering below.



If there is a need to modify a framework to suit individual needs, a diamond-impregnated rubber wheel is recommended using very light pressure. Water cooling can be used, although this is not essential.

How do we ensure that the stages of manufacture do not weaken the framework?

Renishaw produces a range of Raman spectroscopy devices that are able to distinguish between the crystalline forms of zirconia. Damaged material will show an increased percentage of the monoclinic phase, due to transformation processes. Any material that may not be physically cracked but has weakened via phase transformation for other reasons will also be identified. Using this technology, Renishaw has been able to monitor the monoclinic phase content of frameworks after manufacture, manual adjustment and artificial ageing. No monoclinic content was observed.

To add to this, strength testing of completed restorations demonstrates the remarkable integrity of incise™ frameworks. incise™ crown and bridge frameworks are suitable for any region in the mouth.

Renishaw's incise™ frameworks are machined using a CNC (computer numerically controlled) manufacturing process which introduces many innovations, resulting in marked overall improvements in the accuracy, durability and aesthetics of the product received at the laboratory.

- incise™ crown and bridge frameworks are machined exclusively in the fully-sintered, hard state from a solid block of Y-TZP zirconia. No firing cycle is required to sinter the material after machining and therefore, no associated shrinkage. Compensating for shrinkage can introduce errors that ultimately compromise the fit of the restoration.
- Several years of development work on machining technology have overcome the difficulties of cutting such a hard material. Machining in the hard state allows finer details to be reproduced because the zirconia material is at its full strength.
- Renishaw's extensive experience in industrial measurement has been employed, with tools being monitored throughout the machining process. The wear induced on tools by cutting ultra-hard ceramic is compensated for automatically, improving accuracy further.
- After machining, every framework is scanned to analyse the accuracy of fit onto the model, with the results being passed onto the laboratory.

Take advantage of the latest materials and technology backed by cutting edge scientific research. Use incise™ to strengthen your restorations and your business.