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Q: Cubic-Containing Zirconia: Is Adhesive or Conventional Cementation Best?

Dr. McLaren

All materials used in dentistry evolve, perhaps none more so than zirconia. Recently, manufacturers have been able to increase the content of yttria in zirconia (many of today's materials have ~5 mol% yttria), which creates a mix of approximately 50% cubic phase zirconia and 50% tetragonal zirconia. The original material was roughly 100% tetragonal and was very high strength. The newer materials with the high cubic phase benefit from significantly improved translucency, though they surrender some strength to do so. Most of these materials seem to test in the 700 MPa to 750 MPa range.¹ This is generally considered more than adequate strength for single restorations anywhere in the mouth, and many would argue that small bridges are acceptable with proper connector design, especially a monolithic design.

High-strength tetragonal zirconia has been successful whether cemented conventionally or adhesively. Besides the obvious benefit of retention, adhesive cementation is well-known to allow better stress distribution when the system is loaded. This is a fundamental reason why porcelain fused to metal or porcelain bonded to enamel has worked so well over the years. The question posed to this roundtable panel is, with regard to the new, more translucent zirconia (cubic-containing zirconia [CUZR]), are conventional or adhesive clinical techniques recommended for cementation?

First, two important points must be made about this new version of zirconia, CUZR. To date this author could find no published clinical data with a PUBMED search. Also, with the inclusion of the secondary phase of cubic zirconia at approximately 50%, it has now been clearly shown in the literature that alumina-abrading the internal surface degrades the strength

roughly 40%.^{1,2} Thus, after sandblasting, the strength of this material is in the 450 MPa to 500 MPa range—not 750 MPa. Studies have shown that zirconia must be alumina-abraded to achieve a bond with a MDP primer.³ In data recently presented at the March 2018 American Association for Dental Research meeting² and also published in 2017 in *Compendium*,¹ Drs. McLaren and Burgess and their team at the University of Alabama at Birmingham showed that treating the internal surface of the restoration with glass beads instead of alumina did not result in a degradation of strength similar to alumina. It is theorized that the alumina causes damage to the surface, and with the high content of cubic phase there is no “transformation toughening” such that occurs with the original tetragonal material. This property allowed sandblasting without weakening the material.

So, what does this mean clinically?

A benefit of using higher-strength materials is the ability to cement conventionally; thus, for conventional posterior crown cases, I will use conventional cements. For anterior cases, I would still use resin because of the translucent optics. For clinical situations where I want to use a conventional cement I would clean or treat the inside surface of the CUZR with glass beads at 2.5 bars of pressure with 50 μ m. *I would not use alumina.* Those clinical situations would be the same as for a normal crown, ie, situations with good retention and resistance form. I would want to have at least 0.8 mm of wall thickness and 1 mm occlusal thickness.

For clinical situations where I wanted to do more conservative preparations, ie, onlays where there was minimal retentive features in the preparation, I would alumina-abrade the inside with 2 bars of pressure, treat the surface of the CUZR with a separate MDP primer, and use a resin cement. For occlusal thickness, I would not go below 0.8 mm.

Dr. Burgess

Zirconia is a polycrystalline ceramic that contains three phases: monoclinic, tetragonal, and cubic. Yttria is added to the purified zirconia powder to stabilize the tetragonal phase and prevent it from transforming to the weaker monoclinic phase. Three mol% zirconia is often called *partially stabilized zirconia* because it can transform from the tetragonal phase to the monoclinic phase with a 3% to 5% expansion. The benefit of this expansion is that a zone is created around a crack, which inhibits crack growth. This is the primary reason that the original zirconia frame (3 mol% zirconia) does not fracture.

Zhang et al recently classified zirconia by the mol% concentration of yttrium into three categories—3, 4, 5 mol%.⁴ Five mol% yttria-containing zirconia has more than 50% cubic phase, which means that the zirconia will not transform. At UAB we are testing this to verify that this in fact happens. In general, the 3 mol% contains more than 70% tetragonal phase and approximately 10% to 15% cubic phase, which produces the strongest but most opaque material. As more yttria is added to the powder the translucency increases; but as Dr. McLaren noted, flexural strength and fracture toughness decrease because more cubic (a weaker phase) is created. When approximately 50% cubic component is achieved the material does not transform because the cubic phase does not transform. Although weaker, the cubic-containing material is more translucent due to the increased cubic component. Translucency of zirconia depends upon the particle size, firing (sintering) temperature, and composition of the powder. Nano-sized crystals produce a more translucent material.

Dr. McLaren's original idea that alumina abrasion of the intaglio surface of 4 and 5 mol% yttria zirconia weakens those materials significantly because the cubic phase does not transform proved to be correct. Alumina is harder than glass beads and abrades the zirconia, producing stress risers (crack initiation points) to a greater extent than glass beads. To effectively bond to zirconia two things must occur: surface roughening and chemical bonding. Micromechanical abrasion is created by alumina sandblasting and then applying an adhesive that contains the 10-MDP monomer to complete the bonding process. The retention produced when both abrasion and bonding are used creates a zirconia bond with resin cement that is equal to bonding to lithium disilicate using hydrofluoric acid, silane, and a resin cement even after 10,000 thermocycles and 5-month water storage.⁵ Bonding to zirconia requires an abrasive that can bond chemically to zirconia and provide micromechanical retention; when both are accomplished a durable zirconia bond is produced. I would use 30 μ m alumina at 2 bar (30 psi) for 10 to 15 seconds to produce the micromechanical bond. Silica-containing glass beads can also be used for translucent CUZR at 2 bar to create an adequate micromechanical bond. Both alumina and silica sandblasting can clean the restoration effectively after try-in when the zirconia bonding site is blocked by phospholipids from saliva. Cracks may be inhibited by bonding zirconia restorations rather than cementing them. When load cycling and thermocycled, abraded CUZR has the same fracture load as non-abraded restorations.

Low-temperature degradation of zirconia begins at the surface of the zirconia and essentially provides stress relief from the 20% to 30% shrinkage of zirconia during firing and cooling. Over time and occlusal loading microcracks begin to form on the occlusal surface,

water penetrates these cracks, and the crack formation increases. The spread of these cracks is very slow and occurs more frequently in tetragonal zirconia than in CUZR. Zirconia containing more than 50% cubic phase may be more water-stable than tetragonal-containing zirconia, as the cubic phase does not transform to the monoclinic phase. Therefore, even though the cubic-containing materials are weaker, their flexural strength will not decrease as much as the tetragonal-containing materials when stored in water.

To provide an adequate safety margin, my recommended occlusal thickness for posterior zirconia restorations is 1 mm for traditional zirconia and 1.2 mm for CUZR.

Dr. Brucia

Many factors impact the cementation of metal-free tooth-colored restorations, not the least of which is the clinical environment presented. For placement of an indirect restoration, several different clinical conditions should be evaluated, including: margin location and whether enamel remains; whether or not it is a high-risk environment; whether or not the clinician is able to completely control the environment during the cementation appointment; esthetic expectations; pre-existing conditions of the tooth; and the need for predictable results.

All of these factors and more play a role in the selection of cementation protocol and must be considered at the time of the preparation. I have two cementation techniques that I follow routinely: an adhesive cementation requiring a resin cement with a separate bonding agent, and a conventional cementation utilizing material such as a glass ionomer or resin-modified glass ionomer (RMGI).

Conventional cementation would be preferred when a less than ideal clinical environment exists for adhesive cementation with resin materials and techniques. Margins not in enamel are at higher risk for leakage with resin cements.⁶⁻⁸ This concern is heightened when there are clinical findings to support an elevated caries rate and poor home care. Lack of ability to place rubber dam due to difficult patient management or a challenging clinical location also is not ideal for the resin cementation technique.

Material selection also can dictate the requirements for the cement used. Many of the more esthetic materials may sacrifice lower physical properties for improved appearance. Adhesive resin cementation can provide greater strength to some of these materials as compared to conventional cementation materials. Also, with some patients occlusal risk factors play an important role in the need for high strength. When considering a more esthetic restorative material when some of the aforementioned risk factors are present, a more aggressive preparation that allows for greater thickness of the material may enable a conventional cementation.

Many of my indirect restorations are partial-coverage in design. With tooth-colored restoration material options, both preparation design for the tooth and high bond potential for the restorative material are critical to long-term success. A traditional pressed ceramic material works well in these clinical cases. Zirconia-based material does not have the proven long-term bond stability or the near-invisible blending capability with the remaining tooth structure to function well here. Adhesive resin cementation is required.

When some of the discussed risk factors are observed, I begin to

consider a conventional cementation. When high strength is required, a monolithic tetragonal zirconia is my first metal-free material choice. Conventional cementation with this material requires a minimum occlusal material thickness of 1 mm to 1.5 mm and more traditional retention features (>4 mm axial walls, less tapered preparation, box preparations). This monolithic material is weighted more for strength and is generally less esthetic. My restorative material treatment protocol is similar for both a conventional and adhesive cementation because all RMGI cements have some percentage of resin. I clean any possible phosphate contamination after the clinical try-in procedure with either a steam cleaner or a zirconia cleaning material, sandblast at 2.5 bars with 50 μ m alumina oxide or a tribo-chemical treatment, and prime with either a pure zirconia primer, or, if using a tribo-chemical treatment, a combined zirconia and ceramic primer followed by 5 minutes of 155-degree heat. To date, I have experienced 100% retention rates following these guidelines. The restoration should be allowed to cool prior to cementation as the heat will accelerate the cement hardening rate.

When high esthetics is also a clinical requirement and a conventional cementation is indicated, I may consider a full-coverage pressed ceramic (lithium disilicate) or one of the newer cubic-based translucent zirconia materials. Tooth preparation would be similar as discussed above for retentive features but will have an increase in occlusal thickness of 1.5 mm to 2 mm. I also will treat the material for an adhesive cementation even though I have elected to use a conventional cementation material (RMGI). My material treatment is very different as compared to the high-strength zirconia material. If

using the translucent zirconia, after cleaning as discussed above, I will sandblast with 50 μ m glass beads only, as large and more aggressive rocks can damage and weaken the material.^{9,10} I will then use a pure zirconia primer, allow to it dry, and cement the restoration. If using a pressed glass-ceramic, I will again blast with glass beads, followed by 20 seconds of hydrofluoric acid, 15 seconds of phosphoric acid, use of traditional two-bottle silane (eg, Bis-Silane™, BISCO), and 5 minutes of 155-degree heat prior to cementing with RMGI. Again, the restoration should be allowed to cool prior to cementation.

Thus far, I have elected not to rely on an adhesive resin cementation as my first choice with the newer zirconia materials. My three clinical indirect materials of choice are gold, pressed lithium disilicate, and monolithic full-contour tetragonal zirconia. When gold is not used and high strength is required, I conventionally cement a zirconia crown. When a partial-coverage tooth-colored restoration is indicated, a lithium-disilicate restoration is fabricated and an adhesive resin cementation is completed. When high esthetics are required and a full-coverage restoration is indicated, I will prepare for a full-coverage lithium-disilicate crown with increased occlusal material thickness and cement with a conventional technique as discussed above.

Time and more clinical studies may increase my confidence in the newer cubic-filled translucent zirconia materials, but clinically my present toolbox is able to address all my clinical needs with a high and predictable success rate.

➤ *For the full reference list, visit compendiumlive.com/go/ccedxxxx.*