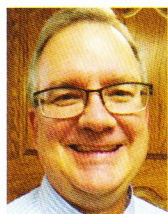


BEAUTY & THE BEAST

By Dave Andrus, CDT



"So what was that ugly crown you have?" was the question Stuart Winter, DDS located in Arvada, Colorado asked. After a brief moment of reflection on my part and delightful chuckle, I realized he was referring to the "Beast" in what we call our "Beauty

and the Beast" crown. (Figure 1a) This is a zirconia crown style we developed which is a full contour zirconia crown with the facial window cut back where we layer translucent veneer porcelain for aesthetics far superior to a monolithic full contour zirconia crown. We call this our "Beauty and the Beast" crown (Figure 1b) because of its beautiful layered veneer porcelain and beastly strength of the full contour zirconia.

From my experience and research I have concluded that the weakest link in porcelain fused to zirconia crowns is the single mode of bond between the veneer porcelain and the zirconia. As a comparison, PFM alloys have three modes of bond with dental porcelain; chemical, mechanical and compressive.

The chemical bond comes from the metal oxides in the opaque porcelains bonding chemically with the oxide layer which forms on the surface of the alloy as it is fired in the porcelain oven.

Mechanical bond is achieved by roughing the surface of the alloy coping/framework by grinding on it with stones, carbide burs and sand blasting the alloy with aluminum oxide. These processes create a roughened surface on the alloy creating

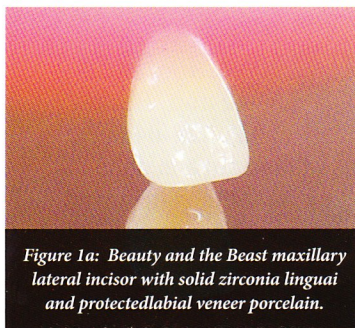


Figure 1a: Beauty and the Beast maxillary lateral incisor with solid zirconia lingual and protected labial veneer porcelain.

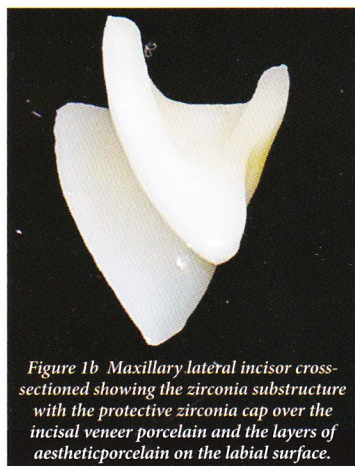


Figure 1b Maxillary lateral incisor cross-section showing the zirconia substructure with the protective zirconia cap over the incisal veneer porcelain and the layers of aesthetic porcelain on the labial surface.

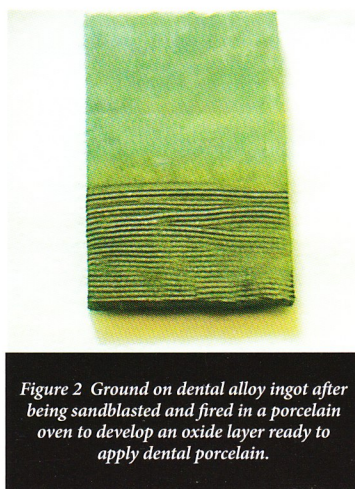


Figure 2 Ground on dental alloy ingot after being sandblasted and fired in a porcelain oven to develop an oxide layer ready to apply dental porcelain.

significantly more surface area per square millimeter than an alloy surface which has not been ground on. (Figure 2)

Compressive bond is developed due to very specific co-efficient of thermal expansion values between the alloy substructure and the veneering porcelain. Co-efficient of thermal expansion, in this case is the rate the two materials expand while being fired in a porcelain oven and more importantly the rate of shrinkage and volume of shrinkage the alloy and the porcelain achieve as a combined unit as they are cooling after being fired in a porcelain oven. If the two very different materials don't have a CTE that matches, the porcelain loses the co-efficient battle and cracks or fractures off. Dental porcelain and dental alloys are designed to work together in a way that as the PFM crown cools after being fired in a porcelain oven the porcelain is left under slight compression adding strength to the porcelain and making the porcelain much stronger than its standalone flexural strength when it is not supported by a metal substructure.

For example, a sheet of glass lying on a perfectly flat table can hold thousands of pounds of pressure because it is under a compressive load. If the same sheet of glass is moved so 25% of it is suspended off the edge of the table, the unsupported portion can break with relatively light pressure, because glass, like dental ceramic, does not survive well when subjected to flexural forces. This is one reason incisal edges break more easily than the mid-occlusal surface of a crown because the incisal edges are subjected to flexural forces rather than compressive forces like the mid-occlusal surface of a crown.

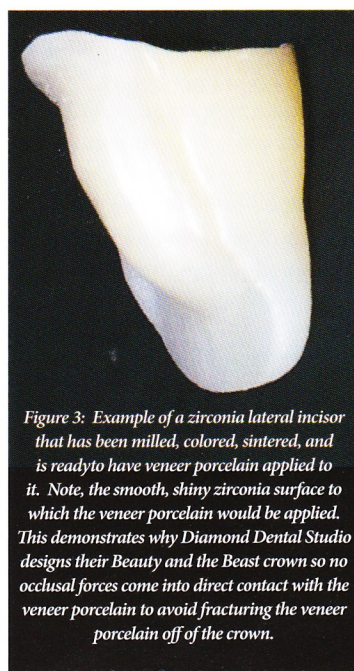


Figure 3: Example of a zirconia lateral incisor that has been milled, colored, sintered, and is ready to have veneer porcelain applied to it. Note the smooth, shiny zirconia surface to which the veneer porcelain would be applied. This demonstrates why Diamond Dental Studio designs their Beauty and the Beast crown so no occlusal forces come into direct contact with the veneer porcelain to avoid fracturing the veneer porcelain off of the crown.

There are two primary weak links with porcelain fused to zirconia, which we have been able to overcome with our Beauty and the Beast crown, single mode of bond and CTE (co-efficient of thermal expansion). The single mode of bond achieved by porcelain fused to zirconia is mechanical. The problem is that the surface of zirconia is very smooth and offers very little opportunity for the veneer porcelain to physically hold on to the surface of the zirconia. (Figure 3) Compared to a dental alloy that is easily manipulated to have a rough surface texture which provides significant mechanical retention of the layered porcelain. The

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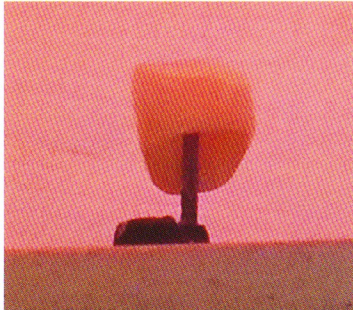


Figure 4: PFZ crowns must be slow cooled when exiting a porcelain oven to eliminate residual stress which can result in layered veneer porcelain cracking or popping off.



Figure 5: All zirconia crowns should always be adjusted with water to help avoid residual stress that may not show up for months after the adjustments have been made.

be caused by localized superheating resulting in immediate or future fracture of the veneer porcelain. If you see the little sparks while adjusting PFZ crowns, you could have set the crown up for failure. Even monolithic zirconia crowns can be fractured by aggressive grinding, without water chairside. (Figure 5)

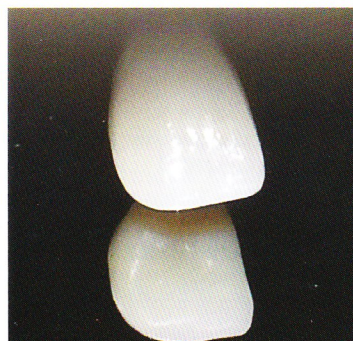


Figure 6: Beauty and the Beast crown with facial layered porcelain for superior aesthetics in the aesthetic zone.

about 60-70 Mega Pascals (MPa) but are very durable when properly bonded to an alloy substructure and properly supported by the alloy frame design. Milled e.max has a flexural strength of about 360 MPa. Pressed e.max has a flexural strength of about 400 MPa. The zirconia we are using has a flexural strength of about 1100 MPa. The design of the facial window cutback of the incredibly strong zirconia is designed to completely surround and protect the more vulnerable veneer porcelain leaving no chance of fracture on posterior and anterior crowns and bridges. (Figures #7a, 7b)

co-efficient of thermal expansion (CTE) with layered porcelain to zirconia can be death to the veneering porcelain if one simple procedure is not followed in the fabrication process. Technicians must SLOW COOL the last glaze bake of a porcelain to zirconia crown (Figure 4). Zirconia stays hot much longer than the veneer porcelain, so if the crown is cooled too quickly, it develops residual stress at the veneer porcelain and zirconia interface resulting in the veneer porcelain fracturing off the zirconia substrate. The interesting thing is that the residual stress may not show up for months after the crown/bridge is in the patient's mouth. PFZ (porcelain fused to zirconia) crowns require a six minute cooling cycle whereas most PFM's can be taken out of the oven immediately. So, if the technician is not aware of the differences between the two materials or rushes the cooling cycle, they can inadvertently cause a future failure. This is also vitally important to know when PFZ crowns are being adjusted in the mouth or chairside. If a PFZ crown is ever adjusted without water, the same residual stress issue can

Why did we design the Beauty and the Beast crown?

First, Beauty; I wanted to be able to offer our clients a zirconia crown that would be suitable in the aesthetic zone. (Figure 6)

Second, the Beast; I wanted to protect the veneer porcelain from any and all occlusal, or flexural forces in the mouth so it would be as strong and long lasting as a monolithic crown that didn't have veneering porcelain on it. The veneering porcelains we use on PFM crowns have an unsupported flexural strength of

We use a technique that allows us to color the incisal portion of the zirconia to blend with the enamel shading and the gingival to match the dentin color leaving the zirconia to porcelain junction virtually undetectable. (Figures #8-13)

The Beauty and the Beast design works equally well for bridges. Figures 14 and 15 shows a six unit maxillary anterior bridge from teeth numbers 6 through 11 including teeth numbers 6, 7, 10 and 11 as abutments and teeth numbers 8 and 9 ovate pontics. This bridge was made for Jonathan Bishop, DDS located in Steamboat Springs, Colorado. ■

About the Author

Dave Andrus, CDT has been a technician for 36 years with a broad background in the dental laboratory arena as well as the operatory.

In 1978, Dave started his career working in dental laboratories and went on to be a research and development technician for Coors Biomedical where he became a technical director responsible for teaching courses, answering technical calls, writing instruction manuals and working with ceramic engineers to help develop and refine dental porcelain. He was also technical director for SS White and Ceramco Porcelain.

In 2003, a US patent #6,547,649B1 was granted to Dave involving dental and jewelry noble and high noble alloys.

Dave has served on the editorial board of the National Association of Dental Laboratories for their Journal of Dental Technology; a peer reviewed publication, is a past president of the Colorado Dental Lab Association. He has been widely published in National and International dental technology publications and has studied occlusion under numerous theories. He has given clinics and lectures for the past 30 years and has owned Diamond Dental Studio, a five person lab, for 28 years; along with Andrus Technologies, a research and development company and is dedicated to the advancement of the dental industry as a whole.



Figure 7a: Cross-section of a maxillary lateral incisor showing the solid zirconia lingual with the incisal capped with zirconia so no occlusal forces are able to contact the labial layered porcelain veneer.



Figure 7b: Six-unit Beauty and the Beast bridge in the un-sintered state before colorant is applied.



Figure 8: Lateral incisor showing the virtually undetectable junction of the zirconia and the translucent veneer porcelain on the mesial proximal surface.



Figure 9: Milled zirconia molar Beauty and the Beast crown with colorant applied before sintering.

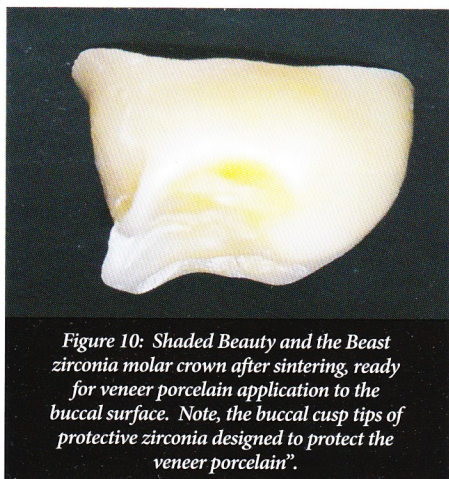


Figure 10: Shaded Beauty and the Beast zirconia molar crown after sintering, ready for veneer porcelain application to the buccal surface. Note, the buccal cusp tips of protective zirconia designed to protect the veneer porcelain.

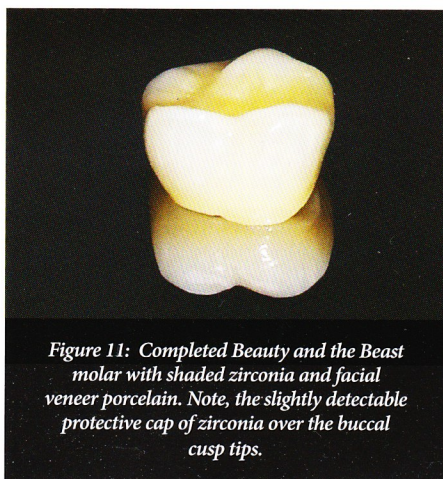


Figure 11: Completed Beauty and the Beast molar with shaded zirconia and facial veneer porcelain. Note, the slightly detectable protective cap of zirconia over the buccal cusp tips.

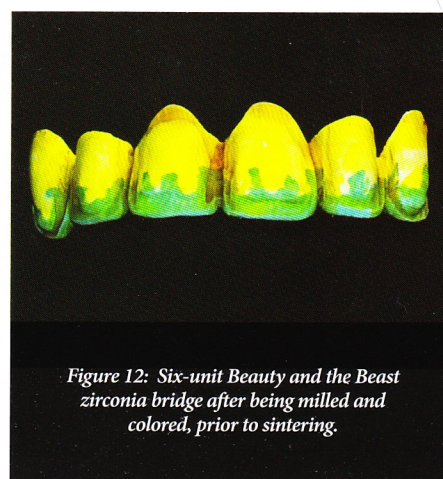


Figure 12: Six-unit Beauty and the Beast zirconia bridge after being milled and colored, prior to sintering.

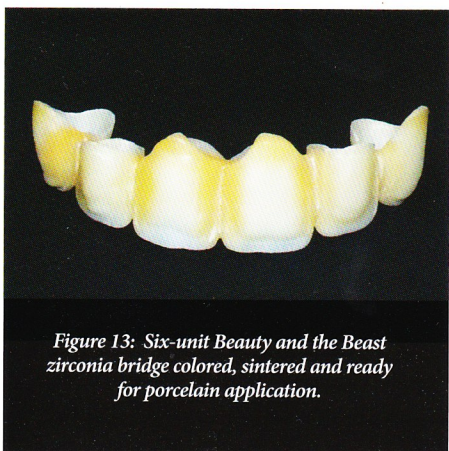


Figure 13: Six-unit Beauty and the Beast zirconia bridge colored, sintered and ready for porcelain application.

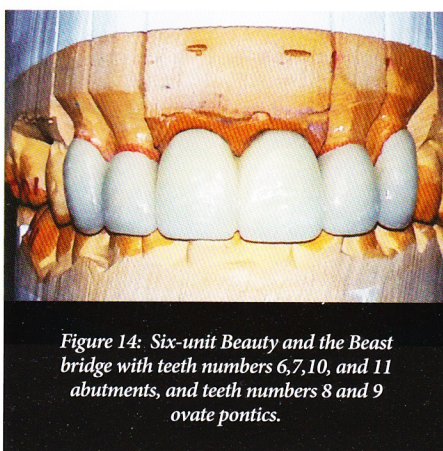


Figure 14: Six-unit Beauty and the Beast bridge with teeth numbers 6, 7, 10, and 11 abutments, and teeth numbers 8 and 9 ovate pontics.

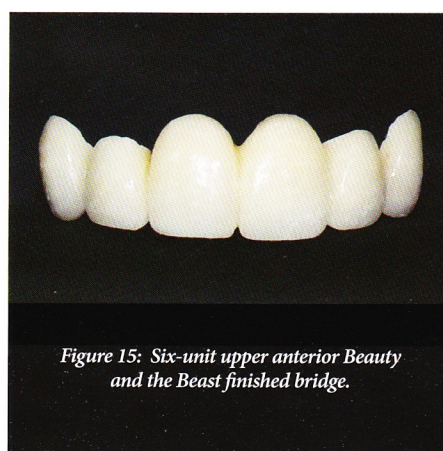


Figure 15: Six-unit upper anterior Beauty and the Beast finished bridge.

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