Technical White Paper

Overview of Recent Developments in Dental Zirconia

Paul Cascone

Senior VP of Research and Development

Argen Corporation

BD-18198-Ver1-12/19

The dental Zirconia market consists of three basic products: zirconia for copings and frameworks high strength “HS” list composition, full contour zirconia in both white and pre-shaded formulations high translucency “HT” list composition and the newest super-translucent zirconia that rivals E.MAX restorations in aesthetics also available in white and pre-shaded formulations super translucent “ST” list composition.

The ArgenZ™ brand covers all three zirconia types:

ArgenZ Ultra for copings and frameworks “HS” list composition

ArgenZ Esthetic for full contour single units and bridgework “HT” list composition

ArgenZ Anterior for single units and three unit bridges “ST” list composition

	BRUXZIR	ArgenZ Esthetic	BRUXZIR ANTERIOR	ArgenZ Anterior	ArgenZ Ultra	3M LAVA
ZrO2+HfO2+Y2O3	>99	>99	>99	>99	>99	>99
Y2O3	4.5-6.	4.5-6.	8.5-10.	8.5-10	4.5-6.	4.5-6.
Al2O3	<.1	<.1	<.1	<.1	<.5	<.5
HfO2	<5	<5	<5	<5	<5	<5
Other oxides	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5
Average Flexural Strength	1100MPa	1100MPa	650MPa	780MPa	1400MPa	1400MPa
Max	1435MPa	1450MPa				

ArgenZ Ultra is the original zirconia formulation made popular by 3M ESPE as 3M ESPE LAVA. This material, and essentially all other zirconia materials prior to 2009 is made from TOSOH 3YSB-E zirconia. In fact, it was not unusual for companies to advertise that they only used TOSOH zirconia.

Since the zirconia was from the same source, the materials chemical and mechanical properties were identical. It was not surprising then to see that the clinical results were all consistent, regardless of the brand used. The major problem seen clinically was porcelain chipping from the zirconia framework. The frequency was higher than that seen on porcelain-fused-to-metal since there was no chemical bond between the zirconia and porcelain and, unlike alloys, the zirconia was not elastic.

There was a desire for a monolithic zirconia but, since zirconia is second only to diamond in hardness, there was concern about wear of the opposing dentition. (3) In the United States, Glidewell took the lead and introduced a monolithic zirconia based on the original TOSOH zirconia except without alumina (BRUXZIR). Alumina had been added to the yttria partially stabilized zirconia in order to reduce the incidence of a destructive phase transformation. The alumina, however, made the zirconia white and opaque. By removing the alumina the zirconia became translucent and retained the majority of its strength. It was determined that the phase transformation had an almost insignificant probability of occurring in dental applications. So far this has held true.

The advantage of a monolithic zirconia list composition was recognized by the industry and a number of new brands entered the marketplace. The chemistry of all of the materials, however, were all the same or very similar, as are the mechanical properties. For example: BRUXZIR zirconia vs ArgenZ zirconia. Furthermore, studies have shown that the wear of natural dentition by the zirconia was not as great as originally feared. Since the chemistry and mechanical properties are similar it is expected that the clinical results would also be similar. Studies have demonstrated this to be true. (2,3)

Once the alumina content was eliminated, it was found that small changes in the zirconia's processing could enhance the translucency of the material without sacrificing strength. ArgenZ Esthetic is the result of those studies. The flexural strength is the same as BRUXZIR (average 1350 MPa , maximum 1480MPa) so there is no concern regarding wear or premature fracture.

A recent retrospective clinical study conducted by Dr. Sulaiman at UNC evaluated five years of zirconia production (over 39,000 units). Numerous brands of zirconia were included in the study including BRUXZIR. The results were a 2% failure rate for anterior units and a 1% failure rate for posterior units. The authors concluded that these were low fracture rates.(1)

The next development in zirconia formulations came within the last two years and introduced a level of translucency rivaling E.MAX. The ArgenZ Anterior is an example of these new formulations. Indications for this product are limited to single units and three-unit bridges. Recently, it has been reported that sandblasting may reduce the strength of zirconia. (5) A reduction in strength was recorded for sandblasting with 50 and 120 micron alumina. This confirms that any surface damage will adversely affect zirconia restorations.

As always, design considerations are always paramount for any of the zirconia formulations. Zirconia at any thickness has been found to be superior in strength to E.MAX (4).

References:

1. Prosthet Dent. 2016 May 10.

   "Fracture rate of monolithic zirconia restorations up to 5 years: A dental laboratory survey."

   Sulaiman TA1, Abdulmajeed AA2, Donovan TE3, Cooper LF4, Walter R5.

2. Oral Rehabil. 2016 Aug;43(8):621-9. doi: 10.1111/joor.12409. Epub 2016 May 20.

   "Clinical assessment of enamel wear caused by monolithic zirconia crowns."

   Stober T1, Bermejo JL2, Schwindling FS1, Schmitter M1.

3. Clin Oral Investig. 2016 Jun 9. [Epub ahead of print]

   Antagonist wear of monolithic zirconia crowns after 2 years.

   Lohbauer U1, Reich S2.

4. Oral Sci. 2015 Sep;57(3):255-61. doi: 10.2334/josnusd.57.255.

   “Fracture strength of ceramic monolithic crown systems of different thickness.”

   Nordahl N1, Vult von Steyern P, Larsson C.

5. Dental Materials, July 2016 Volume 32, Issue 7, Pages 915–920

   “Fatigue behavior of zirconia under different loading conditions”

   Moustafa N. Aboushelib, DDS, MSc, PhD, et.al.