Compendium of Continuing Education in Dentistry

June 2017
Volume 38, Issue 6

New High-Translucent Cubic-Phase–Containing Zirconia: Clinical and Laboratory Considerations and the Effect of Air Abrasion on Strength

Edward A. McLaren, DDS, MDC; Nathaniel Lawson, DMD, PhD; James Choi; Juan Kang; and Carlos Trujillo, DDS

Abstract

Fabricating all-ceramic restorations with minimal or no application of a se phase while maintaining esthetics has been a sought-after goal of the der profession. The objective has been development of a monolithic material optical properties similar to the natural tooth without the need for layering porcelain. This article examines some of the newer cubic zirconia materia in a monolithic form. The authors discuss laboratory-processing issues th esthetics, including evaluation of colorizing, sintering, finishing, and polish assess initial translucency testing of several materials while evaluating the of air abrasion on flexural strength of these cubic zirconias. Lastly, the arti demonstrates an anterior single-unit monolithic case with several of the n materials.

Due to increased patient demands for esthetics and the high cost of gold in r
years, the number of all-ceramic systems on the dental market has proliferate
Zirconia-based ceramics have become one of the prime alternatives to metal
restorations. Zirconia is a metastable material that can exist in various crystal
phases, three types of which have been utilized for dentistry: tetragonal, mor
and cubic.[1] The first version of zirconia employed in dentistry, now in use for
10 years, is a form comprised of the high-strength tetragonal crystalline phas
temperature zirconia exists in the weaker monoclinic crystalline form3; howev
amounts of oxides, or dopants, are added to stabilize the tetragonal crystallir
The main commercial version is stabilized with 3 mol% yttria and is called yttr
stabilized tetragonal zirconia polycrystal (3Y-TZP).[3] Originally, 0.25% of alumir
added because it aids in chemical stability of zirconia, minimizing the potentia
temperature moisture degradation as might occur in the oral environment.[3,5]
brands of high-strength zirconia are enhanced with 0.25% of alumina.

The original high-strength zirconia, while having excellent physical properties
white hue, is opaque and requires layering with porcelain in the same fashion
porcelain-fused-to-metal restoration to obtain even reasonable esthetics.[2] Te
zirconia has a relatively high refractive index. The addition of alumina, with a c
refractive index than zirconia, causes light passing through alumina-doped zi
scattered or absorbed at grain boundaries enough to make it relatively opaqu
1-mm thickness.[2,6] Density of processing (ie, air pockets), particle size, and p
distribution also each play a role in the opacity of tetragonal zirconia.[2]

Dentistry's elusive goal regarding use of all-ceramics is the fabrication of resto
with minimal or no application of a secondary phase while maintaining esthet
other words, the aim is to develop a monolithic material with optical propertie
resembling the natural tooth that can be used without layering of porcelain. H
strength glass-ceramics, such as lithium disilicate, have been developed in a
form with very good optical properties and are used successfully for this purp
initial attempt to produce a more translucent version of zirconia, developers r
alumina content from 0.25% to less than 0.05% and improved processing te
control zirconia grain size and processing density to minimize light refraction a
increase translucency.[2] Manufacturers now generally believe the alumina was
necessary for dental zirconia to prevent low-temperature degradation (phase
transformation), because dental zirconia does not undergo the constant phys
chemical stresses that a joint implant does. It is possible that it was likely adc

Related Articles

Does Six Hours of Contact With Alginate Impression Affect the Dental Cast Properties?
Compendium, June 2017

The Direct-Indirect Technique for Composite Restorations Revisited
Compendium, June 2017

Correction of a Single Discolored Anterior Tooth Due to Internal Resorption: A Clinical Report
Compendium, May 2017

Nanotechnology in Dentistry: Clinical applications, Benefits, and Hazards
Compendium, May 2017

Does Post-etching Cleaning Influence Bond Strength of Lithium Disilicate Laminate Veneers?
Compendium, May 2017

a precaution, although the authors could not find any supportive research. Tw commonly known brands of this generation of zirconia are BruxZir® (Glidewel Laboratories, glidewelldental.com) and Lava™ Plus (3M ESPE, 3MESPE.com materials, while offering a slight increase in translucency compared with origi still lack the necessary optics to be used in the anterior but benefit from minir microlayering of porcelain (Figure 1 and Figure 2). The reduction in alumina ar improvement in processing technique has minimal effect on the mechanical p of the material.[3]

The third and most recent strategy to increase the translucency of zirconia is it with a significant cubic crystalline phase interspersed with the tetragonal ph Increasing the yttria content to more than 8 mol% will stabilize the cubic phas versions of "high-translucent" or "cubic-containing" zirconia have come on th recently, manufactured with approximately 8 mol% yttria to 10 mol% yttria. E these include: Lava™ Esthetic (3M ESPE); Katana™ Zirconia (UTML/STML) (Noritake Dental Inc., kuraraynoritake.com); BruxZir® Anterior (Glidewell Labor ArgenZ™ Anterior (Argen Corp., argen.com); and Imagine® (Jensen Corp.,). amount of cubic phase in these types of materials, though proprietary, ranges to 15%, according to manufacturers. The cubic phase of zirconia is isotropic crystallographic directions, which decreases light scattering that occurs at gr boundaries.[2,8,9] As a result, the cubic zirconia appears more translucent.[2,8,9] T translucency of dental polycrystalline cubic zirconia should not be confused w complete transparency of cubic zirconia used in jewelry, which is a single-cry structure (ie, no grain boundaries). Stabilized cubic zirconia does not transfor temperature; therefore, cubic zirconia will not undergo transformation toughe low-temperature degradation. In other words, it is more susceptible to mecha damage,[2,10] though it will not degrade over time. Generally, all materials on th list their flexural strength at approximately 40% less than the high strength of tetragonal versions. Most manufacturers report their materials to be in the 60 750 MPa range for flexural strength and claim that they have both the translu strength to be used for single restorations anywhere in the mouth.[11]

The purpose of this article is to examine some of the newer cubic zirconia ma used in a monolithic form. First, the authors will discuss laboratory-processin that affect esthetics, including evaluation of colorizing, sintering, finishing, and Second, the authors will assess initial translucency testing of several material evaluate the effect of air abrasion on flexural strength of these cubic zirconias been well established in the literature that to increase the adhesion of zirconia abrasion with aluminum oxide is necessary.[12] Published reports have shown or weakening effects of high-strength zirconia with air abrasion and have dem an increase in strength with some materials, probably due to a monoclinic cry transformation.[13] Known as transformation toughening, tetragonal zirconia “tr into monoclinic-form crystals, which are 3% to 5% larger. This gives it the abi compress crack growth through localized volumetric expansion.[4] Cubic zirco undergo this change. No published reports could be found on the effects alu abrasion has on strength at pressures recommended for increasing adhesion cements and special primers. Lastly, and perhaps most importantly, this artic demonstrates an anterior single-unit monolithic case with several of the newe and contrasts it to what is considered to be a standard in monolithic esthetic disilicate.

Laboratory Considerations That Affect Esthetics

In an extensive search of the literature and social media, the authors could no published information or recommendations (other than from a manufacturer) “pre-finish” (either texturize or colorize) these new cubic zirconia materials for use. The authors considered it very important to laboratory-test colorization a texturization techniques both in presintering and postsintering stages to be a make initial recommendations for how best to handle this material.

Cubic zirconia in its green state, or unsintered, grinds fairly similar to grinding of hard chalk. When ground on, these new materials felt similar to original hig zirconia materials, although they seemed to be more brittle and chip easier at margin when finishing; thus, considerable care needs to be taken in these reg Texturizing the surface of cubic zirconia with different coarseness of carbides laboratory diamonds gave very different results (Figure 3). In the authors' han experience, fine diamonds used in an electric handpiece at approximately 10 to 12,000 RPM resulted in the most natural-looking texture (Figure 4). After u diamonds, the authors tested two different impregnated rubber polishers—on point and one pink point—with the latter used at approximately 8,000 RPM g most natural finish, in the authors' estimation (Figure 5 and Figure 6).

The authors also attempted to integrate texture into postsintered cubic zircon then re-polish. They found that it was either impossible to maintain natural-lo surface texture or the surface was microrough after polishing, which could cr additional problem of abrasion against the opposing tooth.[14] Therefore, the a highly recommend putting all the form surface texture and prepolish into the r prior to sintering, regardless of the brand or type of zirconia used.

Some of the pigments from some of the manufacturers for colorizing and/or g shade color to the cubic zirconia were found to be fairly low in chroma during application. This made it difficult for the authors to know if they had achieved when applying an even coating or a specific pattern (Figure 7). The authors fo the Zirkonzahn pigments (zirkonzahn.com) had the best visible color during a and were the most user friendly (Figure 8). These pigments worked with all sy provided somewhat similar results for each. Thus, if a clinician prefers a pigm specific system, it is possible to use it with another company's zirconia of sim cubic/tetragonal phase relationship. One option to better visualize the applica pigments or colorants the authors tested was to add food coloring (Figure 9 a 10) to the pigments to intensify the visual color and see more clearly the amo applied. The food colorants were added only as a contrast media to better vi actual zirconia color pigment being applied. As long as the food colorant did any form of sugar, it burned out cleanly. The authors used Kroger (kroger.com colorants. It is important to note that the manufacturers have no recommend regarding this technique. The manufacturers provide specific guidance for ho their colorants; adding the food color to low visually chromatic pigments allov applicator to see if the colorants have been applied in the desired pattern. Th of food coloring did not cause any negative postsintering problems.

Based on the visual analysis of the evaluators (McLaren, Kang, Trujillo, and C calibrated photography, and laboratory evaluation in Photoshop from a sectio middle one third of the shade guide and middle one third of the crown (Figure Argen colorants came closest to matching the A2 shade guide when using A pigments, and Zirkonzahn pigments offered the most ability to custom coloriz restoration, which would be more of a need for anterior teeth.

The most significant laboratory concern was a sensitivity to firing temperature change either plus or minus caused a discernable difference in perceptible tra of a molar full-contour crown (Figure 12 through Figure 14). Thus, a high-qua that has even firing parameters throughout the firing chamber is paramount fo controlling esthetic success as it relates to obtaining desired translucency. Th tried three ovens, which were calibrated per manufacturers' recommendation test crowns were fired at different heights within the containing tray as a test determine if different zones in the oven had even heat. Only one oven (Zircom kdfus.com) gave consistent results. This suggests that oven choice is a majo consideration that is perhaps more critical than specific material with cubic zi this early stage of development. The oven quality and correct firing was a crit of the process and must not be overlooked. Once the material is sintered, ch staining will not affect the translucent result of the crown other than by blocki pigments from the surface. The firing of surface pigments will not alter the str physically or optically, unlike glasses.

The effect of the color of the preparation on the final perceived color was eva visually by fabricating a single molar crown that had a 1.2-mm thickness and colorized as closely as possible to match the A2 shade of the Vita classical s (VITA Zahnfabrik, vita-zahnfabrik.com). The crown was placed on five resin co dies fabricated with 1M1 to 5M3 shades based on the Vita classical shade sy

can be seen in the gingival one third of the restoration, which is due to "bleec
This would need to be considered in the shade-matching process. For this ar
amount of color change due to the substrate; however, this will be the topic c

One last important observation by the authors relative to obtaining ideal esthe
judgment, glazing alone did not result in a realistic surface as it might with no
tooth). Rather, mechanical polishing with Dialite polishers (Brasseler USA, bra
polishing paste appeared to give a more realistic finish to the surface (Figure
were done in a light box with even illumination set at 5500 degrees Kelvin.

Translucency and Effects of Air Abrasion Testing Translucency Testing

Manufacturer-fabricated specimens were tested for translucency. The main re
mm in thickness and at least 10 mm in diameter, or square. On arrival, the au
white background and a black line to visually evaluate translucency (Figure 17
zirconia A2 specimens were similar in translucency—that is, slightly visually le
translucency) (Ivoclar Vivadent, ivoclarvivadent.us) and significantly less trans
translucency) (Ivoclar Vivadent). All specimens were A2, but each had a differ
planning a more exhaustive test with exact uniform specimens to test transm

Flexural Strength Testing

The three-point bend flexural strength of a representative sample of transluce
[Dental Direkt, dentaldirekt.com]; Prettau® Anterior® [Zirkonzahn]; BruxZir® Ar
[Jensen Dental]) and traditional (ArgenZ Esthetic [Argen]; DD Bio ZX2 [Dental
according to ISO 6872. Specimens were prepared by sectioning the zirconia
mm, sintering according to manufacturers' recommendations, and polishing
paper. Specimens (N = 5) were then prepared according to three treatment c
(2) particle abrasion at 2-bar (30 psi) pressure; and (3) particle abrasion at 4-b
was performed with 50-μm alumina for 10 seconds from a distance of 10 mm
testing machine on 20-mm separated supports and loaded to failure at 1 mm
was used to calculate the flexural strength. A representative specimen of both
treated with 2-bar alumina particle abrasion and observed with a scanning ele

The results of this pilot study (Table 1) indicated that traditional zirconia does
after particle abrasion, and one traditional zirconia material actually became s
observation is not unique, as previous studies have shown improvements in f
The increase in strength after particle abrasion is presumed to occur following
monoclinic zirconia in transformation toughening. Following 2- and 4-bar part
tested in the study showed a significant decrease in strength. The translucen
phase, which does not transform, and therefore will not undergo transformati
The surfaces of the traditional and translucent zirconia following particle abra

damage (Figure 19 and Figure 20). The similarity of the surfaces provides evic
traditional and translucent zirconia is due to a lack of transformation toughen

No clinical conclusions can be drawn from these data, and the authors are in
may not detrimentally affect the strength of cubic-phase–containing zirconia,
air pressure. These treatments, in combination with proven zirconia primers (i
methacryloyloxydecyl dihydrogen phosphate [MDP]), may enable durable bor
However, it should not be assumed that because this is zirconia it can be use
for posterior crowns. Another assumption is that it would behave clinically the
No evidence supports this claim, and clearly it is much easier to damage or w
already starts with a lower strength. The authors' preliminary recommendatio
to use a system that utilizes 30-µm alumina particles coated in silica followed
Monobond Plus [Ivoclar Vivadent]; Clearfil™ Ceramic Primer [Kuraray]). One b
distribution, which theoretically should minimize crack initiation and crack gro
porcelain works.

Case Evaluation

For clinical evaluation of several commercial systems, a single central crown c
are generally regarded as the biggest esthetic challenge in dentistry. A case w
(Figure 21) with a facial reduction of approximately 1.2 mm. While this article
of patient treatment, it should be noted that when taking shade information a
hydrated because teeth will appear brighter when they are dehydrated. Norita
Argen Anterior (Argen), CubeX2 (Dental Direkt), and Jensen Imagine (Jensen
technique and compared to e.max MT as a control. Presintering colorization
supplied colorants. As stated earlier, to custom colorize, the presintered cubi
shade colorants and shade modifiers to match the adjacent natural tooth. Th
given system to know how the main shade colors behave and how to use cu
ceramist performed the task.

For the Noritake STML, the material is already internally colorized and has mu
colors. A slightly brighter color was chosen than the central to be matched kn
would be necessary to "fine tune" the color match. Shade A2 of e.max was u
control. All systems required two coats of external colorants and separate firi
matched natural tooth. As described in the laboratory section earlier, all syste
mechanically polished to obtain natural surface finish and gloss. Figure 22 thr
results of the four systems (Noritake STML, Argen Anterior, CubeX2, and Jen
depicts the e.max MT. The images clearly show that an excellent esthetic res
zirconia, similar in appearance and esthetic value to that of the control.

Conclusion

Cubic-containing zirconia behaves differently to air abrasion than the original
cubic phase. Thus, one should be cautious making clinical decisions based o

tetragonal zirconia. In the opinion of the authors, cubic-containing zirconia is processing techniques, thus highly controlled processes have to be followed properties reported. Clinical evaluation on monolithic cubic-containing zirconi restoration.

About the Authors

Edward A. McLaren, DDS, MDC

Professor, Founder and Director, UCLA Postgraduate Esthetics; Director UCL and Director, UCLA Master Dental Ceramist Program, UCLA School of Dentis limited to prosthodontics and esthetic dentistry, Los Angeles, California

Nathaniel Lawson, DMD, PhD

Assistant Professor, Director, Division of Biomaterials, Department of Clinical Dentistry, Birmingham, Alabama

James Choi

Co-Director, UCLA Master Dental Ceramist Program, Director Esthetic Dentis Los Angeles, California

Juan Kang

Master Ceramist, Assistant Director of Esthetic Dentistry Laboratory, UCLA S

Carlos Trujillo, DDS

Senior Fellow, UCLA Advanced Esthetics and Restorative Dentistry, UCLA Sc

References

1. Howard CJ, Hill RJ. The polymorphs of zirconia: phase abundance and cry neutron and X-ray diffraction data. *J Mater Sci*. 1991;26(1):127-134.

2. Zhang Y. Making yttria-stabilized tetragonal zirconia translucent. *Dent Mate*

3. Tong H, Tanaka CB, Kaizer MR, Zhang Y. Characterization of three comme high-translucency, high-strength and high-surface area. *Ceram Int*. 2016;42(

4. Denry I, Kelly JR. State of the art of zirconia for dental applications. *Dent M*

5. Matsui K, Ohmichi N, Ohgai M, et al. Effect of alumina-doping on grain bou transformation in yttria-stabilized tetragonal zirconia polycrystal. *Journal of M*

6. Zhang H, Li Z, Kim BN, Morita K, et al. Effect of alumina dopant on transpa

Nanomaterials. 2012;2012(2012):1-5.

7. Sulaiman TA, Delgado AJ, Donovan TE. Survival rate of lithium disilicate re
J Prosthet Dent. 2015;114(3):364-366.

8. Harada K, Raigrodski AJ, Chung KH, et al. A comparative evaluation of the
disilicate for monolithic restorations. *J Prosthet Dent*. 2016;116(2):257-263.

9. Peuchert U, Okano Y, Menke Y, et al. Transparent cubic-ZrO2 ceramics fo
the European Ceramic Society. 2009;29(2):283-291.

10. Lucas TJ, Lawson NC, Janowski GM, Burgess JO. Effect of grain size o
roughness, and modulus of aged partially stabilized zirconia. *Dent Mater.* 201

11. Zhang F, Inokoshi M, Batuk M, et al. Strength, toughness and aging stab
dental restorations. *Dent Mater*. 2016;32(12):e327-e337.

12. Yang B, Barloi A, Kern M. Influence of air-abrasion on zirconia ceramic bo
Dent Mater. 2010;26(1):44-50.

13. Ozcan M, Melo R, Souza RO, et al. Effect of air-particle abrasion protoco
characteristics and phase transformation of zirconia after cyclic loading. *J Me*

14. Lawson NC, Janyavula S, Syklawer S, et al. Wear of enamel opposing zi
polishing and glazing. *J Dent*. 2014;42(12):1586-1591.

15. Kwon SJ, Lawson N, Beck P, et al. Bond strength, wear, and enamel wea
Res. 2016;95(spec iss A): Abstract 0244.