Gordon J. Christensen
Clinicians Report®
Reprint
Serving Dentistry 44 YEARS
Reprinted September 2020, with permission, from Volume 13 Issue 9, September 2020, Pages 1–4
CR is the original and only independent dental product testing organization with funding only from dentists!

ZIRCONIA CROWNS: What dentists and labs need to know in 2020!

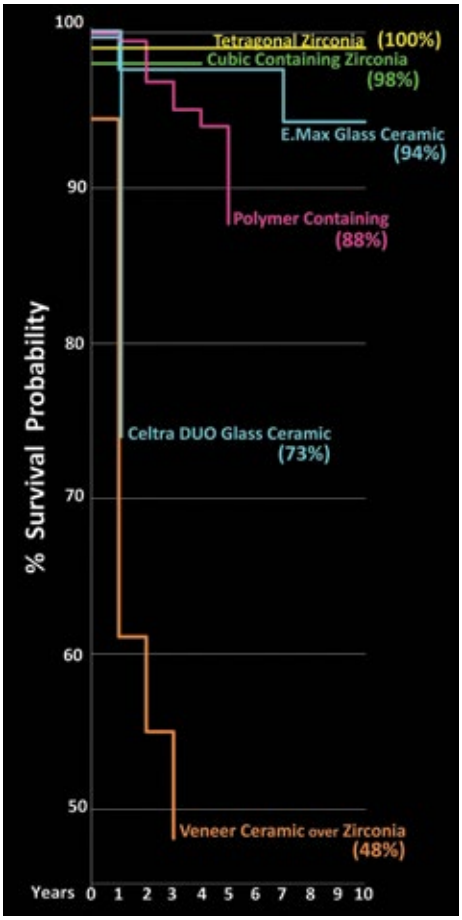
Gordon's Clinical Observations: Monolithic esthetic crowns now dominate the market. However, there are now so many brand names and marketing claims that it is impossible to know which are actually serving best. Are the zirconias serving so well that it is time to abandon metal crowns and multi-unit fixed prostheses? The TRAC Research section of Clinicians Report has been conducting real-world, "in-the-mouth" comparisons of these materials, moving them into clinical study as they were introduced in the U.S. for the past 11 years. *This report is packed with information that will help you make* ***informed decisions*** *with your patients concerning the choice of which materials to use where.*

TRAC RESEARCH

Uncertain economic futures have focused patients on ***durability*** and ***affordability*** of esthetic crowns. Our 10-year continuing study involving 121 dentists and 1,046 esthetic crowns shows ***zirconia ceramics uniquely fulfill these criteria***. So far, ALL of 16 different zirconia ceramics have 100% survival in clinical service, with even the newer unproven esthetic zirconias all surviving their first service year without fracture. **This finding is unique to the zirconias vs. the other esthetic crown materials in this study.**

This report updates clinicians on:

(1) Important terminology
(2) Strength numbers they can expect
(3) Clinical performance of a variety of zirconia formulations
(4) Brand names tied to physical properties claimed by source companies
(5) Emerging contra-indications for zirconia.



Crown Survival Graph *(Kaplan Meier)* **shows fracture survival up to 10 years of 1,046 esthetic molar crowns from 5 material categories. NOTE: Only the 2 Categories of zirconia** *(Tetragonal and Cubic Containing)* **have NO fractures in service.**

Continued on Page 2

A Publication of **CR Foundation®** • 3707 N. Canyon Rd, Bldg 7, Provo UT 84604 • 801-226-2121 • www.CliniciansReport.org

ZIRCONIA CROWNS: What dentists and labs need to know in 2020! *(Continued from page 1)*

1. Critical facts about zirconia—Why isn't this information communicated with every crown?

Transparency about zirconia formulation, physical properties, clinical indications, and specific brand name milled should be *MANDATORY* for every restoration delivered to dentists and their patients. Lack of this information is causing misunderstandings leading to poor choices and handling that affect restoration durability. Patients want restorations that appear to be their natural teeth—and they *expect* them to last! This study is showing zirconia has potential to fulfill these patient expectations. However, labs & dentists must have correct information. The fickle strength numbers are a large part of the overall problem, along with the aggressive promotion of the unproven Cubic Containing 4Y & 5Y formulations, and secrecy about additives to the zirconium oxide which could negatively effect some patients with hypersensitivity issues.

EXPLANATION OF CHART BELOW:

Column (1) lists in red the commonly used "Y" terminology *(which refers to the "mol %" of the oxide yttria in the formulation)*, and lists in black the correct terminolgy established by international agreement.

Column (2) lists the amount of yttria in the formulation by "mol %" *(red)* and by weight % *(black)*.

Column (3) lists the approximate ratio of the strong Tetragonal versus the weaker Cubic crystals in the 3Y, 4Y, and 5Y formulations.

Columns (4) and (5) list the flexural strengths and fracture toughness values agreed upon internationally as reasonable expectations for the Tetragonal and Cubic Containing zirconia formulations.

Columns (6), (7), and 8 list the flexural strengths and fracture toughness values claimed by the companies selling the brand names listed.

INFORMATION NEEDED TO UNDERSTAND ZIRCONIA					STRENGTHS, FRACTURE TOUGHNESS & CLASS CLAIMED BY SOURCE COMPANY ★		
(1) Commonly Used Terms / Correct Terms	(2) Mol % Yttira ✱ / Weight % Yttria	(3)	(4) Internationally Agreed Upon Numbers for the 2 Zirconia Classes: Flexural Strength	(5) Internationally Agreed Upon Numbers for the 2 Zirconia Classes: Fracture Toughness	(6) Flexural Strength *(MPa)*	(7) Fracture Toughness *(MPa√m)*	(8) Brand Names & Source Company
3Y Zirconia Tetragonal or Class 5 Zirconia	3 mol % 4.5–6.0 weight %	~100% Tetragonal & ~0% Cubic	>800 MPa	>5	1200	?	Alien HT *(Alien Milling Technologies)*
					1100	?	Alien Multi-Layer *(Alien Milling Technologies)*
					1250	*testing in process*	ArgenZ HT+ *(Argen)*
					1100+	5.0	BruxZir *(2009) (Glidewell)*
					1100	5.0	BruxZir NOW *(Glidewell)*
					1100+	5.0	BruxZir Shaded *(Glidewell)*
					1243	5.1	ZirCAD LT *(Ivoclar Vivadent)*
					1200	5.1	ZirCAD Prime Core and ZirCAD Prime Incisal *(Ivoclar Vivadent)*
					1200+	5.0+	Zirlux 16+ *(Zahn Dental)*
4Y Zirconia Cubic Containing or Class 4 Zirconia	≥4 mol % 6.0–8.0 weight %	~75% Tetragonal & ~25% Cubic	>500 MPa	>3.5	850	3.6	ZirCAD MT *(Ivoclar Vivadent)*
5Y Zirconia Cubic Containing or Class 4 Zirconia	≥5 mol % 9.05–10.0 weight %	~50% Tetragonal & ~50% Cubic	>500 MPa ●	>3.5 ●	650	2.1	BruxZir Anterior *(Glidewell)*
					870	2.7–3.1	BruxZir Esthetic *(Glidewell)*
					720	4.8	CubeX² *(Dental Direct)*
					748	3.2	Katana STML *(Kuraray Noritake)*
					800	>4.0	Lava Esthetic *(3M)*
			● **NOTE:** ISO does not differentiate between Cubic Containing Zirconia formulations 4Y & 5Y				

✱ **Yttria:** An oxide added originally to zirconium oxide to stabilize the crystal structure in its strongest Tetragonal configuration, now increased to change refractive index and give zirconia more translucence, but increase in yttria results in ***strength reductions***.

★ **Claimed Strengths & Fracture Toughness: Marketing, use of different test methods, and manipulation of techniques cause important variations in strengths claimed by different companies.**

SUMMARY:

- As more yttria is added to improve esthetics *(3Y versus 4Y–5Y)*, the strength and fracture toughness decrease.
- As the percentage of strong Tetragonal phase zirconia is replaced by the weaker Cubic phase *(3Y versus 4Y–5Y)*, the strength and fracture toughness decrease.
- Market competition encourages exaggeration of strength and fracture toughness numbers beyond those generally expected which leads clinicians to choose the less proven Cubic Containing zirconia over the well-proven Tetraganol zirconia since strengths and fracture toughness appear similar in ads, when they are not.

ZIRCONIA CROWNS: What dentists and labs need to know in 2020! *(Continued from page 2)*

2. Which brands and zirconia categories are in this study—and what has been observed?

Brand Name	Mol % Yttria	2020 Service Years	2020 % Clinical Survival
Tetragonal Zirconia *("3Y")*			
Alien HT	3Y	1	100
Alien Multi-Layer	3Y	1	100
ArgenZ HT+	3Y	1	100
BruxZir *(2009)*	3Y	10	100
BruxZir Now	3Y	2	100
BruxZir Shaded	3Y	1	100
Pavati Z40.1	3Y	2	100
ZirCAD LT	3Y	4	100
ZirCAD Prime	3Y core	1	100
Zirlux 16+	3Y	3	100
Cubic Containing Zirconia *("4Y & 5Y")*			
ZirCAD MT	4Y	1	100
BruxZir Anterior	5.5Y	2	100
BruxZir Esthetic	4.7–4.9Y	1	100
CubeX²	5Y	1	100
Katana STML	5–5.5Y	4	100
Lava Esthetic	5Y	3	100
ZirCAD Prime	5Y incisal	1	100
High Strength Glass Ceramic			
Celtra DUO	—	1	73
e.maxCAD	—	10	94
Polymer Containing			
Camouflage Now	—	2	98
CeraSmart	—	4	93
Enamic	—	4	94
Lava Ultimate	—	5	89
Veneer Ceramic over Zirconia			
Press Ceram/Metoxit	3Y	3	48

DURABILITY & ESTHETIC OBSERVATIONS BY CATEGORY

- **Tetragonal Zirconia *("3Y")***
  - Abuse Tolerance: **EXCELLENT**, whether or not cemented. With minimal preparations *(similar to cast gold prep)*, **BruxZir *(2009)*** has survived below stresses for 10+ years:
    – coarse diamond recontouring while hand held before cementing
    – very thin small zirconia areas on occlusal or axial walls
    – all levels and types of occlusal habits
    – refusal to wear night guard
    – endo entry access
  - Blend with surrounding dentition: **FAIR** to **GOOD**, but can be **EXCELLENT** if skilled lab stains in green state, fires correctly, & polishes carefully without over polishing to gray iridescence.

- **Cubic Containing Zirconia *("4Y & 5Y")***
  - Abuse Tolerance: **VERY GOOD** so far—***after* cementation**. These formulations are newer and not yet fully proven, but this study shows materials in this category require careful handling:
    – **Following brands did not always tolerate handheld recontouring and overall 1% fractured *before cementation:***
    Alien Multi-Layer **BruxZir Anterior**
    BruxZir Esthetic **CubeX2**
    – do not tolerate very thin areas
    – may fracture during endo entry access *(endo entry with Class 4 zirconia not needed in this study yet, BUT fracture has been reported by CR readers).* ***(Endodontic referral dentist needs warning of possible fracture.)***
  - Blend with surrounding dentition: **VERY GOOD** & can be **EXCELLENT** if lab technician is careful.

- **High Strength Glass Ceramics**
  - Abuse Tolerance: **E.Max in molars VERY GOOD**. With tooth preps used in this study *(1.5 to 2.0 mm occlusal, 1.5 axial, deep chamfer margin)*, it had 94% fracture survival in 10+ years. **Celtra DUO in molars POOR**. It had 73% fracture survival during 1 service year.
  - Blend with surrounding dentition: **GENERALLY EXCELLENT**.

- **Polymer Containing**
  - Abuse Tolerance **in molars: GOOD** with 88% fracture survival up to 5 years BUT ***retention failure (debonds)*** was unusually high in this category at 25–36%, except for CAMouflage NOW which had only 4% retention failure after 2 service years. **Other crown categories in this study each had ±2% retention failure.**
  - Blend with surrounding dentition: **VERY GOOD** to **EXCELLENT**.

- **Veneer Ceramic over Zirconia**
  - Abuse Tolerance: **POOR**. These had 52% of crowns with large veneer ceramic fractures compromising occlusion and/or proximal contacts by 3 service years.
  - Blend with surrounding dentition: **GOOD** to **EXCELLENT**, depending on lab technician.

ZIRCONIA CROWNS: What dentists and labs need to know in 2020! *(Continued from page 3)*

3. What internationally agreed upon information on ceramics do I need to know?

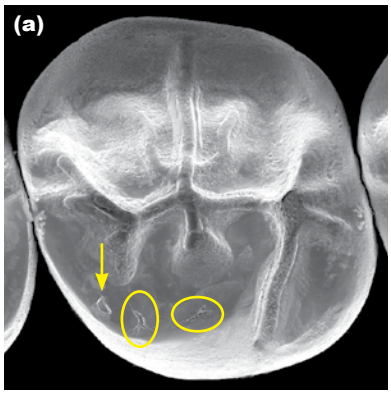
International Terminology	Porcelains	Leucite Glass-Ceramics	Lithium Disilicate High Strength Glass Ceramics	Cubic Containing Zirconia	Tetragonol Zirconia
Classes of Ceramics	**Class 1**	**Class 2**	**Class 3**	**Class 4** "4Y & 5Y" Zirconia	**Class 5** "3Y" Zirconia
International Agreed Upon Strengths to Expect in Each Class	Flexural Strength: **<100 MPa** Fracture Toughness: **<1.0**	Flexural Strength: **>100 MPa** Fracture Toughness: **>1.0**	Flexural Strength: **>300 MPa** Fracture Toughness: **>2**	Flexural Strength: **>500 MPa** Fracture Toughness: **>3.5**	Flexural Strength: **>800 MPa** Fracture Toughness: **>5**
Suggested Appropriate Clinical Uses	Veneering Ceramics	Single Unit Anterior or Posterior Adhesively Cemented	Single Unit Anterior or Posterior	Single Unit Anterior or Posterior	4 or More Units Anterior or Posterior

International ISO 6872 Specification on Ceramic Classification shown in chart form. For FDA registration, companies must present data to prove they are either a Class 4 or Class 5 zirconia. *(Chart adapted from Morris G. Esthetic Ceramic Restorations using ADA Approved ISO Standards. J Dent Technology 2018; 22–24.)*

NOTE: Lab prescriptions specifying just "zirconia" or checking a brand name on a form without knowing true strengths are *negligent*.

4. What are CONTRA-INDICATIONS for any class of zirconia? *(where appropriate cast metal may be indicated)*

- **Tooth preparations allowing less than 0.6 mm occlusal reduction and corresponding inadequate wall thickness.**
- **Zirconia opposing zirconia in extremely active heavy occlusions to avoid microscopic breakdown.** ***(See Fig. 1 below.)***
- **When opposing contact is cast gold or polymer to avoid extreme wear.** ***(See Fig. 2 below.)***
- **Where precision attachments are indicated.**
- **Where optimum esthetics is a priority** ***(unless the lab knows how to stain in green state, fire correctly, & polish without over polishing to gray iridescence (no glaze used)).***



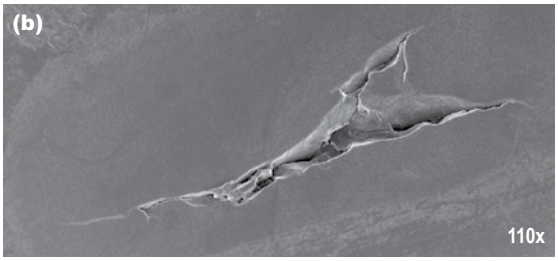


Figure 1. (a) Scanning electron microscope *(SEM)* 10x image shows 1 chip *(arrow)* & 2 very small stress areas *(ovals)* on 8-year Class 5 zirconia. (b) Far right oval area magnified to 110x looks ominous, but it has changed little in 8 years of heavy 24/7 bruxing on zirconia opposing zirconia crowns.

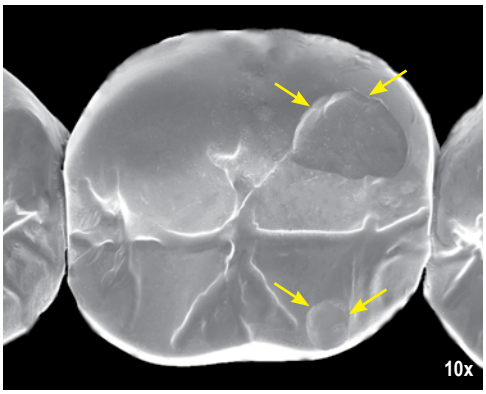


Figure 2. SEM 10x image of cast gold opposing Class 4 zirconia at 3 service years.

KEY CLINICAL ACTION POINTS FROM THIS RESEARCH ARE:

(1) If the patient is seeking durability and affordability, choose Class 5 zirconia whenever possible. BruxZir *(2009)*, now called BruxZir Shaded, has demonstrated excellent durability for 10+ years, and its laboratory fees have not changed since 2009. Class 5 zirconias have the strength and toughness to deliver a margin of safety needed to survive common clinical abuses.

(2) The terminology and numbers in the table above on this page should be memorized or posted on your wall, and sent to your laboratory technician to post on his/her wall so you can communicate.

(3) Demand that your lab provide essential legal data with each restoration. This includes: ● Brand name of the zirconia disk milled for that restoration, ● Zirconia ISO Class, ● Mol % additives to the zirconium oxide *(IdentCeram Certificates do not fulfill these needs, but they provide the only listing of zirconia content available today, and should also be provided with each restoration)*. NOTE: This information is CRITICAL because 1) It is unwise to place materials in patient's bodies without full disclosure of constituents, 2) Rogue zirconia disks are sold directly to labs from uknown sources without FDA clearance documents available, making content and quality unknown.

(4) Collect independent data on performance of specific brand names of zirconia. Choose which you prefer and always specify brand name on every prescription—otherwise the laboratory chooses, and this may or may not be what you had in mind for the patient.

(5) E.max Class 3 non-zirconia ceramic has performed extremely well in this clinical study. It has esthetics and strength well suited to anterior restorations, but is not the most durable choice for molars.

(6) The Cubic Containing zirconias began to appear in the U.S. about 5 years AFTER BruxZir. Their clinical durability is **NOT YET PROVEN** and is confounded by the ongoing introduction of additional formulations. *In vitro* research on Cubic Containing formulations that exceed 4.5 mol % yttria report performance similar to E.max, indicating best for anterior restorations and less durable on molars.

(7) Zirconia does not outperform and outdate metals in all cases. Cast metal and PFM restorations are still indicated *(see Section 4 above)*.

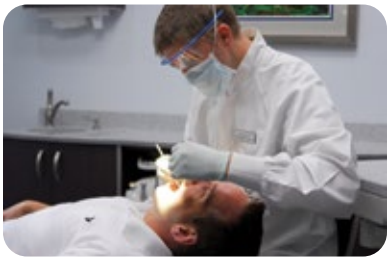
What is CR?

THERE IS NO OTHER ORGANIZATION LIKE CR ANYWHERE IN THE WORLD TODAY!

CR'S ON-SITE PERSONNEL consists of basic scientists, engineers, and support staff. Revenue from CR's "Dentistry Update®" courses and Gordon J. Christensen Clinicians Report® subscriptions support payroll and research expenses.

The ***Gordon J. Christensen Clinicians Report***® is published monthly and has a readership exceeding 100,000. The ***Gordon J. Christensen Dental Hygiene Clinicians Report***® is published six times a year. Electronic versions of all printed English CR resources are available online at www.CliniciansReport.org, which allows rapid searching of *Clinicians Reports* for concepts and products.

THOUSANDS OF DENTAL PRODUCTS from all over the world arrive at CR each year. Products are subjected to at least two levels of CR's three-tiered evaluation processes.



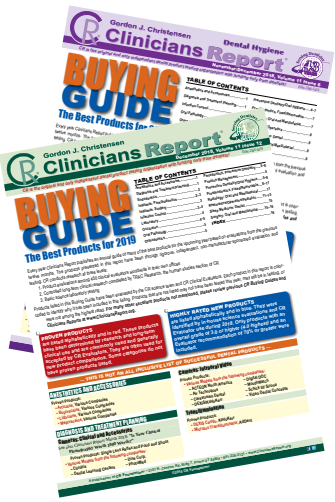
CR ORAL HEALTH CENTER resembles a private dental clinic. However, in this setting, it is the patients who are paid. Examples of products studied here are restorative materials, CAD/CAM, radiography units, caries detection devices, and other types of dental equipment.

Gordon J. Christensen Dentistry Update®

CR DENTISTRY UPDATE WITH GORDON J. CHRISTENSEN

Enroll in the most popular continuing education course in dentistry. Now offering 7 and 14 credit courses in many geographic locations. Visit www.CliniciansReport.org for a complete listing of course dates and locations.

CR CONDUCTS LABORATORY TESTS to determine physical and chemical characteristics of products such as compressive, tensile, and diametral tensile strengths. Thermal stressing and other methods are also used. Assays are conducted to verify product claims.



BUYING GUIDE

Each December, CR publishes a **DENTISTS' BUYING GUIDE** and a **DENTAL HYGIENE BUYING GUIDE** which lists brand names, a brief description, sources, and costs of the best dental products evaluated during the past year. This is an essential resource for dental clinicians and hygienists. These buying guides can be purchased individually by contacting CR.

CR HAS EXTENSIVE MICROBIOLOGY CAPABILITIES. Team members routinely work with pathogenic viruses and bacteria in tests on hundreds of infection control products from around the world. Periodontal pathogens and organisms associated with dental decay as well as microorganisms in water and air are addressed.

FREE ONLINE INFORMATION

A listing of **DENTAL COMPANY INFORMATION** (including addresses, web sites, and telephone and fax numbers) is updated regularly. It is valuable for arranging direct orders, writing for MSDS sheets, contacting companies with product-related questions, and many other uses. www.CliniciansReport.org

What is CR?

WHY CR?

CR was founded in 1976 by clinicians who believed practitioners could confirm efficacy and clinical usefulness of new products and avoid both the experimentation on patients and failures in the closet. With this purpose in mind, CR was organized as a unique volunteer purpose of testing all types of dental products and disseminating results to colleagues throughout the world.

WHO FUNDS CR?

Research funds come from subscriptions to the Gordon J. Christensen Clinicians Report®. Revenue from CR's "Dentistry Update®" courses support payroll for non-clinical staff. All Clinical Evaluators volunteer their time and expertise. CR is a non-profit, educational research institute. It is not owned in whole or in part by any individual, family, or group of investors. This system, free of outside funding, was designed to keep CR's research objective and candid.

HOW DOES CR FUNCTION?

Each year, CR tests in excess of 750 different product brands, performing about 20,000 field evaluations. CR tests all types of dental products, including materials, devices, and equipment, plus techniques. Worldwide, products are purchased from distributors, secured from companies, and sent to CR by clinicians, inventors, and patients. There is no charge to companies for product evaluations. Testing combines the efforts of 450 clinicians in 19 countries who volunteer their time and expertise, and 40 on-site scientists, engineers, and support staff. Products are subjected to at least two levels of CR's unique three-tiered evaluation process that consists of:

1. Clinical field trials where new products are incorporated into routine use in a variety of dental practices and compared by clinicians to products and methods they use routinely.
2. Controlled clinical tests where new products are used and compared under rigorously controlled conditions, and patients are paid for their time as study participants.
3. Laboratory tests where physical and chemical properties of new products are compared to standard products.

Clinical Success is the Final Test

Clinicians Report® a Publication of CR Foundation®
3707 N Canyon Road, Building 7, Provo UT 84604
Phone: 801-226-2121 • Fax: 801-226-4726
CR@CliniciansReport.org • www.CliniciansReport.org

CRA Foundation® changed its name to CR Foundation® in 2008.

This team is testing resin curing lights to determine their ability to cure a variety of resin-based composites.

Every month several new projects are completed.

THE PROBLEM WITH NEW DENTAL PRODUCTS.

New dental products have always presented a challenge to clinicians because, with little more than promotional information to guide them, they must judge between those that are new and better, and those that are just new. Because of the industry's keen competition and rush to be first on the market, clinicians and their patients often become test data for new products.

Every clinician has, at one time or another, become a victim of this system. All own new products that did not meet expectations, but are stored in hope of some unknown future use, or thrown away at a considerable loss. To help clinicians make educated product purchases, CR tests new dental products and reports the results to the profession.