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ZIRCONIA: most durable tooth-colored crown material in practice-based clinical study

Gordon's Clinical Observations: Some tooth-colored monolithic crown materials are serving remarkably well, while others have had numerous challenges. The TRAC Research component of Clinicians Report has been conducting the only large, long-term, **comparative** clinical study of tooth-colored materials available to the profession. *Results from this practice-based study reported below will enhance the service you provide for your patients.*



CAD-CAM methods and materials have revolutionized the dental laboratory industry and dental practice, but— DO THE VARIOUS PRODUCTS SERVE PATIENTS EQUALLY WELL?

For over 40 years TRAC Research has been seeking the following material:

- Tooth colored
- Reasonable cost
- Requires minimal tooth removal
- Cementation is durable and easy
- Tolerates abuse by clinician and patient
- Serves trouble-free at least 10+ years
- Does not wear opposing dentition excessively

Over 200 tooth-colored materials have been studied clinically by this lab over the last 40+ years. The current study includes 20 materials at various stages of clinical service (*see listing on page 2*). The materials differ in many aspects, but all are tooth-colored, monolithic, CAD-CAM fabricated either by commercial labs or in-office; all were recommended for single units anywhere in the oral cavity when entered into this study; and all study restorations are full-contour crowns on molars.



BruxZir 3Y 2009
Initial Placement



BruxZir 3Y
At 8 Years
(Note loss of glaze)

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ZIRCONIA: most durable tooth-colored crown material in clinical study *(Continued from page 1)*

1. Products under study currently *(ordered by similar material description and alphabetical within groupings)*

A	B	C	D	E	F	G	H
Product Name	Company	Where Milled	Material Description <i>(Received from Companies)</i>	Survival † to Date	Cement Type Used	Cementation Failure to Date	Time in Study
ZIRCONIA 3Y-5Y *							
BruxZir 2009	Glidewell Dental	Lab	3Y* zirconia	100%	RMGI	6%	8 years
BruxZir NOW 2016	Glidewell Dental	In-office	3Y zirconia <i>(fully sintered before mill)</i>	100%	RMGI	2%	2 years
BruxZir NOW 2018	Glidewell Dental	In-office	3Y zirconia <i>(fully sintered before mill)</i>	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>
BruxZir Shaded 2018	Glidewell Dental	Lab	3Y zirconia	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>
Pavati Z40.1	CCRI <i>(same Zr as inCoris TZI)</i>	Lab	3Y zirconia	100%	Resin	0%	1 year
IPS ZirCAD LT	Ivoclar Vivadent	Lab	3Y zirconia	100%	Resin	10%	2 years
Zirlux 16+	Zahn Dental	Lab	3Y zirconia	100%	Resin	0%	1 year
ArgenZ HT+	Argen Corporation	Lab	4Y translucent zirconia	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>
IPS ZirCAD MT	Ivoclar Vivadent	Lab	4Y translucent zirconia	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>
BruxZir Esthetic	Glidewell Dental	Lab	4.9Y translucent zirconia	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>	<i>new in study</i>
CubeX ²	Dental Direkt	Lab	5Y translucent zirconia	100%	RMGI	0%	1 year
Katana STML	Kuraray Noritake	Lab	5Y translucent zirconia color blended	100%	Resin	0%	2 years
Lava Esthetic	3M Dental	Lab	5Y translucent zirconia color blended	100%	Resin	9%	1 year
BruxZir Anterior	Glidewell Dental	Lab	5.5Y translucent zirconia	100%	RMGI	0%	2 years
GLASS CERAMIC							
Celtra DUO Non-Fired	Dentsply	In-office	lithium silicate + 10% zirconia	76%	Resin	0%	1 year
IPS e.maxCAD	Ivoclar Vivadent	In-office	lithium disilicate	95%	Resin	5%	8 years
CERAMIC – POLYMER							
CAMouflage NOW	Glidewell Dental	In-office	79% ceramic 21% polymer	98%	Resin	2%	1 year
CeraSmart	GC America	In-office	71% ceramic 29% polymer	97%	Resin	29%	2 years
Enamic	Vita USA	In-office	86% ceramic 14% polymer	89%	Resin	26%	4 years
Lava Ultimate	3M Dental	In-office	80% ceramic 20% polymer	95%	Resin	25%	5 years

* Y = Mole Percent of yttria added to zirconia. Higher amount of yttria increases translucence, but lowers strength.

† Survival means crown did not require replacement due to material inadequacy.

2. Summary of 2018 results

Of 17 characteristics graded clinically and in the laboratory, so far the 3 below have shown clinically concerning results:

- (1) Terminal fracture *(missing material that compromises contact(s) or occlusion; or crack(s) ≥6mm in length)*
- (2) Cementation failure
- (3) Greater than expected opposing dentition wear.

BELOW, 3 MATERIAL GROUPS IN ABOVE CHART ARE COMPARED BY 3 CLINICALLY CONCERNING RESULTS:

Clinically

Concerning Result	Zirconia	Glass Ceramic	Ceramic-Polymer	Summary
Terminal Fracture	Zirconia had NO Terminal Fractures in 1-8 yrs	Glass Ceramic Celtra DUO Non-Fired had 26% Terminal Fractures in 1 yr	Ceramic-Polymer had 2-4% Terminal Fractures in 1-5 yrs	26% terminal fractures of Celtra DUO Non-Fired resulted in its statistically lower 1-year survival in this study.
Cementation Failure	Zirconias IPS ZirCAD LT 10% in 2 yrs * Lava Esthetic 9% in 1 yr * IPS ZirCAD LT problem addressed with new cement SpeedCEM Plus	Glass Ceramic Celtra DUO Non-Fired and IPS e.max CAD had cementation failure at 0-5% respectively in 1-8 yrs	CeraSmart 29% 1 yr * Enamic 16% 1 yr 26% 4 yrs Lava Ultimate 14% 1 yr 25% 5 yrs CAMouflage NOW 2% 1 yr * CeraSmart problem addressed with new cement G-CEM LinkForce	All the ceramic-polymer products in this study <i>(except CAMouflage NOW)</i> had high cementation failure at 1 year of clinical service, and the numbers increased over time.
Greater-Than-Expected Opposing Dentition Wear	Some zirconia brands had greater than expected wear of opposing dentition <i>(5 of the 9 brands)</i> at 1 yr Pavati Z40.1 57% of crowns Katana STML 50% of crowns IPS ZirCAD LT 45% of crowns BruxZir NOW 2016 39% of crowns CubeX ² 33% of crowns	Glass Ceramic had NO greater-than-expected wear on opposing dentition	Ceramic-Polymer had NO greater-than-expected wear on opposing dentition	5 zirconia brands caused <u>concave facets</u> on opposing dentition. More time in service is needed to determine the clinical significance of this finding.

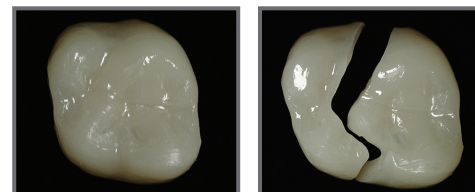
ZIRCONIA: most durable tooth colored crown material in clinical study *(Continued from page 2)*

3. Observations

A. Zirconia is a robust material. Zirconia was the only material category in this study where all products tested so far show 100% survival. This is an important finding considering the differences represented in the brands tested (*e.g., powders from Japan and China, formulation differences, disk/block processing differences*).

B. 3Y zirconia gives best chance of long-term durability. 3Y maximum fracture toughness zirconia restorations have demonstrated ability to tolerate minimal tooth reduction preparations, clinical abuse such as occlusal adjustments made both in hand and after cementation, and subsequent endodontic access preparation through the crown.

C. 5Y zirconia needs more gentle handling by dentists before cementation and during endodontic access procedures. Crown fracture during seating occurred in 2% of the 5Y zirconia crowns when there was: Inadequate tooth reduction causing thin finished crowns, or crowns were hand held during occlusal adjustment before cementation. Fracturing can also occur in 5Y zirconia when endo entry preparation is aggressive.



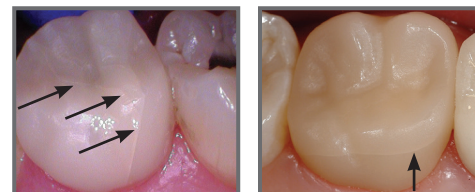
5Y zirconia crown broken during hand-held occlusal adjustment

D. Glaze is not long lasting. No glaze used in this study has been long lasting, regardless of material category. By year 7 over 90% of original BruxZir 3Y and IPS e.maxCAD crowns had lost occlusal glaze. Glaze lasts longer on smooth surfaces, but characterizing techniques that require glaze to seal in colors will not be as durable as patients desire. *(See photos page 1.)*

E. Ceramic-polymer crowns have higher than expected cementation failure. For reasons not fully apparent, ceramic-polymer crowns have experienced high cementation failure, both in this study and in clinical practices. Yet ceramic-polymer crowns have highly desirable characteristics (*e.g., mill rapidly and smoothly with minimal bur wear, do not require post-mill procedures, wear opposing dentition minimally, have good to excellent esthetics, have high survival rates with minimal fracturing*). This material category is worthy of further investigation to solve the problem with cementation failure. The new CAMouflage NOW is showing promise with only 2% cementation failure in its first year of service.

F. Celtra DUO Non-Fired developed long (≥ 6 mm) craze line fractures within 1 year after seating.

Celtra DUO was not post-mill fired in this study because we hoped to verify the claim that it was a ceramic-based product that could be milled & seated without need for post-mill firing. After noting study crowns with long craze line fractures, we conducted a survey which identified randomized Celtra DUO users and confirmed frequent fracture of Celtra DUO when crowns were fired or non-fired. This indicates the need for improvement of this material to gain the robust performance necessary clinically.



Celtra DUO Non-Fired crack appearance

TRAC Research CONCLUSIONS: It is too early in the service life to reach final conclusions on many of the products in this large diverse study. However, after just one to two years, several materials are no longer sold (*BruxZir Anterior, BruxZir NOW 2016, Pavati Z40.1*) and several others are no longer recommended for full-contour **molar** crowns (*cubeX², Lava Ultimate*).

The following **important trends** are indicated by the data *so far*, and these trends could be helpful now to clinicians and patients attempting to select products for treatment:

- A. Zirconia demonstrated best durability** with 0% terminal fractures in all 9 brands in this study, in spite of differences in material sources, formulations, and manufacturing methods.
- B. BruxZir 2009 3Y zirconia best meets the 7 ideal characteristics.** Importantly, throughout its 8-year clinical history it has not worn opposing dentition excessively and it has demonstrated excellent tolerance of clinical abuse.
- C. A skilled laboratory technician and possible added cost still necessary for optimum esthetics.** Increased translucence has helped—but not solved—the difficulty of blending zirconia with surrounding dentition.
- D. If glass ceramic or ceramic-polymer products are used for full-contour molar crowns, expect higher numbers of fractures, cementation failures, and need for more tooth removal** to gain the material thickness needed for strength. In this study, IPS e.maxCAD lithium disilicate has performed very well as a molar crown material, with 95% survival at 8 years, when tooth preparations provided adequate material thickness.
- E. Cementation failure with zirconia crowns was relatively infrequent in this study.** This was attributed to careful following of cementation instructions by the dentists. IPS ZirCAD LT cementation material problems have been corrected by the manufacturer.
- F. When unknown company and brand names are chosen to save costs, watch for inconsistencies** in purity, density, and distribution of formulation components, all of which may ultimately affect long-term durability.
- G. Clinically at this time, 3Y zirconia indications are molar full-contour crowns, posterior multi-unit restorations, patients with bruxing/clenching habits, where minimal tooth preparation is desired, and anytime maximum durability is desired. 3Y, 4Y, and 5Y zirconia and IPS e.maxCAD or Press can all fulfill expectations where optimum esthetics is desired, if fabricated by a skilled laboratory technician.**