MATERIAL CHOICES FOR THE PROVISION OF CROWNS AND ASSOCIATED CEMENTATION TECHNIQUES

Dr Tom Bereznicki
DISCLAIMER
• The only treatment options until the early 70’s were gold or porcelain jacket crowns.
• Mid 70’s brought the advent of MCC’s
• 1984 porcelain veneers introduced
JOHN McLEAN & MICK KEDGE

John W. McLean

The Science and Art of Dental Ceramics

Volume II:
Bridge Design and Laboratory Procedures in Dental Ceramics

To Mick
In recognition of your unswerving effort and concentration which has contributed so much to this book.

John W. McLean
30th July 1980.
45 YEAR OLD SEMI-FIXED INLAY BRIDGE
A SHOULDER BEVEL GIVES A BETTER FIT AT THE MARGIN IF THE CROWN DOES NOT FULLY SEAT – GOLD IS MALLEABLE
PORCELAIN JACKET CROWN

The all porcelain crown (PJC) has been around since a century. However, as mentioned before these were very brittle and fractured easily (halfmoon fractures). The marginal adaptation was also quite poor. Because of these problems its popularity gradually waned. This prompted McLean and Hughes to develop the PJC with an alumina reinforced core in 1965. This crown was developed in an attempt to improve the strength of the earlier porcelain jacket crowns. The increased content of alumina crystals (40 to 50 percent) in the core strengthened the porcelain by interruption of crack propagation.
A VIEW OF PORCELAIN FUSED TO METAL CROWNS 28 YEARS AGO

NOTE THE WHITE OPAQUE APPEARANCE
NEW MCC’S IN 2006 – THE TWO PJC’s ON THE LOWER CENTRALS ARE 30 YEARS OLD
1984 VENEERS ARE INVENTED
Minimally invasive dentistry?
Allergic response to the metal used in the MCC
NEW MATERIAL FAILURE IN THE 90’s

**Casting Machine:**

- The Dentsply DICOR casting machine features a platinum electric resistance-type muffle mounted on a electrically driven straight centrifugal casting arm.
- The machine is fitted with a special receptacle to hold the Dicor crucible.
2000’s - Metal Free Porcelains

Procera® Perfection

E.max

BruxZir®
Solid Zirconia Crowns & Bridges
LATE 1990’s AND EARLY 2000’S SAW THE ROOTS OF THE GREAT ADVANCES WE SEE TODAY

• Pressed ceramics – lithium di-silicate e.max – new improved e.max appeared in 2006
• CAD/CAM technology - milled porcelains – Alumina and Zirconia
what is e.max?
2006 - e.max pressed
CONSERVATIVE PREPARATION
MARGINAL RIDGE PRESERVATION
EMAX OVERLAYS TO AVOID POSTS IN ROOT TREATED PREMOLARS
3. Lithium Disilicate 15% (examples: IPS e.max CAD and IPS e.max Press by Ivoclar Vivadent)

**Advantages:** IPS e.max is among the stronger ceramic restorations. Esthetic results are good to excellent with three levels of translucency for e.max CAD and four levels for IPS e.max Press. They have proven themselves clinically for single-unit restorations, and look promising for some short-span or anterior multiple-unit restorations. Restorations can be bonded to tooth or cemented with conventional cements.

**Limitations:** These ceramics require relatively deep tooth preps. More research is needed for fixed prostheses. Requires superficial coat of low fusing ceramic for characterization. Difficult to remove when necessary when bonded to preparation because of similar color to tooth structure. Cannot use stress-breakers. IPS e.max CAD requires a furnace for sintering after milling.
Onlays covering all cusps vs. onlays or inlays leaving uncovered cusps: Leaving cusps uncovered with restorative material should only be done when there is a significant amount of supportive dentin under the remaining cusp to support it (1 mm or more). Onlays covering all cusps with most of the ceramics reported in this publication provide restorations stronger than natural teeth (see Clinicians Report January 2012 for details).

Bonding restorations: Onlays, inlays, and other partial crown restorations should be bonded and cemented with resin cement for optimum retention and esthetics.

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**Should You Change from PFM to Full-Ceramic Restorations? (Continued from page 2)**

<table>
<thead>
<tr>
<th>Comparing Restoration Types</th>
<th>Type</th>
<th>Strength</th>
<th>Esthetics</th>
<th>Bonding Required</th>
<th>Longevity</th>
<th>Cement</th>
<th>Units</th>
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<td>PFM</td>
<td>High</td>
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<td>Single or Multiple</td>
<td>Easy</td>
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<td>Excellent-Good</td>
<td>if desired</td>
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<td>Crowns: any; Onlays: resin</td>
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<td>Zirconia-based with overlay</td>
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<td>Any</td>
<td>Single or Multiple</td>
<td>Difficult</td>
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<td>Leucite-reinforced ceramic</td>
<td>Moderate-Weak</td>
<td>Excellent</td>
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<td>Good</td>
<td>Resin</td>
<td>Single</td>
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<tr>
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<td>Feldspathic ceramic</td>
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<td>Resin</td>
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<td>Moderate</td>
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<td>Other, polymer</td>
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<td>Other, resin-nano ceramic</td>
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<td>Easy</td>
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</tbody>
</table>
iTero

The iTero is a digital impression scanner utilizing parallel confocal imaging to capture a 3D digital impression of the teeth, soft tissue contours, and gingival margins. The scanner has the ability to capture preparations for crowns, bridges,...
THE HOLY GRAIL OF DENTISTRY – ELIMINATION OF THE METAL CORE TO PRODUCE LIFE-LIKE TRANSLUCENCY IN CROWNS
Early 2000’s
THE MILLED ALUMINA CORE IS CLEARLY VISIBLE AND ALLOWS LIFE-LIKE TRANSLUCENCY AND DEPTH OF COLOUR IN THE CROWN

2000 onwards Procera AllCeram and Zirconia cores were developed
PROCERA CORES WITH FELDSPATHIC PORCELAN
ZIRCONIA CORES WITH FELDSPATHIC PORCELAIN

For aesthetic cases use layered Procera crowns but in the posterior segments where aesthetics are a bit less of an issue use layered Zirconia crowns as they are stronger but in both cases warn the patient of potential porcelain fracture or delamination.
Porcelain-Fused-to-Metal Restoration

Backlit view shows shadowing of the PFM restoration due to the metal substructure

Lava Zirconia Restoration

Backlit view shows the Lava restoration’s beautiful, natural translucency

Porcelain-Fused-to-Metal Crown

Metal can show over time

Lava Zirconia Crown

Porcelain-Fused-to-Metal Restoration vs Lava Zirconia Restoration

Porcelain-Fused-to-Metal Restoration vs Lava Zirconia Restoration

Porcelain-Fused-to-Metal Restoration vs Lava Zirconia Restoration
THE PROBLEM WITH ‘LAYERED’ FELDSPATHIC PORCELAIN CROWNS IS CHIPPING AND DELAMINATION – EVEN PROCERA AND VERY THIN ZIRCONIA CAN FRACTURE
MONOLITHIC CROWNS

These crowns are milled from one solid piece of material and the four currently available are

- IPS e.max Cad – lithium disilicate
- Procera – alumina
- Lava, Bruxzir etc – Zirconia
- Translucent Zirconia – translucency is achieved by increasing the amount of Yttrium in the material but at the same time reducing the flexural strength by half
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<th>Strength Range</th>
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<tr>
<td>1</td>
<td>PFM / Press to metal</td>
<td>1200-1400 MPa flexural strength</td>
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<td>2</td>
<td>Zirconia</td>
<td>1100-1200 MPa</td>
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<td>3</td>
<td>Procera alumina</td>
<td>650-690 MPa</td>
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<td>4</td>
<td>’Monolithic’ lithium silicate / disilicate</td>
<td>350-520 MPa (i.e. eMax / Suprinity)</td>
</tr>
<tr>
<td></td>
<td>In-ceram alumina</td>
<td>350-400 MPa</td>
</tr>
<tr>
<td>5</td>
<td>Captek / other min metal PFM</td>
<td>350-400 MPa</td>
</tr>
<tr>
<td>6</td>
<td>Layered lithium disilicate pressed</td>
<td>360-440 MPa (i.e. eMax / Suprinity)</td>
</tr>
<tr>
<td>7</td>
<td>Lava Ultimate (monolithic)</td>
<td>200 MPa</td>
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<tr>
<td>8</td>
<td>Enamic (monolithic)</td>
<td>150-160 MPa</td>
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<td>9</td>
<td>Leucite-reinforced pressed</td>
<td>160-200 MPa           (i.e. Empress)</td>
</tr>
<tr>
<td>10</td>
<td>Earlier castable ceramics</td>
<td>135M MPa              (i.e. Dicor)</td>
</tr>
<tr>
<td>11</td>
<td>Powder-liquid</td>
<td>50-100 MPa</td>
</tr>
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HAMMER TEST
WHICH IS THE PFM AND WHICH IS THE TRANSLUCENT ZIRCONIA?
TRANSLUCENT ZIRCONIA

More beauty, plenty of brawn

**BruxZir® Anterior** is the latest advancement in the BruxZir® Solid Zirconia product line. This highly esthetic restorative material is designed specifically to satisfy the esthetic and functional requirements of the anterior region of the mouth. Exhibiting an average flexural strength of 650 MPa with translucency and color similar to natural dentition, BruxZir Anterior is an ideal, esthetic solution for your anterior cases.
Translucent Zirconias: Tooth Reduction & Chairside Adjustment Issues

Gordon's Clinical Observations: Zirconia advertisements from many different labs are monopolizing dental publications. However, none of the promotions make clear the fact that the new translucent, esthetic zirconia is more structurally strong and physically more similar to the original zirconia used in full-strength BruxZir and for substructures. This has led clinicians to believe that they can handle the new zirconia in the same way they have the lower translucent formulations of the past. The below critical FIRST LOOK information from a new TRAC Research controlled clinical study warns dentists and laboratory technicians to handle the new translucent zirconia differently.

Zirconia earned its reputation in the U.S. for being tough, white, and affordable with BruxZir full strength (1000- 1500) solid zirconia restorations. Now, several years later, the translucent zirconia formulations are being promoted heavily without informing clinicians that these zirconia are very different from the original BruxZir in strength, toughness, and ability to tolerate stress. We are finding the new translucent zirconia require more tooth reduction, more gentle handling during chairside adjustment, and possibly use in less stringent situations—especially when occlusal restorations are considered. This report contains urgent information based on three randomized controlled clinical studies on zirconia with data at 6 months, 6 years, and 10 years. Together the three studies include over 270 practicing dentists from 36 U.S. states, 29 dental laboratories, and 18 materials (six brands studied in charts at bottom of page 3). The three studies follow the evolution of zirconia backwards in time from the present introduction of today's innovations (mastication, staining, notching and/or hand finishing, and partial zirconia formulations) through the BruxZir era, back to zirconia's beginning as a substructure material. Notably, ALL the recent innovations have produced a decrease in strength and toughness compared to full-strength BruxZir and the original substructure materials. We are just beginning to learn the indications and contra-indications for the innovations, and much is still unknown. However, it is important for clinicians to realize that the new translucent and addition of coloring have decreased zirconia's strength and resistance to stress.

This report:
1. Summarizes what we have learned about zirconia over the past 11 years,
2. Enumerates what is still unknown,
3. Offers a few predictions and recommendations based on data from the three studies.

2. Critical unknowns related to ALL the new zirconia brands now flooding the market

A. Performance compared to full-strength BruxZir
B. Wear of opposing dentition
C. Best cementation regimen
D. Failure if, when, and how
E. How to locate the responsible source if problems occur, such as early failure or hypersensitivity due to widespread private labeling

3. Predictions and recommendations based on data from the 3 controlled clinical TRAC Research studies

A. Prediction: Zirconia is here to stay for the foreseeable future. Best performing types and brands of zirconia will become apparent with clinical use.
B. Recommendation: Clinicians should use new brand names cautiously and be skeptical of claims that solve all challenges. When new products with minimal data are used, keep lists of who, where, and when these products are used so performance can be monitored.
C. Recommendation: Consider use of RGMII cement based on excellent performance in the above 3 clinical studies. BruxZir full-strength zirconia molar crowns show 96% debond at 6 years with RGMII cement (Relay Luting Plus, 3M) used by 40 different dentists. Zirconia 3-unit posterior fixed partial dentures (FPD) show the same 96% debond at 10 years with RGMII cement (Relay Luting Plus, 3M) used by 115 different dentists. Maybe we are making zirconia cementation too complex—too many steps, too many different products.

TRAC Research Conclusions:

In the push to create translucent, colored, and partial zirconia formulations, the flexural strength and the transformation toughening unique to zirconia have been sacrificed. Clinicians are advised to: 1) avoid excessive chairside adjustments, 2) adhere to manufacturer's recommendations for preparation design, and 3) use the esthetic translucent zirconia for anterior teeth. Issues cited in this report are due to misunderstanding of differences between full-strength and current generation translucent zirconia. Full-strength zirconias are advised for metal, bracing/anchoring patients, multi-unit, and when minimal tooth preparation and/or maximum longevity are desired.
Clearing the Confusion: The Array of Monolithic Restorations

The six main types of current monolithic materials are listed below (others also exist) along with clinical guidance for their use.

### Full-Strength Zirconia
- **Example brands:** BruxZir® (Glidewell), Zirconstar T (Vivadent), Lava Zirconia (3M), Pavati Z4/01 (CERDEC)
- **Tooth reduction required:** Minimal
- **Material thickness:** 0.5–1.0 mm
- **Esthetics:** Fair. Low translucency. Multiple shades available.
- **Durability:** Excellent. BruxZir has the longest track record of success in CR/TRAC Research (over 10 years). Other brands are expected to follow a similar trend, although this remains unproven.
- **CR suggested use:** posterior crowns, multiple-unit fixed prostheses, onlays. Best for patients with abusive occlusion (bruxers).

### Lithium Disilicate
- **Brands:** IPS e.max CAD/Press and IPS e.max Press Multi (Vivadent), Initial LSI Press (GC America, new, research pending)
- **Tooth reduction required:** Moderate
- **Material thickness:** 1.0–2.0 mm
- **Esthetics:** Excellent. High translucency. Newer IPS e.max Press Multi offers shade layering.
- **Durability:** Excellent. Recent CR survey results show clinical performance is practically the same as full-strength zirconia for posterior single crowns. CR/TRAC Research has also seen very limited failure in long-term studies.
- **CR suggested use:** posterior crowns, onlays, anterior crowns, veneers. Consider full-strength zirconia for patients with abusive occlusion (bruxers). Consider multiple-unit fixed prostheses if this material is limited.

### Translucent Zirconia
- **Example brands:** BruxZir Anterior (Glidewell), Zirox (Dental Arts Laboratories), Katan StML (Katsumori Toshihiko), Zirox Anterior (Argent)
- **Tooth reduction required:** Minimal–Moderate
- **Material thickness:** 0.8–1.5 mm; more research needed
- **Esthetics:** Good. Moderate translucency; still less than lithium disilicate. Multiple shades.
- **Durability:** Partly unknown. CR/TRAC Research shows potential strength issues with some clinical failures upon placement (see Clinicians Report July 2016).
- **CR suggested use:** (pending additional research): onlays, anterior crowns, veneers

### Lithium Silicate
- **Example brands:** Obisam (Glidewell)
- **Tooth reduction required:** Moderate
- **Material thickness:** 1.0–2.0 mm
- **Esthetics:** Excellent. High translucency. Multiple shades available.
- **Durability:** Unknown. Slightly different composition than lithium disilicate, but should have comparable strength.
- **CR suggested use:** (pending additional research): similar to lithium disilicate. Has been promoted as veneering for layered restorations.
- **Tooth reduction:** Follow manufacturer instructions to avoid over or under cutting preps.
- **Avoid glazes:** Glaze wears opposing dentition. See Clinicians Report June 2014.
- **Cement:** Most monolithic zirconia use with RGMi cement and composite tooth preps. Resin cement is suggested for lithium disilicate, polymer-based composites, and short or non-receptive preps.
- **Informed consent:** Educate patient on restoration choices available; obtain informed consent, especially if using newer monolithic materials with limited clinical research.

### CR Conclusions:
Among monolithic materials, full-strength zirconia continues to exhibit best durability for single crowns and fixed prostheses, with lithium disilicate exhibiting excellent durability and superior esthetics for single crowns. More research is needed for translucent zirconia, lithium silicate, and mixed monolithic materials; obtain informed consent prior to placing any of these newer materials. Proper tooth preparations, proper cementation, and avoiding glaze help contribute to monolithic restoration success.

### Mixture of Zirconia and Lithium Silicate
- **Example brands:** Celcon Duo (Dentsply), Suprinity (VITA)
- **Tooth reduction required:** Moderate
- **Material thickness:** 1.0–2.0 mm
- **Esthetics:** Good. Moderate translucency. Multiple shades available.
- **Durability:** Unknown. Zirconia addition should provide additional strength.
- **CR suggested use:** (pending additional research): onlays, crowns, veneers

### Mixture of Polymer and Ceramic
- **Example brands:** Lava Ultimate (3M), Enamel (VITA), CeraSmile (GC America)
- **Tooth reduction required:** Moderate
- **Material thickness:** 1.0–1.5 mm
- **Esthetics:** Good. Moderate translucency. Multiple shades available.
- **Durability:** Partly unknown. Recent CR survey results show some clinical success for onlays, comparable to performance of lithium disilicate for onlays.
- **CR suggested use:** (pending additional research): onlays, anterior crowns, veneers (Note: Lava Ultimate by 3M currently undergoing change in formulation; additional indications may follow).
**Figure 1.** All-ceramic and metal-ceramic crowns. Translucent unlayered (left to right): Dicor (Dentsply, York, Pa.; no longer on the market), IPS Empress Esthetic (Ivoclar Vivadent, Amherst, N.Y.), OPC (Pentron Ceramics, Somerset, N.J.). Opaque layered: In-Ceram Alumina (Vita Zahnfabrik, Bad Säckingen, Germany), In-Ceram Spinel (Vita Zahnfabrik), Procera Zirconia (Nobel Biocare, Göteborg, Sweden). Metal-ceramic crown with porcelain labial margin and conventional metal-ceramic crown.
DIFFERENTIAL WEAR
HARDER MATERIALS ABRade SOFTER ONES. ENAMEL, DENTINE, COMPOSITE, GOLD AND PORCELAIN ALL WEAR AT DIFFERENT RATES. THE RESULTANT UNEVENESS OF THE OCCLUSAL LINE RARELY INTRODUCES PREMaturITIES IN CENTRIC BUT OFTEN INTRODUCES INTERFERENCEs IN ECCENTRIC MANDIBULAR MOVEMENTs.
CROWN ADJUSTMENT

GLAZED PORCELAIN

SURFACE TEXTURE FOLLOWING ADJUSTMENT WITH A DIAMOND
ALWAYS POLISH CROWNS (EVEN GOLD) AFTER ADJUSTMENT

SURFACE TEXTURE FOLLOWING ADJUSTMENT WITH A DIAMOND

PORCELAIN SURFACE AFTER POLISHING WITH THE MEISINGER PORCELAIN
e.Max and Zirconia in particular require specialist finishing kits.

1 ZIRCONIA FINISHING & POLISHING - CRA SEPT 16

**Zirconia Finish and Polish: What Works Best?**

- Zirconia is often used in various dental applications, including implant frameworks, bridges, and veneers. It offers excellent esthetics and strength, making it a popular choice in modern dentistry.
- However, finishing zirconia can be challenging due to its lack of elasticity and the need for precise, high-precision instruments.

### Products

- **CERCON® All-Ceramic Finishing & Polishing Kits**: These kits are designed to provide a comprehensive range of finishing and polishing options for zirconia restorations. They include various abrasives and polishing burs that are specifically formulated to be gentle yet effective on zirconia surfaces.
- **E.MAX® Zirconia**: Known for its translucency and aesthetic properties, E.MAX zirconia offers the possibility of producing highly esthetic restorations that closely mimic natural teeth.
- **DENTSPLY SIRONA**: Offers a range of finishing and polishing solutions that complement zirconia materials, ensuring a smooth, polished finish without compromising the integrity of the restoration.

### Techniques

1. **Abrasive Finishing**
   - Use fine-grit abrasives to remove surface imperfections and achieve a smooth finish.
2. **Polishing**
   - Employ polishing burs and compounds to enhance the luster and esthetics of the zirconia surface.
3. **Surface Treatment**
   - Consider applying a bonding agent or ceramic sealant to protect and enhance the surface characteristics of the zirconia.

### Conclusion

By combining the right products and techniques, it is possible to achieve a high-quality, polished finish on zirconia restorations. Regular practice and careful attention to detail are essential in mastering the art of zirconia finishing and polishing.

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*Note: This article is a part of a series on dental materials and techniques.*
COMPOSITE CROWNS
COMPOSITE CROWNS
5 Year old composite – it deteriorates with time
Composite also wears with the passage of time – this overlay is 12 years old and is nearly worn through on the occlusal surface.
LUTING CEMENTS
ZINC OXIDE EUGENOL
ZINC PHOSPHATE
POLYCARBOXYLATE
GLASS Ionomer
RESIN MODIFIED GLASS IONOMER
COMPOSITE RESIN LUTING CEMENTS

• Conventional
• Self adhesive
• Self etch
• Panavia
Conventional
Self adhesive
Self etch
ROCHETTE RETAINER 23 YEARS POST PLACEMENT – STILL SUCCESSFUL
THE AESTHETIC RESULT IS EXCELLENT AND THE PROCEDURE NON-INVASIVE
25 YEAR OLD MARYLAND
<table>
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<th>Type</th>
<th>Resin-Modified Glass Ionomer</th>
<th>Self-Adhesive Resin Cement</th>
<th>Self-Etch Resin Cement</th>
<th>Total-Etch Resin Cement</th>
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<tr>
<td><strong>Brand</strong></td>
<td>FujiCEM Automix</td>
<td>Maxcem Elite</td>
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<td><strong>Radiopacity ‡</strong></td>
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<td>330</td>
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<td><strong>Film Thickness (microns)</strong></td>
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<td><strong>Dentin with GLUT/HEMA</strong></td>
<td>0.4 †</td>
<td>4.1</td>
<td>25.8</td>
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<td>**Expansion in Water **</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<td><strong>Self-Cure Intraroral Setting Time ††</strong></td>
<td>Long</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
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<tr>
<td><strong>Compressive Strength (MPa) ‡‡</strong></td>
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<td>High: 273</td>
<td>High: 278</td>
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<td><strong>Potential for Marginal Opening after Cementation $§§</strong></td>
<td>Moderate</td>
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<td><strong>CR Recommended Best Use</strong></td>
<td>Moderate to high risk patients</td>
<td>Posts</td>
<td>Non-retentive preps that need high retention</td>
<td>Veneers</td>
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<td>Adequate tooth preps</td>
<td>Good preps that need more retention</td>
<td>Full-ceramic crowns, onlays, etc.</td>
<td>Non-retentive preps that need highest retention (with adequate de-sensitization)</td>
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<td>Self-Etch Resin Cement</td>
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<tr>
<td>PFM, Full-Metal</td>
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<td>✔</td>
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<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>Lithium Disilicate <em>(IPS e.max)</em></td>
<td>✔ (crowns)</td>
<td>✔</td>
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<tr>
<td>Leucite-Reinforced <em>(IPS Empress, etc.)</em></td>
<td>✗</td>
<td>✔</td>
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<tr>
<td>Feldspathic on Enamel <em>(veneers)</em></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>Polymer</td>
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CROWN REMOVERS
FINISHING LINES
CHAMFER
SHOULDER
SHOULDER BEVEL
FEATHER