The Evolution of Pediatric Dentistry: Changing Concepts in Clinical Practice

Texas Dental Association, May 2018
Mark Cannon DDS MS
FAAPD, FADM, FICD, FAAOSH, etc.

- Professor
- Division of Dentistry
- Department of Otolaryngology
- Feinberg School of Medicine
- Research Director- Lurie Children’s Hospital of Chicago
- Chicago, IL USA
- Full time practice
Agenda- Pediatric Updates

- **Bioactive**- enhance the formation of apatite in simulated body fluid
- **Biointeractive**- release of ions that enhance re-mineralization
- **Bulk Fill**-
  - Dual cure materials- can be Bioactive or Biointeractive
  - Self cure- biointeractive
  - Light cured- low refraction of light, currently not bioactive nor biointeractive
Biologic Materials for Pulpal Vitality

- Indirect Pulpal Therapy
- Direct Pulpal Therapy
- Pulpotommy
- Pulpectomy
- Trauma
New Biologic Materials for Pulpal Vitality
Research and Clinical Protocols
Where does calcium silicate come from?

- Calcium silicate is a white free-flowing powder derived from limestone and diatomaceous earth. It has a low bulk density and high physical water absorption. It is used in roads, insulation, bricks, roof tiles, table salt and occurs in cements, where it is known as belite (or in cement chemist notation C2S).
- It is used as an anti-caking agent in food preparation and as an antacid. It is approved by the United Nations' FAO and WHO bodies as a safe food additive in a large variety of products.

Wikipedia
Biologic Materials

- MTA
- Biodentine
- Lime Lite
- NeoMTA
- TheraCal LC and DC
Biologic Materials

• MTA- the original, Portland cement type ASTM I from the California Portland Cement company.

• Slow set, grey color, mixed with water, very expensive and difficult to place or control.

• Replaced by white MTA- Type III?
Biologic Materials

- Biodentine
- Sets in 10–12 minutes
- Versatile usage: endodontic repair and restorative procedures.
- Natural micro mechanical anchorage for excellent sealing properties without surface preparation.
- Similar mechanical properties and mechanical behavior as human dentin.
- 3.5mm Aluminum radiopacity for easy short and long term follow-up.
Biolitic Materials

• NeoMTA Plus™ is a stainproof, tricalcium silicate-based bioactive cement that can be used universally for vital pulp and other endodontic indications in primary and permanent teeth.

• NeoMTA Plus™ is a bioceramic cement that triggers the healing process. With NeoMTA Plus™, general dentists, pediatric dentists, and endodontists now have a superior and reasonably priced bioceramic.

<table>
<thead>
<tr>
<th>Product brand name</th>
<th>Tri/dicalcium silicate</th>
<th>Radiopaque*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProRoot® MTA (white)</td>
<td>76</td>
<td>20</td>
</tr>
<tr>
<td>Biodentine®</td>
<td>83</td>
<td>4</td>
</tr>
<tr>
<td>BioRoot™</td>
<td>63</td>
<td>37</td>
</tr>
<tr>
<td>MedCem MTA®</td>
<td>70</td>
<td>23</td>
</tr>
<tr>
<td>TheraCal®</td>
<td>78</td>
<td>17</td>
</tr>
<tr>
<td>EndoSequence® Sealer</td>
<td>41</td>
<td>59</td>
</tr>
<tr>
<td>EndoSequence® Root Repair</td>
<td>59</td>
<td>33</td>
</tr>
<tr>
<td>EndoSequence® BP Root Repair</td>
<td>55</td>
<td>37</td>
</tr>
<tr>
<td>EndoSequence® RRM</td>
<td>63</td>
<td>34</td>
</tr>
<tr>
<td>NeoMTA Plus®</td>
<td>72</td>
<td>25</td>
</tr>
<tr>
<td>Grey MTA Plus®</td>
<td>72</td>
<td>25</td>
</tr>
</tbody>
</table>

* Bismuth oxide, barium zirconate, zirconia, and/or tantalite
the innovative light-curable Calcium Silicate-based pulp-capping material
Human pulp response after an adhesive system application in deep cavities.

Hebling J¹, Giro EM, Costa CA

Abstract

OBJECTIVE: To assess the effect of a sodium hypochlorite-based, one-step adhesive system (ALLBOND 2) on human pulp responses after deep cavity preparations.

METHOD AND MATERIALS: All permanent human teeth were extracted, stored in 0.5% sodium hypochlorite for 48 hours, and randomized into three groups: (1) control (no treatment), (2) sodium hypochlorite (3% sodium hypochlorite for 10 minutes), and (3) sodium hypochlorite and adhesive (3% sodium hypochlorite for 10 minutes followed by the adhesive system). Teeth were sectioned into deep cavities, and pulps were exposed to either sodium hypochlorite or the adhesive system. After 28 days, pulps were removed, and tissue responses were evaluated.

RESULTS: No necrotic pulps were observed. Four 97-day pulps exhibited necrosis associated with stained bacteria. One 97-day pulp contained dentin chips throughout the pulp and demonstrated no healing, no reparative dentin, and no stained bacterial profiles.

CONCLUSION: Normal soft tissue reorganization and dentinal bridge formation were observed in 86% of pulps treated with sodium hypochlorite and either adhesive system.
In vitro cytotoxicity of six dentin bonding agents.

Koliniotou-Koubia E, Dionysopoulos P, Koulouzidou EA, Kortsaris AH, Papadogiannis Y

Abstract
The cytotoxicity of six dentin bonding agents (Syntac, Solobond, Bond 1, Scotchbond 1, HelioBond and F-2000) was tested against an established cell line, L929. Under aseptic conditions 3, 5 and 10 microL dentin bonding agents were placed in the centre of Petri dishes. Each dish was covered with a 5-mL suspension of fibroblasts at a concentration of 40 000 cells mL⁻¹. The cultures were incubated at 37 degrees C and cytotoxicity was assessed by a quantitative technique at 24 and 72 h. All the dentin bonding agents were found to be cytotoxic. Scotchbond 1 and F-2000 showed the highest cytotoxicity followed by Solobond and Bond 1. HelioBond and Syntac were the least toxic materials.

Cytotoxicity of modern dentin adhesives--in vitro testing on gingival fibroblasts.

Szep S, Kunkel A, Ronge K, Heidemann D

Abstract
The present investigation was designed to test cellular toxicity of modern dentin adhesives. With the use of the products Ariston Liner, Etch & Prime 3.0, Optibond Solo, Prime & Bond NT, Scotchbond 1, and Syntac Sprint, test specimens were prepared according to the manufacturers’ instructions and transferred into a culture medium. Eluates were obtained and pipetted onto fibroblast cultures, incubated, and subsequently stained. The respective cell densities and the numbers of normal, altered, and dead cells were determined and compared with control cell cultures. Statistical analysis of the data showed that all materials caused cytotoxic effects. Scotchbond 1 displayed the highest number of dead cells. The difference was statistically significant compared to Etch” 3.0, Optibond Solo, Prime&Bond NT, and the control. The lowest cell density was found for Scotchbond 1 and Ariston Liner. The difference was also statistically significant in comparison with Etch” 3.0, Optibond Solo, Prime&Bond NT, and the control. To conclude, all tested dentin adhesives caused cytotoxic reactions. Taking the limitations of an in vitro experiment into consideration, Prime&Bond NT, Optibond Solo, and Etch” 3.0 appear to be the most recommendable products, and Scotchbond 1 and Ariston Liner the least.
Confused?

2001: A Space Odyssey

an adhesive odyssey
### Material Safety Data Sheet

**Issued:** 08/16/2012  
**Revision Number:** 3

#### 1. Identification of Substance/Preparation
- **Product Name:** TheraCal
- **Manufacturer:**
- **Telephone:**
- **Emergency Telephone Number:**
- **EC Representative:**

#### 2. Composition/Information

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Concentration Range (%)</th>
<th>CAS Number</th>
<th>Symbol/Risk Classification</th>
<th>OSHA PEL (mg/m³)</th>
<th>ACGIH (mg/m³)</th>
<th>LD50 (mg/kg, rat/oral)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland Cement Type III</td>
<td>&lt;60.</td>
<td>65997-15-1</td>
<td>Xi, R36/38/43</td>
<td>5.</td>
<td>10.</td>
<td>N/D</td>
</tr>
<tr>
<td>Polyethylene glycol dimethacrylate</td>
<td>&lt;50.</td>
<td>23852-47-5</td>
<td>Xi, R36/38/43</td>
<td>N/D</td>
<td>N/D</td>
<td>N/D</td>
</tr>
<tr>
<td>Barium zirconate</td>
<td>&lt;10.</td>
<td>12009-21-1</td>
<td>Xn; R20/22.</td>
<td>5.</td>
<td>5.</td>
<td>420.</td>
</tr>
</tbody>
</table>
SEM Evaluation of Internal Adaptation of Bases and Liners under Composite Restorations

Dimitrios Dionysopoulos * and Eugenia Koliniotou-Koumpia

Department of Operative Dentistry, School of Dentistry, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece; E-Mail: jeny@dent.auth.gr

Table 1. The materials tested in the present study.

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dycal</td>
<td>Dentsply, Culk, USA</td>
<td>Calcium hydroxide liner</td>
</tr>
<tr>
<td>VitreBond</td>
<td>3M ESPE, St. Paul, MN, USA</td>
<td>Resin-modified glass ionomer cement</td>
</tr>
<tr>
<td>Clearfil Tri-S Bond</td>
<td>Kuraray, Japan</td>
<td>One-step self-etch adhesive system</td>
</tr>
<tr>
<td>Clearfil Majesty</td>
<td>Kuraray, Japan</td>
<td>Nanohybrid composite resin</td>
</tr>
</tbody>
</table>
# Bases and Liners - Dycal and Vitrebond

<table>
<thead>
<tr>
<th>Group</th>
<th>Materials</th>
<th>Mean gap width (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dentin - Clearfil Tri-S Bond + Clearfil Majesty</td>
<td>3.6 ± 2.1</td>
</tr>
<tr>
<td>2</td>
<td>Dentin - Dycal + Clearfil Tri-S Bond + Clearfil Majesty</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Dentin - Dycal + Vitrebond + Clearfil Tri-S Bond + Clearfil Majesty</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Dentin - Vitrebond + Clearfil Tri-S Bond + Clearfil Majesty</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dentin - Clearfil Tri-S Bond + Vitrebond + Clearfil Majesty</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Dentin - Clearfil Tri-S Bond + Vitrebond + Clearfil Tri-S Bond + Clearfil Majesty</td>
<td>21.6 ± 8.6</td>
</tr>
</tbody>
</table>

**Note:**
- Values marked with the same letter (A, B) indicate no statistically significant difference.
Figure 5. Representative SEM photomicrograph of a Group 4 specimen. The arrows indicate microgap between resin-modified glass ionomer cement (Vitremer) and dentin.

"Mind The Gap"
Configuration Factor, C-Factor

THAT WINDOW...

HAS A SMALL CRACK IN IT.
IADR 2011 Abstract #2520 Gandolfi et al.
Apatite-forming ability of TheraCal pulp capping material

IADR 2011 Abstract #2521 Gandolfi et al.
Chemical-physical properties of TheraCal pulp capping material
Conclusions: TheraCal was able to induce the formation of apatite and represents a promising material in direct pulp-capping clinical procedures. The ability to form apatite may play a critical/positive role in new dentine formation.
### Ca$^{+2}$ Ion Release (ppm)

<table>
<thead>
<tr>
<th></th>
<th>Calcium Released In Soaking Water (ppm)</th>
<th>(n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 hrs</td>
<td>1 day</td>
</tr>
<tr>
<td>TheraCal</td>
<td>74.7 (9.2)</td>
<td>37.4 (4.5)</td>
</tr>
<tr>
<td>Control</td>
<td>1.2 (0.3)</td>
<td>0.5 (0.4)</td>
</tr>
<tr>
<td>ProRoot</td>
<td>32.2 (4.5)</td>
<td>29.8 (3.5)</td>
</tr>
</tbody>
</table>

### pH changes

<table>
<thead>
<tr>
<th></th>
<th>pH of Soaking Water (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 hrs</td>
</tr>
<tr>
<td>TheraCal</td>
<td>10.96 (0.03)</td>
</tr>
<tr>
<td>Control</td>
<td>6.96 (0.19)</td>
</tr>
<tr>
<td>ProRoot</td>
<td>11.52 (0.75)</td>
</tr>
<tr>
<td>Water</td>
<td>6.88 (0.04)</td>
</tr>
</tbody>
</table>

IADR 2011 Abst. #2521 Gandolfi et al.
Chemical-physical properties of TheraCal, a novel light-curable MTA-like material for pulp capping

M. G. Gandolfi, F. Siboni & C. Prati
Laboratory of Biomaterials and Oral Pathology, Department of Odontostomatological Sciences, University of Bologna, Bologna, Italy

Abstract

Aim To evaluate the chemical-physical properties of TheraCal, a new light-curable pulp-capping material composed of resin and calcium silicate (Portland cement), compared with reference pulp-capping materials (ProRoot MTA and Dycal).

Methodology Calcium (Ca) and hydroxyl (OH) ion release over 28 days, solubility and water uptake (weight percentage variation, Δ%) at 24 h, cure depth and radiopacity of TheraCal, ProRoot MTA and Dycal were evaluated. Statistical analysis (P < 0.05) for release of ion was carried out by two-way repeated measures ANOVA with Tukey, whilst one-way ANOVA with Tukey test was used for the other tests.

Results TheraCal released significantly more calcium than ProRoot MTA and Dycal throughout the test period. TheraCal was able to alkalize the surrounding fluid initially to pH 10–11 (3 h–3 days) and subsequently to pH 8–8.5 (7–14 days). TheraCal had a cure depth of 1.7 mm. The solubility of TheraCal (Δ = 1.58%) was low and significantly less than that of Dycal (Δ = 4.58%) and ProRoot MTA (Δ = 18.34%). The amount of water absorbed by TheraCal (Δ = 10.42%) was significantly higher than Dycal.

Conclusions TheraCal displayed higher calcium-releasing ability and lower solubility than either ProRoot MTA or Dycal. The capability of TheraCal to be cured to a depth of 1.7 mm may avoid the risk of untimely dissolution. These properties offer major advantages in direct pulp-capping treatments.

calcium hydroxide, Dycal, ProRoot MTA, pulp capping materials, resin-modified calcium silicate, TheraCal.

Received 14 July 2011; accepted 29 December 2011
Biocompatibility of Dental Materials

Cytotoxic Effects of Resin-Based L/C Pulp Capping Materials
Applied on the Immortalized Odontoblast Cell Line MDPC-23

Prof. Dr. Carlos Alberto de Souza Costa

Araraquara School of Dentistry – UNESP
Department of Physiology and Pathology
1. **TheraCal** (Bisco) – MTA (“Portland” Cement) based resin
2. **Ultra-Blend Plus** (UltraDent) – Ca (OH)$_2$ based resin
3. **Vitrebond** (3M/ESPE) – Resin modified glass ionomer
4. **DMEM** (Dulbecco’s Modified Eagle Medium) – Control (complete culture medium)
TheraCal presented the **lowest decrease in cell metabolic activity**

Figure 1. Succinic dehydrogenase (SDH) production detected by the MTT assay according to the groups and extract aging. Letters allow comparison among groups within the same period. Bars indicated by the same letter do not differ statistically (Mann-Whitney, p>0.05). Asterisks indicate statistical difference between periods within the groups (Mann-Whitney, p<0.05).
TheraCal presented the **lowest suppression of cell protein expression**

Figure 2. Total protein expression (μg/mL) according to the groups and extract aging. Letters allow comparison among groups within the same period. Bars indicated by the same letter do not differ statistically (Mann-Whitney, p>0.05). Asterisks indicate statistical difference between periods within the groups (Mann-Whitney, p<0.05).
Each quadrant was randomly assigned to one of four treatment groups;

*(Group A), TheraCal (Bisco)* was applied to the pulpal tissue and light cured for 15 seconds

*(Group B), pure Portland cement* mixed with a 2% chlorhexidine solution and applied

*(Group C), Triage, Fuji VII (GC America)* mixed in capsule and injected

*(Group D), VLC Dycal (Dentsply)* applied and light cured

The pulp capping bases were then covered with a RMGI (Fuji II LC GC America).
Results:

- TheraCal LC

Very little if any inflammation and good hard tissue bridge formation.
Results:

- Glass Ionomer Cement

Some bridging Inflammatory cells
Results:

- Visible Light Cured Bond

  - Very poor dentin bridging
  - Some Inflammatory infiltrate and vacuoles
Results:

- Hard Tissue Bridge Thickness
  - TheraCal and Portland average the same thickness
  - Glass Ionomer and VLC Dycal average less than a fifth as thick as TheraCal

<table>
<thead>
<tr>
<th>Material</th>
<th>TheraCal</th>
<th>GIC</th>
<th>PC</th>
<th>Dycal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>50.27μ</td>
<td>10.72μ</td>
<td>60.72μ</td>
<td>10.90μ</td>
</tr>
</tbody>
</table>
Measured thickness of the hard tissue bridges with the pure Portland and TheraCal groups statistically greater than that of the other two groups (H= 15.849 with 3 degrees of freedom, P=0.002).
Primate Pulpal Healing after Exposure and TheraCal Application

Cannon M*/ Gerodias N**/ Vieira A***/ Percinoto C****/ Jurado R*****

**Aim:** The purpose of this in vivo study was to compare the effectiveness of a new light cured resin based dicalcium/tricalcium silicate pulp capping material (TheraCal LC, Bisco), pure Portland cement, resin based calcium hydroxide or glass ionomer in the healing of bacterially contaminated primate pulps. **Study design:** The experiment required four primates each having 12 teeth prepared with buccal penetrations into the pulpal tissues with an exposure of approximately 1.0 mm. The exposed pulps of the prime teeth were covered with cotton pellets soaked in a bacterial mixture consisting of microorganisms normally found in human pulpal abscesses. After removal of the pellet, hemostasis was obtained and the pulp capping agents applied. The light cured resin based pulp capping material (TheraCal LC) was applied to the pulpal tissue of twelve teeth with a needle tip syringe and light cured for 15 seconds. Pure Portland cement mixed with a 2% Chlorhexidine solution was placed on the exposed pulpal tissues of another twelve teeth. Twelve additional teeth had a base of GIC applied (Triage, Fuji VII GC America) and another twelve had a pulp cap with VLC DYCAL (Dentsply), a light cured calcium hydroxide resin based material. The pulp capping bases were then covered with a RMGI (Fuji II LC GC America). The tissue samples were collected at 4 weeks. The samples were demineralized, sectioned, stained and histologically graded. **Results:** There were no statistically significant differences between the groups in regard to pulpal inflammation ($H = 0.679, P = 1.00$). However, both the Portland cement and light cured TheraCal LC groups had significantly more frequent hard tissue bridge formation at 28 days than the GIC and VLC Dycal groups ($H = 11.98, P = 0.009$). The measured thickness of the hard tissue bridges with the pure Portland and light cured TheraCal LC groups were statistically greater than that of the other two groups ($H = 15.849, P = 0.002$). In addition, the occurrence of pulpal necrosis was greater with the GIC group than the others. **Conclusion:** TheraCal LC applied to primate pulps created dentin bridges and mild inflammation acceptable for pulp capping.

**Key words:** pulp exposures, pulp response, bacteria, primate

The Journal of Clinical Pediatric Dentistry Volume 38, Number 4/2014
This study was conducted to evaluate and compare pulpal responses to ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK), RetroMTA (BioMTA, Seoul, Korea), and TheraCal (Bisco Inc, Schamburg, IL) in dog partial pulpotomy models.
Complete calcific barrier formation was observed in 33% of the TheraCal specimens. Mild tubule formation was observed in 75% of the specimens. The TheraCal dental pulp exhibited mild (45%) to moderate (18%) inflammation, with 90% showing mild dental pulp congestion. The palisading pattern of the odontoblastic cell layer was visible in only 9% of the specimens, with 36% showing odontoblasts and odontoblast-like cells.

**Inverse-square law**

The inverse-square law, in physics, is any physical law stating that a specified physical quantity or intensity is inversely proportional to the square of the distance from the source of that physical quantity.
The conflicting results between this study and the previous in vivo study concerning TheraCal could be caused by limitations in the pulpotomy experimental design. The previous in vivo study by Cannon et al. (16) used pulp capping models in primate teeth, with better access of the curing light. Our study was based on partial pulpotomy models in dogs’ teeth, inevitably with more difficulty in complete curing of the material. The uncured monomer contents leach into the pulp and dentinal tubules and have cytotoxic effects on pulpal cells (32, 35, 36). In our study, the prominent tubules that were present within the newly formed calcific barriers in teeth treated with TheraCal could have also been the result of exposure to leaching of the uncured monomer contents.
Retrieval Studies! TheraCal LC

Hyper-mineralized zone
Retrieval Studies! Pulpotomy
Retrievals - 9 years old
Failed Amalgam – painful, cracked

- Constant sensitivity to cold and hot
- Spontaneous pain
- Can’t eat
Failed Amalgam – painful, cracked

- Bleu Cheese **Dycal**- soft, recurrent caries, stained margins, amalgam flies out
Failed Amalgam – painful, cracked

- **Dycal** and underlying carious dentin removed, microleakage stain left for photo
Failed Amalgam – painful, cracked

- TheraCal DC placed after etching, light cured for 20 seconds (but dual cure, base)
TheraCal Products

Indications:
- Pulpotomy
- Pulp capping
- Base
- Liner
- Dentin replacement
- Temporary filling
- Therapeutic remineralization

Effects of Novel TheraCal Formulation Extracts on OD21 Cells

Yantong Wang, Satin Salehi, John C. Mitchell, Byoung In Suh

Objectives: The purpose of this study was to evaluate the effect of three novel pulp capping compounds on the growth of immortalized murine pulp cells (OD21).

Methods: Light-cured discs (D=10mm x 1mm) of TheraCal LC (LC), TheraCal DC (Experimental mixture DC) and TheraBag65 LC (Experimental mixture TB3) (N=4 each) were soaked in Dulbecco's Modified Eagle Medium (DMEM) for 4 days at 37°C. The discs were removed and the extraction solution was filtered and supplemented with 10% Fetal Bovine Serum. OD21 cells were placed into 24-well culture plates at 10K cells/well and allowed to grow for 24 hours in control media at 37°C 5% CO2. Wells (N=5 each) were treated once (24 hours), or twice (24 and 48 hours) with extract media and followed over a four day period for the once-treated group, or over three days for the twice-treated group. Cells grown in standard αMEM with FBS were used as a control. Cell growth/number was assessed by culturing the cells for 1 hour daily in 10% AlamarBlue media and measuring the metabolic product using a fluorescent microplate reader. Percentages of control fluorescence were compared using ANOVA with α=0.05.

Results: The cell growth/number (standard deviations) after one and two treatments are shown in the figures below. Differences were examined by ANOVA with α=0.05.

Conclusions: At every time point, cell survival following the first treatment with all three materials tested, were all similar and greater than 80%. The Day3 cell survival rate following the second treatments showed differences between materials, with DC and TB superior to LC, however by day 4, only DC remained significantly different from the other two materials. All three materials tested were not detrimental to OD21 cells.
Completed Restoration

- Molar resto ALLBOND Universal and Activa Restorative
- Occlusion adjusted, slightly into cuspal contact due to STA
Calcium Fluoride - insoluble

- FDA - cannot have bioactive calcium and fluoride in a water based toothpaste
- MI Paste Plus - from GC - has virtually NO water
Objectives: The aim of this in vitro study was to evaluate the effects of overlaying RMGI (Vitrebond Plus, 3M Oral) on the calcium release of resin-modified calcium silicate (TheraCal LC) and bond strength between TheraCal LC (Bisco) and resin composite (Reveal Bulk, Bisco).
Material and Methods: For calcium release study, fully cured TheraCal LC disks were prepared (2-cm-diameter and 0.1-cm-high). One side of TheraCal LC disk was covered by other materials (as shown in Table 1). Disks were then stored in 20ml of deionized water at 37ºC. Release of ions was measured on Orion Model 710A+ after 1 day, 3 days and 7 days with new deionized water being replenished after each test. For shear bond strength study, fully cured TheraCal disks (6mm-diameter, 3mm-height) was bonded with resin composite as shown in Table 1 (group 1 and 2), by using notched-edge shear bond strength test method (ISO 29022:2013). The specimens were then stored in 37ºC-water/24-hours before breaking by Instron tester (crosshead-speed 1mm/min). The data were analyzed statistically by one-way ANOVA and Student-t Tests.
Calcium Fluoride - **insoluble**

### Results

Table 1. Mean shear bond strength (n=5) between TheraCal and composite in MPa (standard deviation) and mean calcium release (µg/cm²) (n=3) of TheraCal. Means with different letters (a, b) are statistically different in the same row (p<0.05).

<table>
<thead>
<tr>
<th>Group</th>
<th>Techniques*</th>
<th>Shear bond strength</th>
<th>Calcium release (day 1)</th>
<th>Calcium release (day 3)</th>
<th>Calcium release (day 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TheraCal - AllBond Universal - Reveal Bulk</td>
<td>20.9 (3.1)a</td>
<td>208.6 (39.8)a</td>
<td>245.0 (26.9)a</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TheraCal - Vitrebond - AllBond Universal - Reveal Bulk</td>
<td>16.5 (4.1)a</td>
<td>143.1 (12.5)a</td>
<td>181.5 (26.3)b</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TheraCal - Vitrebond</td>
<td>N/A</td>
<td>27.5 (1.1)b</td>
<td>66.5 (5.1)b</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:** The overlaying RMGI reduced the calcium release of TheraCal. This would also be true for Dycal!!!
**ALLBOND UNIVERSAL:**
Non-permeable Hydrophobic Adhesive

Calcium Release of TheraCal Discs with and without Adhesive Coating

<table>
<thead>
<tr>
<th>Coating Adhesive</th>
<th>Ca(ug/cm²)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>284.2 (0.0)</td>
<td>100.0%</td>
</tr>
<tr>
<td>One-Step</td>
<td>79.6 (23.8)</td>
<td>28.0%</td>
</tr>
<tr>
<td>AB3</td>
<td>31.2 (15.5)</td>
<td>11.0%</td>
</tr>
<tr>
<td>ABSE</td>
<td>44.9 (16.4)</td>
<td>15.8%</td>
</tr>
<tr>
<td>DreamBond</td>
<td>5.7 (2.0)</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

TheraCal (a calcium-release pulp capping material) disks were coated with different adhesives. Calcium release was measured after TheraCal discs were immersed in 37°C-DI water for 1 day.
Shear bond strength (Dycal-RMGI): 0.0±0.0 Mpa the MUSH zone!!
Majority of Failure Modes: Adhesive failure between Dycal & VitreBond
Shear bond strength (Dycal-Composite): 4.5±1.3 MPa
Majority of Failure Modes: Substrate-Dycal Broken
Shear bond strength (TheraCal-Composite): 15.0±4.1MPa
Majority of Failure Modes: Substrate-TheraCal Broken
TheraCal LC displayed the highest SBS (p<0.001). MTA bonded with the 1-step self-etch adhesive showed the lowest SBS (p<0.001), while SBS of TheraCal LC and Fuji IX did not differ between either adhesive (p>0.05). TheraCal LC is the preferred choice in pulp capping procedures when using resin composite restorations.
Conclusions
MTA interacts with other dental materials with resultant elemental migration in adjacent materials. Zinc oxide eugenol based cements should be avoided in the presence of MTA as zinc causes retardation of cement hydration with increased porosity. Glass ionomer cements absorb the water of hydration from the MTA also resulting in increased porosity and incomplete hydration of MTA.
Important Concepts:

There Ain’t No Such Thing As A Free Lunch

Must balance everything:
- Bioactivity versus Stability
- Resorbability versus Dissolvability
- Calcium release versus Mechanical strength
RESULTS:
The analysis of variance that compared the experimental groups revealed the presence of significant differences among the groups (P < 0.001). The highest (19.3 MPa) and the lowest (3.4 MPa) bond strength value were recorded for the MB composite-TheraCal and the GIC-TheraCal, respectively. There were significant differences in bond strength between the TheraCal and the MTA groups for the MB composite subgroup (P < 0.001) and the SB composite subgroup (P < 0.05); however, there was no significant difference in bond strength for the GIC subgroup (P > 0.05).

CONCLUSIONS:
The results from this in vitro study suggest that the new pulp capping material, known as light-curable MTA, showed clinically acceptable and higher shear bond scores compared to MTA when used with the MB composite.
Bioactivity and Dental Materials

DIAGNOdent reading of 68 Odd radiolucency on radiograph
“Giant tubular dentin” defect in mesial fossa

Figure 3. Transverse demineralized section of a non-erupted human deciduous incisor tooth showing dentinal tubule holes (small arrow), giant tubules (large arrow), and interglobular dentin (*). Picosirius. Original magnification: 250X.
Bioactivity and Dental Materials

Selective etching of enamel for 30 seconds followed by application of semi-gel to dentin for 3 seconds
TheraCal DC placed on affected dentin for re-mineralization
Light cure for 20 seconds with at least 500 milliwatts/cm²
ALLBond Universal exp applied to preparation creates glossy appearance to TheraCal exp
Light cure for ten seconds at 500 milliwatts/cm²
Bioactivity and Dental Materials

Liner/base placed
Dentin replacement
- biomemetic
- bioactive
- biofunctional
MColorpHast™
pH-indicator strips (non-bleeding)
pH 0 - 14
Universal indicator
pH-Indikatorstäbchen (nicht blutend)
Bandelettes indicatrices de pH
(ne déteignant pas)
Tiras indicadoras del pH (no destiñen)
Non-Alkaline, No Ca release
RMGI- Fuji II LC acid/base
Bioactivity and Dental Materials

Restoration completed by placement of a nano-hybrid restorative material, replacing the enamel.
Rubber dam removed and occlusion checked - Restoration polished.
Carious Pulp Exposure

- Pulp exposure
- Not symptomatic
- All decay removed
• TheraCal applied
• Thin layer - can see blush through it

resin based tricalcium silicate and dicalcium silicate
• Six month recall
• Totally asymptomatic
• Marginal integrity quite good
Six years later
Still totally asymptomatic
Marginal integrity still acceptable
• Complicated profound crown fracture
• Pinpoint exposure of less than one hour duration - non bleeding
- Complicated profound crown fracture
- Exposure protected by TheraCal
- Fragment re-attached
• Complicated profound crown fracture
• GlasSpan splint applied for lateral luxation of adjacent Central incisor.
• Lateral luxation - TheraCal LC
• 2 years later - in orthodontics

GlasSpan splints TheraCal LC
• 4 years later- post orthodontics!

GlasSpan splints- TheraCal LC
Esthetics- Problems

mom states that he is “not ideal dental patient”.
Esthetics - Problems

- Rubber dam isolation after STA anesthesia
- Patient very cooperative
Esthetics - Problems

- Extensive dental caries - history of sensitivity but not mobile, reversible pulpalitis
All deep areas are covered with bioactive TheraCal LC to re-mineralize and to maintain vitality!!
Esthetics - Problems

- Restored with Activa Pulpdent restorative material - note the margins!
Esthetics - Problems

Very happy patient thanked me for making him numb! He said it was the "FIRST TIME"!
How to care
Why one...closest thing
April 20, 2018

The three...better
Clinical Case

- Caries involving central and lateral incisors
Clinical Case

- Proper isolation critical for pulpal survival
Clinical Case

- Preparation performed, very soft dentin, caries close to pulp horns, straight in!
Clinical Case

- No pulp exposure so etched first with Uni Etch 32% with BAC
- 30 seconds enamel and 3 seconds dentin
Clinical Case

- Rinsing off etchant gel
- Rinse sufficient time to remove all etchant and debris
• Placement of TheraCal - precise, but flash easily removed
Clinical Case

- Two coats of ALLBOND Universal
Clinical Case

- Light cure ALLBOND Universal for 10 seconds-
Clinical Case

- Aelite Enamel place with composite non stick instrument and mylar strips
Clinical Case

- Light cure resin based composite and polish with discs and tapered gold finishing carbides.
• Finished resin based composite restorations

Clinical Case
Limitations:

- Already necrotic pulpal tissue
- Leaky restorations
- Hemorrhage
- Infected dentin
- Misuse and misapplication

Raising the dead!
A transient peak was observed in brain Al level of MTA Angelus group on day 7, while MTA Fillapex and Theracal LC groups reached highest brain Al level on day 60. Brain TBARS level, CAT, SOD and GPx activities transiently increased on day 7 and then returned to almost normal levels. *This in vivo study for the first time indicated that initial washout may have occurred in MTA Angelus, while element leaching after the setting is complete may have taken place for MTA Fillapex and Theracal LC*

Rats were killed 7, 30 or 60 days after operation. Brain tissues were obtained before killing.
EndoCal DC

Indications:
– Endodontic sealer
– Furcation repair
– Internal resorption
– External resorption
– Apicoectomy
THIS IS

HOCKEY!!!!!
Upper left lateral incisor fracture with exposed pulp and mobile palatal segment. Diagnosis-complicated crown root fracture.
Post anesthesia, loose fragment removed, judged restorable, and pulp polyp excised with sterile spoon excavator
What?! No rubber dam??- was afraid of tissue movement and bleeding. Bad place for a clamp…mea culpa, mea culpa.
Estelite Sigma- TheraCal-Trauma

Vista 3% sodium hypochlorite placed with slight but positive pressure for hemostasis and disinfection - judgement call on time necessary. Difficult picture for team member.
No bleeding, prepped for Miomir Cvek pulpotomy
Estelite Sigma- TheraCal-Trauma

Very carefully as to not instigate bleeding.
Sufficient coverage.

TheraCal LC placed
Estelite Sigma- TheraCal-Trauma

Thick layer of TheraCal LC, didn’t want to jeopardize clotting

20 seconds light cure
Estelite Sigma- TheraCal-Trauma

Facial view of crown form
Estelite Sigma- TheraCal-Trauma

Palatal view, tight fit, but NO bleeding..
Estelite Sigma- TheraCal-Trauma

Poking air vents....

Only air needs to vent, NOT composite, dumb old ideas DIE hard… use a tight fit to decrease polishing and less voids, fill crown form carefully
Etched facial enamel first than went to palatal and dentin. Did not etch directly next to the TheraCal LC.
ALLBOND Universal applied and light cured. Thinned with air to insure open interproximals, nothing worse then bonding the contacts shut and being unable to seat crown form.
Estelite Sigma- TheraCal-Trauma

Light cure- Adhesive layer
Seat crown form and remove extruding composite with micro-brush lubed with adhesive resin or modeling resin.
Estelite Sigma- TheraCal-Trauma

Light cure

Palatal, facial, then incisal. To reduce pull from dentin bond, which is the weakest.
Very natural looking lateral incisor- bleeding is from the polishing
Estelite Sigma- TheraCal-Trauma

Palatal view—increased bulk for strength-not in occlusion
Estelitite Sigma- TheraCal-Trauma

Post operative check at recare
"THE DOSE MAKES THE POISON"

APPLE SEEDS  PEARS  POTATOES  COURGETTES

CONTAIN AMYGDALIN  CONTAIN FORMALDEHYDE  CONTAIN SOLANIN  CONTAIN CUCURBITACIN E
~0.6g/kg of seeds  ~0.06g/kg  ~0.2g/kg (higher in green potatoes)  Variable (higher in bitter courgettes)

ALL OF THE FOOD ITEMS ABOVE CONTAIN NATURAL CHEMICALS THAT ARE TOXIC TO HUMANS. HOWEVER, THEY ARE USUALLY PRESENT IN VERY SMALL AMOUNTS, FAR BELOW THE HARMFUL DOSE.

JUST BECAUSE A CHEMICAL IS PRESENT, DOES NOT MEAN THAT IT IS HARMFUL IN THE AMOUNT PRESENT.
Bioactivity and Dental Materials

Pulpally involved, pulp extirpated from chamber. Ferric sulfate placed for hemostasis.
Bioactive treatment with sodium hypochlorite for disinfection, clot debridement and removal of pulpal tags. Step most often skipped.

Vital versus non-vital.

Warm Bodies

Great parody of life-death.
Bioactivity and Dental Materials

Remove excess sodium hypochlorite. If concentrated but water may contaminate chamber PROBLEMATIC
Hemostasis obtained, all pulp contents removed, essential for pulpal therapy success.
Bioactivity and Dental

Pulpal dressing - TheraCal DC

extremely biologically kind.
Bioactivity and Dental Materials

Light cure to initiate polymerization but will dual cure completely due to proprietary technology.
Etch enamel for 30 seconds with Uni Etch BAC. Rinse with copious water flow.
Cured adhesive and TheraCal DC obturation of chamber
Inject dual cure RMGI or Activa into cavity preparation
Bioactivity and Dental Materials

Explorer tine to evenly spread Activa without void incorporation “Pulse” cure
Bioactivity and Dental Materials

Matrix and wedge removed. Note gross anatomy.
Bioactivity and Dental Materials

Post operative visit
TheraCal DC directions

Place TheraCal DC

Restore

Exp Bisco bulk-fill

TheraCal DC or SC
Clinical Implications

TheraCal: Placed after hemostasis. All infected dentin removed. Affected may re-mineralize. Etch and adhesive placed.

“Grey” composite removed. RMGI excavated with mush layer exposed.


Dual cured resin based composite placed and polished.
Retrospective Study of Calcium Hydroxide and TheraCal for Pulp Capping

Ali Alqahtani, University of Michigan
Peter Yaman, University of Michigan
Joseph Dennison, University of Michigan
Neville McDonald, University of Michigan

Objectives: To compare the clinical success rate of TheraCal (light-cured, resin-modified calcium silicate) to calcium hydroxide as pulp-capping materials in permanent teeth with closed apices.
• Methods: This study involved a retrospective electronic record review. Post-operative data were collected from 60 patients for each material involving 69 teeth using calcium hydroxide and 79 teeth using TheraCal. The treatment was categorized as clinically successful if the tooth was still present at the succeeding appointment and no further pulpal treatments or root canal therapy were needed. However, if the tooth was extracted or additional pulpal treatment was done, the tooth was categorized as unsuccessful.
Results: There was no significant difference between the clinical success rate of TheraCal (67 successful, 12 failures) for 84.8% and calcium hydroxide (59 successful, 10 failures) for 85.5% using Fisher's exact test (p<0.05). Indirect pulp capping success for calcium hydroxide was 93% and for Theracal 88%. Direct pulp capping success for calcium hydroxide was 50% and for Theracal 69%.

Conclusions: Based on this retrospective data, Theracal may be considered an equivalent treatment to calcium hydroxide as both a direct and indirect pulp capping material.
• **Calcium-ion Release from Pulp-Capping Agents: Diffusion Through Various Dentin Thicknesses**

Erica Mueller, Midwestern University  
Dustin Mueller, Midwestern University  
M. Teresa Pulido, Midwestern University  
John Mitchell, Midwestern University

• **Objectives:** An important property of pulp-capping materials is Ca-ion release, which leads to biological deposition of reparative dentin. This study examined the ability of Ca2+ ions to diffuse through varying remaining dentin thicknesses (RDT) to affect cells in the pulp chamber.

• **Methods:** Caries-free, extracted human molars were selected and ground to remove the roots at the CEJ. Standardized class 1 occlusal cavities were prepared on the coronal side. Pulp tissue was excised and the pulp-side dentin removed to obtain a standardized pulp-side chamber. Teeth were divided into four groups based on their RDT values: 0.5mm, 1mm, 1.5mm and 2mm (±0.2 mm). RDT was measured using a digital caliper.
Samples were immersed in EDTA, rinsed with deionized water, and each RDT group (N=10 each) was randomly divided into two further groups: one received Dycal (Dentsply, Caulk, Milford, DE, USA) and the other received TheraCal (Bisco Dental, Schaumburg, IL, USA). Direct pulp-capping was performed according to the manufacturer’s instructions. Coronal obturations were completed with composite (Empress Direct, Ivoclar Vivadent, Amherst, NY, USA), and the external/outer surface of each tooth was covered with nail varnish, except the pulpal cavity.

Samples were stored at 37°C in 10 mL of deionized water. For 0mm RDT, discs of TheraCal and Dycal were placed directly into 10 mL of deionized water. As a negative control, both occlusal and pulpal cavities were filled with composite. Ca2+ ion concentration was measured using a Ca2+ ion-selective electrode at 2 hours, 24 hours and 48 hours following placement. Ion release values were compared using ANOVA with post-hoc Tukey (α=0.05).

Conclusions: Use of both TheraCal and Dycal resulted in significant Ca2+ ions diffusion through up to 2mm thicknesses of dentin.
Esthetics - Problems

- No time to play golf - yet to be a dentist
Esthetics - Anterior Problems

• General Anesthesia Case (not mine) - patient had come to our office first - then had case done by another peds

SSC with facings - yuck
Esthetics - Anterior Problems

- General Anesthesia Case (not mine) - 
  mom unhappy with esthetics but teeth mobile - red gingiva - no drainage

Going!!! - what in canals?

6 months
Esthetics- Anterior Problems

• General Anesthesia Case (not mine)-mom wanted new PA at one year

Gone!!!- dissolved

One Year
Esthetics - Anterior Problems

- General Anesthesia Case (not mine) - no abscesses but roots totally resorbing - other office refuse to tell what was used. Disappearing act.
Esthetics - Pulpectomy

**PULPDENT:** Makers of the Original Calcium Hydroxide Paste

Since developing the first pre-mixed calcium hydroxide aqueous methylcellulose pulpal dressing in 1947, the Pulpdent name has been synonymous with calcium hydroxide and is the standard against which all others are measured.

- What to use? Needs to be biocompatible, resorbable but not dissolvable, both radiopaque and antibacterial.
Forendo Paste
with iodoform

Pre-mixed calcium hydroxide paste with iodoform in a silicone oil base – a strong disinfectant

• Creamy consistency – non-setting
• Radiopaque
• Syringe delivery with curved applicator tips
• Available in a 2.2 gm syringe with 20 curved applicator tips for direct dispensing into the root canal

Competes with Vitapex, Diapex and Metapex

• Forendo- non-dissolvable, silicone oil, but radiopaque and antibacterial.
Esthetics - Problems

- High caries rate children
- Recurrent caries
- Poor compliance
- Bad diets
- No oral hygiene
- 14 days for white spot to develop

What is your preventive plan?
NeoMTA-technique

Hypoplastic first primary molar-depth cuts made for ZR crown. Decay implies need for pulpal therapy.
Bioactivity and Dental Materials

NeoMTA-technique

Ragged, hemorrhagic pulp, debris present and hypoplastic, hypomineralized tooth structure
Debris removed and hemostasis obtained with cotton pellets damp with sodium hypochlorite (Vista, comes in 3 or 6% and in 3 or 12 ml. DOESN’T last long!!)
After pellet of NeoMTA placed much faster to protect with Temp It from Centrix. Sets with water contact. Seals so crown preparation starts immediately.
Bioactivity and Dental Materials

NeoMTA-technique
After try-in, thoroughly rinse the restoration with water spray and dry with oil-free air.

Dry with oil-free air.
Universal Cleaning Gel

MAYBE IF WE TELL PEOPLE THE BRAIN IS AN APP

THEY WILL START USING IT
Instructions for Use:

- Protective eyewear and gloves should be worn by operator and assistant.
- After try-in, thoroughly rinse the restoration with water spray and dry with oil-free air.
- Remove cap from ZirClean, securely attach tip and verify flow of material prior to application.
- Cover all bonded surfaces of the restoration with a layer of ZirClean.
- Allow **20 seconds** for the cleaning action of ZirClean to take effect, then **thoroughly rinse with water spray** and dry with oil-free air.
- Next, prime the bonding surface of the restoration with a suitable primer (e.g. Z-PRIME™ Plus* or PORCELAIN PRIMER*) according to manufacturer’s instructions.
Bond strength on Zirconia

Shear Bond Strength (MPa)

- No Contamination, No Cleaning
- Saliva Contaminated, Water Cleaned
- Saliva Contaminated, ZirClean Cleaned

TheraCem

Z-Prime – Duolink
NeoMTA-technique

Bioactivity and Dental Materials

adjacent dentition.
Bioactivity and Dental Materials

Corresponding crown is now cemented with NuSmile BioCem Universal BioActive cement- using a cotton tip applicator to stabilize. TheraCem is also great!
Tack cure with light unit before cleaning off excess. Length of tack cure depends on output of light.
Extra cement may now be removed with scaler and floss. Majority of bleeding from second molar gingiva and not crown. No blanching of tissue from crown. Dryze from Parkell very useful in controlling pre-cementation bleeding.
recurrent caries

~50\% of restoration failures

Four Types of Cements

- **Light-cure veneer Resin cement** (Bonding Procedure, require bonding agent)
- **Dual-cure Resin cement**
- **Self-adhesive Resin cement** (Luting Procedure, do not require bonding agent)
- **(Resin-modified) Glass ionomer cement**

Cements can be classified as:
- **Cariogenic**
- **Cariostatic/Bioactive** (F⁻/Ca²⁺ release)

Strength:
- **Weak**
- **Strong**
• More friendly to pulp, e.g. Ca(OH)$_2$, MTA
• May inhibit bacteria
• Neutralize local acid

J Endod 2016;42:1355–1361
The pH of some common foods is as follows:

- Fresh orange juice: pH 3.8
- 7-Up: pH 3.2
- Sprite: pH 3.2
- Minute Maid Pomegranate Juice: pH 3.0
- Coca-Cola Classic: pH 2.4
- Pepsi: pH 2.4

These pH values indicate the relative acidity of the beverages.
Relax ... it's a diet soda.
PURPOSE

TheraCem (alkaline pH)

Acidic Solution (pH 2.4)

DI Water

Calcium Release Bond Strength

UniCem 2

Acidic Solution (pH 2.4)

DI Water

Bond Strength
MATERIALS & METHODS

Calcium Release Test

Disks preparation (2cm-diameter, 1.0 mm-thick, n=3) with TheraCem (self-cured 15min/37ºC)

Storage in 0.1 N Lactic Acid Solution (pH2.4, 37ºC)  
Storage in DI Water at 37ºC

Test calcium release after 1, 5, 7, 14 days (with new DI water or acid solution being replenished after each test)
Shear Bond Strength Test

Zirconia (sandblasted with alumina sand)

ISO 29022:2013 Dentistry – Adhesion
Notched-edge shear bond strength test

TheraCem (S/C 15min/37°C)

UniCem2 (S/C15min/37°C)

in Lactic Acid (pH 2.4, 37°C)

Storage in DI Water at 37°C

Tested by Universal Testing Machine (Instron, 1mm/min), n=5

SEM examination of debonded cement surface

Ultradent jig, area 4.5mm²

Ultradent jig, area 4.5mm²
RESULTS & DISCUSSION

Accumulative Calcium Release of TheraCEM (µg/cm²)

<table>
<thead>
<tr>
<th>Storage Time</th>
<th>In DI Water</th>
<th>In Acidic Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>11.7</td>
<td>21.3</td>
</tr>
<tr>
<td>5 days</td>
<td>62.3</td>
<td>122.9</td>
</tr>
<tr>
<td>7 days</td>
<td>432% up</td>
<td>477% up</td>
</tr>
<tr>
<td>14 days</td>
<td>490% up</td>
<td>664% up</td>
</tr>
</tbody>
</table>

Calcium silicate by-product

Ca(OH)₂

Water/Hydration

Ca²⁺
Shear Bond Strength on Zirconia (MPa)

- **TheraCem**
  - In DI water: 20.4 MPa
  - In acidic solution: 20.5 MPa

- **UniCem2**
  - In DI water: 16.6 MPa
  - In acidic solution: 10.5 MPa (37% down)

The graph compares the shear bond strength of TheraCem and UniCem2 in DI water and in an acidic solution.
UniCem2 (water) 

Normal Cohesive fracture
UniCem2 (acid)

Marginal Degradation
TheraCem (water) 

Normal Cohesive fracture
TheraCem
(acid)

Normal Cohesive fracture
ACKNOWLEDGEMENTS

Co-authors

Rebecca Wang
Jie Yang
Byoung In Suh

谢谢 grazie Je vous remercie Thank you ขอบคุณ
Danke gracias 謝謝 ありがとう 고맙습니다

“Smart” Materials
Remove rubber dam and clean up flash.

Old zirconium crowns usually appeared bulbous.
Bulk Fill

- Depth of Cure - essential!
- Low Young’s Modulus
- Low Shrinkage
- Properties - wear resistance, compressive strength, tensile strength
Fusion Wedges- Case 1

Interproximal caries on mesial first molar and distal second premolar.
Proper isolation is necessary for patient safety and for a quality restoration.
Features & Benefits

A real softie.

3D Fusion’s Soft-Face over-mold allows the wedge to do what no other wedge can truly do – actually adapt to interproximal irregularities.
Keep it clean (and dry!)
3D Fusion’s patent pending design easily follows the contours of the teeth sealing things up nice and tight while preventing overhangs.
Pre-wedging provides for isolation and proper contact. Prep into the wedge for ideal “extension for prevention”.
330 bur produces correct preparation design for resin based composite restorations
Number 4 round bur to remove decay and to round axial-pulpal line angels. This reduces stress from occlusal forces.
Properly prepared preparations for a resin based composite resin. Note condition of wedge....
Fusion Wedges - Case 1

Garrison matrix, wedge and bitine place to separate teeth and provide for proper restoration.
Fusion Wedges - Case 1

Bisco Uni-Etch for total etch starting with enamel for 20 seconds then dentin for 3 seconds.
After total etch a universal adhesive is placed, ALLBOND Universal, in two coats, then light cured.
Fusion Wedges- Case 1

Light cure for 10 seconds with at least a 800 milliwatt light curing unit, always check the output of all your units with a radiometer!
Fusion Wedges - Case 1

Inject Activa Restorative Dual Cure Restorative Resin Based Bioactive Material.
Garrison Wedges and Matrix

Light cure Activa Restorative from Pulpdent in layers, but remember it is dual cured. The autocure continues, don’t remove matrix until it is done!!!
Fusion Wedges- Case 1

Correctly positioned Garrison system, Pulpdent Activa Restorative injected and manipulated with dental explorer.
Garrison Fusion bitine, matrix and wedge removed. Normal contours evident, leads to correct specific microbiome for contact area.
Fusion Wedges- Case 1

Occlusion adjusted with spiral fluted carbide polishers
Wrap it up – Full Curve bands wrap further around the tooth, out of the way, making ring placement easier. Still dead-soft and a skinny 0.0015” thin, they’re the perfect choice.
Garrison- Fusion Matrix and Wedges

• Clinical Cases: Interproximal Form
• Dental Caries- mesial distal premolar and mesial molar
Garrison- Fusion Matrix and Wedges

Rubber dam and pre-wedge with Garrison Fusion Wedges Protects tissue and rubber dam, opens contacts
Garrison- Fusion Matrix and Wedges

Preparations with contacts opened, tissue and dam protected—no bleeding
Garrison- Fusion Matrix and Wedges

Fusion Matrixes placed and Garrison bitine ring placed for mesial contact of pre-molar
Garrison- Fusion Matrix and Wedges

Total etch-enamel for 30 seconds and dentin for 3 seconds
Garrison- Fusion Matrix and Wedges

ALLBOND Universal adhesive placed, two coats and dwell time of 10-15 seconds
Garrison- Fusion Matrix and Wedges

Light cure of adhesive with minimum of 500 milliwatts for 10 seconds- but 20 seconds best due to deep box preparations and matrix band blockage of light
Garrison- Fusion Matrix and Wedges

Very Important!
Mesial box filled with composite-graded slope to distal axial pulpal angle
Garrison- Fusion Matrix and Wedges

Light cure for 20 seconds- and move bitine ring to distal of premolar
Now fill distal of premolar and mesial of molar with composite - in layers or with new bulk fill. This was done with Activa-Pulpdent.
Light cure distal of premolar and mesial of molar—should have great contacts and contour!

Don’t cure just the surface!!!
Don’t use T bands or Tofflemires!
No polishing—only bitine, matrixes and wedges removed. Now create anatomy with raptor bur and polish with spiral gold fluted carbide.
Garrison- Fusion Matrix and Wedges

Occlusion adjusted and contacts checked with floss- very tight!!!!!
New Rings

Short & Tall Rings

The two main separator rings, short (blue) and tall (orange), are the heart of the new Composi-Tight® 3D Fusion™ system. These are your “go-to” rings and will be used for the majority of restorations.
Garrison- Fusion Matrix and Wedges

New Garrison bitines
Garrison- Fusion Matrix and Wedges

Fits over clamp, wedges, on short teeth
Garrison- Fusion Matrix and Wedges

Normal contour and contact
Garrison- Fusion Matrix and Wedges

Garrison polishers- new!!!
Garrison- Fusion Matrix and Wedges

Garrison polishers- Rally
Garrison - Fusion Matrix and Wedges

Rally polishers - final result
Components & Use

Starter Kit

Rally™ polishers are single-patient resin polishing devices designed for the final polishing of all accessible composite resin and hybrid ceramics restorations. A full range of applications are covered with three grits (fine, medium and coarse) and two shapes (point and cup).

The Rally™ starter kit contains everything you need:
- Fine points and cups
- Medium points and cups
- Coarse points and cups
Components

Starter Kit

FitStrips are a complete line of interproximal trimmers and finishers from the company that invented tight interproximal contacts, Garrison Dental Solutions.

- Composite restorations: contouring/finishing all interproximal surfaces
- Orthodontics: IPR/tooth slenderizing
- Crown and bridge: cement removal and clean-up

I JUST WANT TO TALK TO YOU ABOUT YOUR INSURANCE POLICY
Reveal HD
Bulk Fill
A brand for a company is like a reputation for a person. You earn a reputation by trying to do hard things well.

- Jeff Bezos, CEO of Amazon.com
REVEAL HD Bulk is a light-activated restorative composite, optimized to allow for simpler and faster posterior restorations.

REVEAL HD Bulk combines superior levels of handling, depth of cure, and polishability thanks to its proprietary HD Filler Technology, to perform as an optimum functional and aesthetic bulk fill composite.
Why Bulk Fill?
<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>Depth of Cure (mm)</th>
<th>Radiopacity (mm Al)</th>
<th>Hardness Degree of Conversion (%)</th>
<th>Compressive Strength (MPa)</th>
<th>Volumetric Shrinkage (%)</th>
<th>Hardness (Top/Bottom)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVEAL HD Bulk</td>
<td>6.04</td>
<td>4.00</td>
<td>97.0</td>
<td>370.0</td>
<td>2.31</td>
<td>67.0</td>
</tr>
<tr>
<td>Voco X-Tra Fill</td>
<td>4.15</td>
<td>3.00</td>
<td>96.0</td>
<td>292.0</td>
<td>2.26</td>
<td>71.5</td>
</tr>
<tr>
<td>Kerr Sonic Fill 2</td>
<td>3.06</td>
<td>1.60</td>
<td>94.0</td>
<td>222.0</td>
<td>1.88</td>
<td>70.0</td>
</tr>
<tr>
<td>Ivoclar Tetric EvoCeram</td>
<td>3.32</td>
<td>3.50</td>
<td>88.0</td>
<td>207.0</td>
<td>2.36</td>
<td>65.0</td>
</tr>
<tr>
<td>Densply SureFill SDR (Flowable)</td>
<td>3.97</td>
<td>3.10</td>
<td>85.0</td>
<td>222.0</td>
<td>4.31</td>
<td>81.5</td>
</tr>
<tr>
<td>3M Filtek One</td>
<td>3.88</td>
<td>2.80</td>
<td>91.0</td>
<td>250.0</td>
<td>2.25</td>
<td>64.0</td>
</tr>
<tr>
<td>3M Filtek Bulk Fill</td>
<td>3.91</td>
<td>3.00</td>
<td>95.0</td>
<td>236.0</td>
<td>2.51</td>
<td>64.5</td>
</tr>
</tbody>
</table>
Depth of Cure

- REVEAL HD Bulk: 6.04
- VOCO X-tra Fill: 4.15
- Dentsply SureFil® SDR® (flowable): 3.97
- 3M Filtek™ Bulk Fill: 3.91
- 3M Filtek™ One: 3.88
- Ivoclar Tetric EvoCeram®: 3.32
- Kerr Sonic Fill™: 3.06
**Recommended Curing Times**

Adequate curing is essential for restorative function. Uncured or undercured composite material is far more likely to experience some form of clinical failure. Kerr recommends regular inspections of your curing lights to ensure they are functioning and providing the expected irradiance. SonicFill 2 is intended to be cured by a halogen or LED light with a minimum light intensity of 650 mW/cm² and a light wavelength output within the 400-520 nm range. Please refer to the table below for curing recommendations.

All times refer to a single occlusal surface cure. In any posterior restoration, Kerr recommends additional 10 second cures on both the buccal and lingual surfaces of the tooth.

<table>
<thead>
<tr>
<th>Curing Method</th>
<th>All Shades</th>
<th>20 Seconds</th>
<th>10 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optilux (or light with output 650 – 1000 mW/cm²)</td>
<td>20 Seconds</td>
<td></td>
<td>10 seconds</td>
</tr>
<tr>
<td>Demi Ultra / Demi Plus (or light with output &gt;1000 mW/cm²)</td>
<td>20 Seconds</td>
<td></td>
<td>10 seconds</td>
</tr>
</tbody>
</table>

### 3.6 Curing

- Light cure each area of the restoration surface.

**Pulp Injury due to excessive heat - curing output >2000 mW/cm²**

- Check Curing Light manufacturer's literature for stated output.
- Consult Curing Light manufacturer's Directions for compatibility curing recommendations.
- Do not use table below for recommended curing times with output >2000 mW/cm².

<table>
<thead>
<tr>
<th>Curing Recommendations*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade</td>
</tr>
<tr>
<td>Universal</td>
</tr>
<tr>
<td>High Power LED Lights 1000-2000 mW/cm²</td>
</tr>
<tr>
<td>A1, A2, A3</td>
</tr>
<tr>
<td>High Power LED Lights 1000-2000 mW/cm²</td>
</tr>
<tr>
<td>Product</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Ivoclar Tetric EvoCeram</td>
</tr>
<tr>
<td>Dentsply SureFil SDR (flowable)</td>
</tr>
<tr>
<td>VOCO X-tra Fill</td>
</tr>
<tr>
<td>3M Filtek Bulk Fill</td>
</tr>
<tr>
<td>3M Filtek One</td>
</tr>
<tr>
<td>Kerr Sonic Fill 2</td>
</tr>
</tbody>
</table>
Hardness Degree of Conversion (%)

<table>
<thead>
<tr>
<th>Material</th>
<th>Degree (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVEAL HD Bulk</td>
<td>97.0</td>
</tr>
<tr>
<td>Voco X-Tra Fill</td>
<td>96.0</td>
</tr>
<tr>
<td>3M Filtek Bulk Fill</td>
<td>95.0</td>
</tr>
<tr>
<td>Kerr Sonic Fill 2</td>
<td>94.0</td>
</tr>
<tr>
<td>3M Filtek One</td>
<td>91.0</td>
</tr>
<tr>
<td>Ivoclar Tetric EvoCeram</td>
<td>88.0</td>
</tr>
<tr>
<td>Densply SureFill SDR (Flowable)</td>
<td>85.0</td>
</tr>
<tr>
<td>Zest Dental BulkEZ</td>
<td>83.0</td>
</tr>
</tbody>
</table>
Volumetric Shrinkage (%) RD-001

<table>
<thead>
<tr>
<th>Material</th>
<th>Volumetric Shrinkage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerr Sonic Fill 2</td>
<td>1.88</td>
</tr>
<tr>
<td>3M Filtek One</td>
<td>2.25</td>
</tr>
<tr>
<td>Voco X-Tra Fill</td>
<td>2.26</td>
</tr>
<tr>
<td>REVEAL HD Bulk</td>
<td>2.31</td>
</tr>
<tr>
<td>Ivoclar Tetric EvoCeram</td>
<td>2.36</td>
</tr>
<tr>
<td>3M Filtek Bulk Fill</td>
<td>2.51</td>
</tr>
<tr>
<td>Zest Dental BulkEZ</td>
<td>2.98</td>
</tr>
<tr>
<td>Densply SureFill SDR (Flowable)</td>
<td>4.31</td>
</tr>
</tbody>
</table>

Volumetric Shrinkage (%) RD-001: 4.31 2.98 2.51 2.36 2.31 2.26 2.25 1.88
Refractive Indices

- Apparent position of fish
- Real position of fish

Air

Water
Light Transmission

REVEAL HD Bulk

Bulk Fill Competitor
Shearing Effect

Increased shearing effect, better handling

Decreased shearing effect, lesser handling

Barrel and Tip

Material
Clinical Case 1:

- Dental caries- distal of first premolar
- Odd shaped and larger tooth
- STA used
Clinical Case 1:

- Pre-wedge
Clinical Case 1:

• Prophylaxis!
Clinical Case 1:

- Garrison-wedge, matrix and bitine ring
Clinical Case 1:

- 30 second etch of enamel and 3 second dentin etch
Clinical Case 1:

- Apply Universal Adhesive - two coats
Clinical Case 1:

- Light Cure for at least 10 seconds
- Regularly check lights with radiometer (eBay 20$?)
Clinical Case 1:

- Reveal
- Bulk Fill- A2
- Will look translucent
Clinical Case 1:

- Bulk fill-dentin replacement
Clinical Case 1:

- Universal Flowable Composite for Enamel Layer
Clinical Case 1:

- Esthetic - durable and quick
Clinical Case 1:

- Adjust occlusion
- Polish with Carbides and Points
- Floss contacts
Clinical Case 1:

- Power cure for 20 seconds
- Hardens exposed surface
Clinical Case 2:

- Deep caries of maxillary second pre-molar
Clinical Case 2:

- Rubber dam placed
- Pre-wedged
- STA only
Clinical Case 2:

• Pumice prophylaxis
Clinical Case 2:

- Classic “Ireland” Preparation
Clinical Case 2:

- Deep Caries
- Close to pulp
Clinical Case 2:

- Very deep preparation but all caries removed
Clinical Case 2:

- Etch enamel for 30 - dentin for 3 seconds
Clinical Case 2:

- TheraCal LC placed in deep portions of preparation.
- Will re-mineralize the affected dentin.
- Protects pulp.
Clinical Case 2:

- Light cure TheraCal LC for 20 seconds - could use TheraCal SC or DC
Clinical Case 2:

- Apply Universal adhesive - ALLBOND Universal
Clinical Case 2:

- Light cure adhesive layer and further cure TheraCal LC
Clinical Case 2:

- Cured adhesive and TheraCal
Clinical Case 2:

- Inject Reveal HD Bulk Fill
Clinical Case 2:

- Condensable
Clinical Case 2:

- Dentin replacement
- - could be one fill
Clinical Case 2:

- Power Cure Bulk Fill HD
- Cure buccal and lingual
- Peel back Sectional Matrix
Clinical Case 2:

- Place enamel layer - Estelite Sigma Quick OA1
Clinical Case 2:

- Use lateral condenser for anatomy
- Power cure the enamel layer
- Peel back matrix
Clinical Case 2:

- Raptor bur creates anatomy
- Polish with fluted carbide
- Remove overhangs
Clinical Case 2:

- Rough anatomy
- Remove rubber dam and adjust occlusion
- Polish
Estelite Bulk Fill Flow

Mark Cannon DDS MS- Prof. Division of Dentistry Dept. of Otolaryngology, Feinberg School of Medicine Northwestern University, Chicago, IL USA
Case 1: Second Primary Molar

• Occlusal Caries second molar - to be restored with Estelite Bulk Fill Flow
Case 1: Second Primary Molar

- Occlusal Caries - removed, deep preparation
Case 1: Second Primary Molar

- Etching of the enamel for 30 seconds
Case 1: Second Primary Molar

- No etchant on dentin surfaces - yet!
Case 1: Second Primary Molar

- Etchant is applied to dentin surfaces for 3 seconds to remove smear layer only
Case 1: Second Primary Molar

- Copious rinsing of the preparation removes all etchant debris and calcium phosphate salts
Case 1: Second Primary Molar

- Application of base/liner (TheraCal LC) to deepest portions of preparation
Case 1: Second Primary Molar

- Light curing for 20 seconds with intense light source

Demi Ultra
1400-1650 milliwatts
Case 1: Second Primary Molar

- Application of seventh generation universal adhesive – two coats! Light cure 10 seconds
Case 1: Second Primary Molar

- Estelite Bulk Fill Flow is injected into preparation and teased into place with explorer tine.
Developed over 25 years ago by Tokuyama’s Research & Development Team in Japan, Estelite’s spherical filler particles have won numerous awards for delivering superior benefits to Dentists and patients alike. With an average particle size of **200 nanometers (supra-nano)**, the spherical filler particles are the foundation to delivering simple, lasting and beautiful results.
Estelite Bulk Fill Flow

A stronger, more durable bulk fill
Stronger than one of the leading bulk fill flowables
Formulated to let patients bite with confidence.

Compressive and Flexural Strength

<table>
<thead>
<tr>
<th></th>
<th>Flexural (MPa)</th>
<th>Compressive (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estelite Bulk Fill Flow</td>
<td>396</td>
<td>375</td>
</tr>
<tr>
<td>SureFill SDR flow*</td>
<td>260</td>
<td>120</td>
</tr>
<tr>
<td>Filtek Bulk Fill Flowable*</td>
<td>111</td>
<td>122</td>
</tr>
<tr>
<td>Filtek One Bulk Fill*</td>
<td>122</td>
<td>160</td>
</tr>
<tr>
<td>SonicFill 2*</td>
<td>343</td>
<td>121</td>
</tr>
<tr>
<td>Tetric EvoCeram Bulk Fill*</td>
<td>372</td>
<td></td>
</tr>
</tbody>
</table>

Excellent wear resistance
Estelite Bulk Fill Flow highly resists abrasion and wear for long-lasting posterior restorations.

Composite wear (mm^3)**

The lowest wear and abrasion.

Opposite teeth abrasion depth [µm]**

Estelite Bulk Fill Flow  Tetric EvoCeram Bulk Fill*
Cured to the bottom of the restoration

Thanks to its high translucency at placement, Estelite Bulk Fill Flow cures all the way to the bottom of a 4mm deep restoration in only 10 seconds.

<table>
<thead>
<tr>
<th>Material</th>
<th>Bottom/Top Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estelite Bulk Fill Flow</td>
<td>93%</td>
</tr>
<tr>
<td>SureFil SDR flow+*</td>
<td>84%</td>
</tr>
<tr>
<td>Filtek Bulk Fill Flowable*</td>
<td>90%</td>
</tr>
<tr>
<td>Filtek One Bulk Fill*</td>
<td>93%</td>
</tr>
<tr>
<td>SonicFill 2*</td>
<td>70%</td>
</tr>
</tbody>
</table>

Minimal shrinkage stress

The spherical fillers used in Estelite Bulk Fill Flow reduce shrinkage stress and linear shrinkage to a minimum.

Shrinkage Stress and Linear Shrinkage:

- **Shrinkage Stress (MPa):**
  - Estelite Bulk Fill Flow: 2.6
  - SureFil SDR flow+*: 2.1
  - Filtek Bulk Fill Flowable*: 0.64
  - Filtek One Bulk Fill*: 0.81
  - Tetric EvoCeram Bulk Fill*: 1.25

- **Linear Shrinkage (%):**
  - Estelite Bulk Fill Flow: 2.5
  - SureFil SDR flow+*: 0.65
  - Filtek Bulk Fill Flowable*: 1.4
  - Filtek One Bulk Fill*: 0.54
  - Tetric EvoCeram Bulk Fill*: 1.5
Estelite Bulk Fill Flow

A bulk fill for worry-free restorations
The best cavity adaptation

Estelite Bulk Fill Flow easily adapts to the cavity, flowing into the nooks and crannies, providing an excellent marginal seal and preventing restoration failure.

*Marginal failure, gaps, and voids were common in other tested brands.

- Marginal sealing and restoration adaptation, no SonicFill voids
Case 1: Second Primary Molar

- Light curing of Estelite Bulk Fill Flow-becomes opaque
Case 1: Second Primary Molar

- Anatomy created with Raptor bur
Case 1: Second Primary Molar

- Finished restoration! Remove rubber dam and check occlusion
Case 1: Second Primary Molar

- Recare follow up - no microleakage
Advantages

• Estelite Bulk Fill Flow- translucent
• Allows deep curing
• After polymerization- becomes opaque
• Doesn’t have voids/ displays excellent adaptation
Chris- back home.... Yay!!

Thanks! See you this afternoon??