**THE MAJOR CURRENT TRENDS OF TECHNOLOGY CHANGE**
- Non-Ionizing Diagnostics
- Remineralization & Remineralizing Materials
- More Stable Adhesive Strategies
- Advances in Lasers
- Biomimetic, Bioactive Materials
- Lasers – Smaller, Lower Cost, More “Real” Uses
- Tissue Engineering, Advanced Implant Surfaces
- Antimicrobial, More Durable Composites
- Technology for Minimally Invasive Dentistry (MID)
- Stronger All-Ceramic Materials

**PRODUCT TRENDS 2015**
- Minimally Invasive Dentistry (MID)/Early Diagnostics/Early Treatment
- Bulk Fill Restoratives
- The Latest Emerging Class of Adhesives - Universal Adhesives
- Non-Radiographic Diagnostics
- Regenerative Pulp Therapy & Endodontics
- New Resin Cement Formulations
- Bioactive Restoratives & Luting Agents
- CAD/CAM-Generated Fabricated Restorations
- High-Strength All-Ceramics
- Repair & Maintenance of Existing Restorations

**DRIVERS/OBSTACLES FOR TECHNOLOGY ADOPTION**
- Improved Performance
- Improved Efficacy
- Reduced Treatment Time
- Reduced Procedure Cost
- Less Invasive
- New Information Forces Change
- Reasonable Payback on Investment
- More Complex
- High Cost
- Increased Procedure Time
- Limited/Short Training
- Too New
- Lack of Efficacy Data
- Lack of Effectiveness Data
- Limited or No Clinical Data

**MINIMALLY INVASIVE DENTISTRY (MID)**
**EARLY DIAGNOSTICS - EARLY TREATMENT**
**REMINERALIZATION TECHNOLOGY**
**INFECTION TECHNOLOGY**

**What’s new in caries diagnosis & treatment?**
- Early diagnostics
- Transmission of organisms
- Risk Assessment
- Virulence factors
- NEW DIAGNOSIS DEVICES
- Populations in need/access to care
- Individualized treatment plan
- REMINERALIZATION TECHNOLOGY

**Caries Diagnostic Technologies/Techniques**
- Visual
- Radiographic – Computer Assisted Interpretation - Logicom
- DiagnDent
- Spectrum & Spectra (Caries Detection/Intra-Oral Camera)
- Conventional Translumination
- DEXIS CarisMedical
- The Canary System
- Intraoral Microscopy (Microscope)
Useful diagnostic?
- Sensitivity (false negatives?)
- Specificity (false positives?)
- Reliability
  - Intra-examiner
  - Inter-examiner

Laser-Induced Fluorescence of Carious Tissue
- Kutsch, in 1992, illuminated carious and non-carious tissue together with an argon laser together with dark field photography.
- He reported that while illuminating, carious lesions in teeth had a clinical appearance of dark, fiery, orange-red color.
- Will discuss hard tissue fluorescence further in the section of new caries diagnostic devices.

QLF contrast enhancement
- White light
- QLF

Principle of operation
- Contrast enhancement follows from scattering properties of tooth tissue

Translumination & An Idea?
- Why not combine a quality transluminator with a high-resolution intra-oral camera?

Caries Diagnostic Technologies/Techniques
- Visual
- Radiographic – Computer Assisted Interpretation - Logicom
- DiagnoDent
- SoproLife & Spectra (Caries Detection/Intra-Oral Camera)
- Conventional Translumination
- Dexis CariVu
- The Canary System
- Intraoral Microscopy (Microscope)

Operating Microscope
- Advantages of the operating microscope are:
  - Homogeneous illumination;
  - A 3-dimensional view,
  - Together provide clear visualization of the examination site.

A NEW APPROACH IN CARIES DISCLOSING DYE
GC Tri Plaque ID Gel

AN UNMET CHALLENGE IN CARIES DIAGNOSIS
- We do not yet have a diagnostic method of device that with accuracy or precision indication the size and depth of the carious lesions.
THE FINAL CHALLENGE

WE DO NOT YET HAVE A DIAGNOSTIC TEST OR DEVICE WHICH WILL TELL US IF THE CARIOUS LESION IS "ACTIVE" OR "INACTIVE"!!

ADVANCES IN REMINERALIZATION FOR EARLY CARIOUS LESIONS: THE EMERGING QUEST IN ORAL HEALTH

New Remineralization Technology
Treatment of Incipient Carious Lesions
Integration with Minimally Invasive Dentistry (MID)

Caries Therapies

• Early – remineralization techniques
• Late – restorative techniques
• Mid – combination of above

The Oral Equilibrium Between Demineralization/Remineralization

Oral Microbes + Fermentable Carbohydrates

Remineralization

Salivary Components: Calcium, Phosphate, pH Buffers, Fluoride

FLUORIDE THERAPY

New Calcium-Based, Remineralization Agents

AMORPHOUS CALCIUM PHOSPHATE (ACP)
CASEIN PHOSPHOPEPTIDE (RECALDENT)
TRI-CALCIUM PHOSPHATE (TCP)
PARTICULATE BIOGLASS (NOVAMIN)

Amorphous Calcium Phosphate

• A reaction product of dicalcium phosphate and tetracalcium phosphate, developed by Ming S. Tung at the American Dental Research Association’s Paffenbarger Research Center.
• The calcium and phosphate remain in a relatively "amorphous" or "non-crystalline" state, increasing their bioavailability.

ACP

• AMORPHOUS Calcium Phosphate
• NO Structure
• ACP is created through chemical reaction
• TCP is a crystal put into rosin medium
• ACP dissolves into saliva and is delivered directly to teeth (4X and 2X)

Recaldent®

• Recent developments by Recaldent have made it possible to bring calcium and phosphate in an amorphous form to the mouth.
• By means of casein phosphopeptide, a complex is created with the amorphous calcium phosphate and the resulting CPP-ACP molecule binds to biofilms, plaque, bacteria, hydroxyapatite and surrounding soft tissue, thus localizing the bio-available calcium and phosphate.
• Recaldent is available in a MI Paste and MI Paste Plus (contains fluoride) from GC Dental.
• Numerous claims: remineralization, desensitization, caries inhibition (MI Plus – has Fluoride).
Recaldent

- A phosphopeptide is a peptide incorporating one or more phosphate groups, typically associated with protein phosphorylation.
- Caseins are a special group of phosphopeptides found usually in milk and milk products.
- May enhance stability and transport of calcium via phosphopeptide group interactions.

What is NovaMin?

NovaMin is the brand name of a particulate bioactive glass that is used in dental care products for Remineralisation of teeth. It was developed and patented by NovaMin Technology, Inc.

In aqueous solutions, NovaMin consists of 45% SiO₂, 24.5% Na₂O, 24.5% CaO and 6% P₂O₅.
This active ingredient is called Calcium Sodium Phosphosilicate (CaNa₂Si₅O₈).
NovaMin delivers an ionic form of calcium, phosphorus, silica, and sodium that are necessary for bone and tooth mineralization.

SO IS THERE CLEARLY A SUPERIOR PRODUCT FOR REMINERALIZATION?

- NOT CLEAR AT THIS TIME.
- FLUORIDE IS STILL THE MAJOR COMPONENT – BOTH IN RESISTANCE TO DEMINERALIZATION & PROMOTION OF REMINERALIZATION.
- ALL CONTAIN THE MAXIMUM AMOUNT OF FLUORIDE (i.e. VARNISH – 5%).
- ONLY RCT CLINICAL DATA CAN SOLVE THE ISSUE – VERY EXPENSIVE!!!
**Dental Lasers**

**Diode Laser**
- **Advantages**
  - Affinity for pigments in tissues and hemoglobin
  - Bacteria
  - Little contraction and scarring
  - Little postoperative gingival recession
  - Minimally invasive
  - Reduced chance of tissue/tooth damage

**Disadvantages**
- Unable to cut bone or tooth (can be an advantage)
- Cost
- Slower cutting than electrosurgical

---

**Clinical Uses – Diode Laser**

**Other “MID” or Tooth Preparation Technology**

---

**Icon™ Resin Infiltration System**
- Incipient caries indication still needs further clinical documentation & lacks reimbursement codes.
- Fluoride Gel/ variolox interproximal application are alternative treatments.
- Esthetic treatment of white spot lesions has attracted more attention, especially in the US.

---

**ADVANCES IN MATERIALS & RESTORATIVE PROCEDURES**

- CAD/CAM & HIGH STRENGTH CERAMICS
- ADVANCES IN COMPOSITE RESIN DIRECT RESTORATIVES
- NEW MATERIAL CATEGORY – BIOACTIVE MATERIALS

---

**AN OVERVIEW OF CAD-CAM DENTAL TECHNOLOGY**

- LAVA COS
- Itero
- CEREC
- E4D

---

**THE FABULOUS FOUR OF DENTAL CAD-CAM**

---

**SYSTEM OPERATING FACTORS**

- OPTICAL VS. LASER SCANNER
- POWDER VS. NO POWDER
- STILL IMAGES VS. VIDEO IMAGES

---

**THE EVOLUTION OF CHAIRSIDE CAD-CAM - CEREC**

- First restorations placed in 1985
- 2D to 3D imaging
- Separation of the imaging and milling units
CEREC SYSTEM
(Sirona Dental System, Germany)

- CEREC is XE-Continuation
- The latest iteration of the CEREC unit was
- demonstrated as a digital impression method
- with a comprehensive (digitization) module
- single-station
- workstation. The current development included
- improved and 3-D range imaging and functionally
- controlled mastication of the restoration.

CEREC 1, 1a, & 2 CAD/CAM RESTORATIONS

- CEREC was first CAD/CAM program in
- restorative dentistry.
- CEREC 1 was introduced in 1985.
- Second generation CEREC system in CEREC 2, was
- Third generation CEREC system in CEREC 3, was
- introduced in 2000.

CERAC 1 & 2 – LONG-TERM CLINICAL DATA

- Conclusion:
  The long-term results (95.5% survival after
  nine years) are excellent, although CEREC 1
  and CEREC 2 did not achieve today’s level of
  clinical precision and quality of the marginal
  integrity (however compensated for using
  macrofilled luting materials).
- Posselt A, Korschbaum T, Longevity of 2328
  chairside CEREC inlays and onlays, Int J
  Comput Dent; 6: 231–248

A CONUNDRUM?

TERIBLE MARGINS

BUT

EXCELLENT, LONG-TERM
CLINICAL RESULTS?

WHY?

Occlusal forces on Proximal
Box

AMALGAM
- CS: 300 –
500 MPa
- FS: 130 –
170 Mpa
- Modulus:
  15 – 55
GPa

COMPOSITE
- CS: 250 –
380 MPa
- FS: 90 –
150 Mpa
- Modulus:
  2 – 12 GPa
CEREC 3D

- The LAVA C.O.S. captures the 3-D surfaces of the teeth directly in the mouth using video capture.
- This data is then used to create SLA resin models from which any restoration can be fabricated.
- Unique features:
  a. Real-time video capture and feedback (3-D-in-motion)
  b. Intuitive touch screen interface
  c. LAVA (Zirconia) copings can be milled in the laboratory direct from the capture data.

CEREC: 3D INFRARED VS AC BLUC CAM

- The LAVA C.O.S. captures the 3-D surfaces of the teeth directly in the mouth using video capture.
- The data is then used to create SLA resin models from which any restoration can be fabricated.
- Unique features:
  a. Real-time video capture and feedback (3-D-in-motion)
  b. Intuitive touch screen interface
  c. LAVA (Zirconia) copings can be milled in the laboratory direct from the capture data.

LAVA C.O.S.

- The LAVA C.O.S. captures the 3-D surfaces of the teeth directly in the mouth using video capture.
- The data is then used to create SLA resin models from which any restoration can be fabricated.
- Unique features:
  a. Real-time video capture and feedback (3-D-in-motion)
  b. Intuitive touch screen interface
  c. LAVA (Zirconia) copings can be milled in the laboratory direct from the capture data.

iTero

- User interface:
  The iTero utilizes a wireless foot pedal during the image capture process to allow the operator to confirm or retake each image. The pre- and post-capture input is done with a wireless mouse and a sealed keyboard.

- What it does:
  The iTero captures the 3-D surfaces of the teeth directly in the mouth using a confocal (laser and optical) image series (usually about 21 images). This data is then used to create CAD/CAM resin models (Figure rt) from which any restoration can be fabricated.

- Features:
  a. True powder-less image capture
  b. Takes user through each of the 21 images
  c. Geller-type (resin) models.

iTero

- User interface:
  The iTero utilizes a wireless foot pedal during the image capture process to allow the operator to confirm or retake each image. The pre- and post-capture input is done with a wireless mouse and a sealed keyboard.

- What it does:
  The iTero captures the 3-D surfaces of the teeth directly in the mouth using a confocal (laser and optical) image series (usually about 21 images). This data is then used to create CAD/CAM resin models (Figure rt) from which any restoration can be fabricated.

- Features:
  a. True powder-less image capture
  b. Takes user through each of the 21 images
  c. Geller-type (resin) models.

E4D System

- Workflow for E4D is similar to CEREC, but there are system differences.
- E4D captures images from 3 separate angles (buccal, lingual, and occlusal) for each tooth using a laser. This reduces any error that might be introduced by automated "patching" (filling in) of areas that are below the height of contour and cannot be picked up from a top-down image alone. However, it does increase the number of images that must be taken.

- The E4D mill can produce all types of indirect restorations (inlays, onlays, crowns, veneers, etc) from a variety of materials (composite, leucite-reinforced and lithium disilicate ceramics).

NYU Marginal Fit Study: E4D vs. Cerec

- NYU Marginal Fit Study: E4D vs. Cerec

Graph showing marginal fit comparison between E4D and Cerec.
Observations & Conclusions of the NYU Marginal Fit Study

- E4D exhibited a reduced and more homogeneous fit based on assessment of fit at buccal, lingual, and center positions. This might be due to software improvement and/or different machining approaches used in the E4D system.
- The CEREC-produced specimens in this study fit least well at the center.
- Studies by the NYU group (Silva NR, de Souza GM, Coelho PG, Stappert CF, Clark KE, Melo FR, Thompson PF. Effect of water storage time and composite cement thickness on the load to initiate a radial crack in a porcelain-ceramic crown. J Biomed Mater Res B Appl Biomater. 2008 Jan;84(1):117-23) suggest that increased cement thickness reduces the load required to initiate a radial crack in this area of the crown, potentially making crowns with less precise fit more vulnerable to fatigue failure.
- The CAD/CAM technology has been considerably improved in the past years. However, marginal accuracy of CAD/CAM restoration is still dependent upon adequate cavity preparation and equipment operation.

Critical Problem for Optical & Conventional Impressions – margins at or below the margin of the gingival sulcus

What's New in Impression Materials?

- Aquasil Ultra Cordless (Dentsply/Caulk)
- Imprint 4 (3M ESPE)

What's New in Impression Materials – Aquasil Ultra Cordless?

The PFM Restoration

- The gold standard for ceramic restorations is clearly porcelain-fused-to-metal (PFM). With PFM, it is reasonable to expect a 10- to 15-year survival rate of 95%, with the incidence of porcelain chipping around 4 to 10%.
- With the use of porcelain facial margins and proper tooth preparations, good to excellent esthetic results can be anticipated.
- PFM restorations have been popular for decades because they provide a combination of reasonable esthetics coupled with maximum longevity.

Winds of Change

- However, recent years have seen dramatic increases in the basic price of gold and other noble metals used with porcelain bonding alloys, which has resulted in a significant increase in laboratory costs.
- This increase in cost, coupled with society's obsession with esthetics, has resulted in increased interest in ceramic restorations.
Ceramic Materials - 2015

- There are four (4) groups of ceramic materials that have a sufficient level of clinical testing and/or anecdotal evidence that clinicians should investigate and consider for use with their patients:
  1. Leucite-reinforced glass-ceramics
  2. Lithium disilicate glass ceramic restorations
  3. Layered zirconia crowns
  4. Monolithic zirconia restorations

Dental Ceramic Classification by Composition

Pressable Ceramics – 2nd Generation

- **Empress 2 now eMax**
  - Material type: Lithium disilicate glass ceramics
  - Strength ~ 350 MPa
  - Toughness ~ 2.0
  - Brand examples: Empress 2 – NOW eMax

- **Advantages:** Highly aesthetic, translucent, slightly stronger
- **Indications:** Single crowns, anterior 3 unit bridges (large 4x5mm connectors)
- **Bonding & conventional cementation**

Press temperature EP 600 [°C]

- 915 to 920

Microstructure – Lithium Silicate Crystals

Zirconia – Framework Restorations

- **Status - 2015**

Clinical Results: eMax Press Crowns

- Meets the “500 Units/5 Years” criteria!

Clinical Results: eMax CAD Crowns

- Encouraging, but doesn’t yet meet the “500 Units/5 Years” criteria

Dental Ceramic Classification by Composition

- Heavy filled glassy ceramics
- Moderately filled glassy ceramics
- Glassy ceramic materials
- Polycrystalline ceramic materials

Pressable Pressable Ceramics – 2nd Generation

- 2nd Generation

Table 1. Properties of IPS e.max Press.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTE (100-400°C)</td>
<td>10.2 x10^-6/K</td>
</tr>
<tr>
<td>CTE (100-500°C)</td>
<td>10.5 x10^-6/K</td>
</tr>
<tr>
<td>Flexible strength</td>
<td>360 MPa</td>
</tr>
<tr>
<td>Fracture toughness</td>
<td>2.25 MPa m^0.5</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>95 GPa</td>
</tr>
<tr>
<td>Vickers hardness</td>
<td>5,800 MPa</td>
</tr>
<tr>
<td>Chemical resistance</td>
<td>40 µg/cm^2</td>
</tr>
<tr>
<td>Press temp. (670°C)</td>
<td>915 to 920°C</td>
</tr>
</tbody>
</table>

Table 2. Properties of IPS e.max CAD.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTE (100-400°C)</td>
<td>10.2 x10^-6/K</td>
</tr>
<tr>
<td>CTE (100-500°C)</td>
<td>10.5 x10^-6/K</td>
</tr>
<tr>
<td>Flexible strength</td>
<td>400 MPa</td>
</tr>
<tr>
<td>Fracture toughness</td>
<td>2.75 MPa m^0.5</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>95 GPa</td>
</tr>
<tr>
<td>Vickers hardness</td>
<td>5,800 MPa</td>
</tr>
<tr>
<td>Chemical solubility</td>
<td>40 µg/cm^2</td>
</tr>
<tr>
<td>Crystallization temp</td>
<td>840 to 850°C</td>
</tr>
</tbody>
</table>

Zirconia – Framework Restorations

- **Status - 2015**

Clinical Results: eMax CAD Crowns

- Encouraging, but doesn’t yet meet the “500 Units/5 Years” criteria

Empress 2 now eMax

- Material type: Lithium disilicate glass ceramics
- Strength ~ 350 MPa
- Toughness ~ 2.0
- Brand examples: Empress 2 – NOW eMax

- **Advantages:** Highly aesthetic, translucent, slightly stronger
- **Indications:** Single crowns, anterior 3 unit bridges (large 4x5mm connectors)
- **Bonding & conventional cementation**

Empress 2 now eMax

- Lithium Disilicate ~ 85%

Table 1. Properties of IPS e.max Press.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTE (100-400°C)</td>
<td>10.2 x10^-6/K</td>
</tr>
<tr>
<td>CTE (100-500°C)</td>
<td>10.5 x10^-6/K</td>
</tr>
<tr>
<td>Flexible strength</td>
<td>360 MPa</td>
</tr>
<tr>
<td>Fracture toughness</td>
<td>2.25 MPa m^0.5</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>95 GPa</td>
</tr>
<tr>
<td>Vickers hardness</td>
<td>5,800 MPa</td>
</tr>
<tr>
<td>Chemical resistance</td>
<td>40 µg/cm^2</td>
</tr>
<tr>
<td>Press temp. (670°C)</td>
<td>915 to 920°C</td>
</tr>
</tbody>
</table>

Table 2. Properties of IPS e.max CAD.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTE (100-400°C)</td>
<td>10.2 x10^-6/K</td>
</tr>
<tr>
<td>CTE (100-500°C)</td>
<td>10.5 x10^-6/K</td>
</tr>
<tr>
<td>Flexible strength</td>
<td>400 MPa</td>
</tr>
<tr>
<td>Fracture toughness</td>
<td>2.75 MPa m^0.5</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>95 GPa</td>
</tr>
<tr>
<td>Vickers hardness</td>
<td>5,800 MPa</td>
</tr>
<tr>
<td>Chemical solubility</td>
<td>40 µg/cm^2</td>
</tr>
<tr>
<td>Crystallization temp</td>
<td>840 to 850°C</td>
</tr>
</tbody>
</table>

Zirconia – Framework Restorations

- **Status - 2015**

Clinical Results: eMax CAD Crowns

- Encouraging, but doesn’t yet meet the “500 Units/5 Years” criteria

Zirconia – Framework Restorations

- **Status - 2015**

Clinical Results: eMax CAD Crowns

- Encouraging, but doesn’t yet meet the “500 Units/5 Years” criteria
Introduction - 2001
• Limited clinical data was available.
• Nevertheless, use of CAM and CAD-CAM was a considerable driving force;
• As was the possibility of a high-strength, metal-free alternative;
• As was laboratory efficiencies in production; including overseas production.

Possible Solutions to the Zirconia Problem?
ALL ZIRCONIA vs Emax
Choices
• Strength vs Durability?
• Esthetics?
• Clinical Data (of any kind)?

Clinical Data on All Zirconia
Limited – But now available
Two Sources
➢ Trac Research (Formerly CRA)
➢ The Dental Advisor

Retrospective Clinical Evaluation: BruxZir Monolithic Zirconia

Clinicians Report – TRAC Research
Drs. Gordon & Rella Christiansen

TRAC Conclusions:
• “BruxZir and e.maxCAD full-contour crowns on molars have demonstrated clinical service superior to all other tooth-colored materials studied clinically by TRAC over 39 years. To date, their service record resembles that of cast metal.”
• “Clinical service over three plus years has begun to answer many critical clinical questions, but important questions remain on possibility of phase change of zirconia in 100% humidity of the oral cavity, glaze use, service life, and failure mode.”
• “Status reports will be forthcoming as answers to these and other pertinent questions emerge through this study.”

CRA Zirconia Study Data & Specific Framework Recommendations

NYU In-Vitro Fatigue Study: Zirconia vs. eMax
**Bruxzir Clinical Video**

https://www.youtube.com/watch?v=f2-sWcSPbhk

**Major Clinical Issue – Zirconia Frames/All - Zirconia**

RETENTION

**Surface Contamination - Zirconia**

- Salivary Phospho-Proteins
- Ivoclean

**A SILENT REVOLUTION??**

<table>
<thead>
<tr>
<th>RESTORATION TYPE</th>
<th>2007</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFM</td>
<td>~72%</td>
<td>~24%</td>
</tr>
<tr>
<td>ALL CERAMIC</td>
<td>~22%</td>
<td>~73% (~50-70% as all zirconia)</td>
</tr>
<tr>
<td>OTHER</td>
<td>~6%</td>
<td>~3%</td>
</tr>
</tbody>
</table>

**Comparative Unit Costs of Metal-based & All Ceramic Crowns**


**Layered Zirconia Crowns**

- One problem with layered zirconia crowns, which has been seen in almost all clinical trials, is the cohesive chipping of the veneering ceramic.
- This chipping, which occurs approximately five times more frequently than with PFM restorations, does not always necessitate replacement of the crown, but it has been a persistent problem.
- Causes of the chipping may be lack of support of the veneering ceramic by the core and the low thermal conductivity of the core material.
- The latter problem may have been resolved by utilization of slower cooling cycles, and the former issue has been resolved with improved software programs to ensure optimum support by the core.


**Update & Key Facts: Zirconia Restorations**

- Monolithic zirconia restorations have only been in use for a few years, so no long-term clinical trials are available.
- Most authorities are optimistic regarding survival rates based on the fact that so few zirconia cores have fractured in clinical trials, and a monolithic or full-contour zirconia crown is essentially an unveneered zirconia core.
- They have very high flexural strength (1200–1400 MPa) and have been used experimentally with large multi-unit restorations.
- Because of these excellent properties, more conservative tooth preparations are possible compared with those used with PFM, lithium disilicate, or layered zirconia crowns.
Update & Key Facts: Zirconia Restorations

• Another advantage of monolithic zirconia crowns is that when polished well, they are very kind to opposing tooth structure, and multiple in vitro studies have shown much less wear of enamel than with other types of ceramic.
• These restorations are relatively opaque, resulting in reduced esthetics compared with layered restorations.
• They are also relatively inexpensive with an average cost of $171.
• The major indication for monolithic zirconia crowns is for posterior teeth where esthetics is not critical, especially for second molars when patients decline cast gold restorations.
• Because zirconia crowns can be fabricated with significantly less tooth reduction, another indication is for crowns on mandibular anterior teeth.

Update & Key Facts: Zirconia Restorations

• Zirconia cannot be etched with hydrofluoric acid because their molecular structure is different from glass ceramics.
• Protocols involving airborne particle abrasion bonding with MDP primers and resin cements have been tested in vitro, but they generally form relatively weak bonds that deteriorate with aging and run the risk of transformation of the entire crown or core as a result of particle abrasion.
• In the opinion of the authors, zirconia crowns are best used with retentive preparations and cemented.

Update & Key Facts: Zirconia Restorations

• It should be noted that the internal surface of zirconia crowns is usually contaminated with saliva and possibly blood during try-in, and has a strong affinity to salivary proteins that are not easily removed. If these are not removed, crowns can be prematurely dislodged.
• The best protocol for cleaning the internal surface is to use a solution of zirconium oxide (zirconia) in sodium hydroxide (Ivoclean, Ivoclar Vivadent) for 20 seconds followed by rinsing with water.

SUMMARY & CONCLUSIONS: ALTERNATIVES TO PFMS

SUMMARY AND CONCLUSIONS

• Clearly PFM is the gold standard for esthetic crowns restorations, but the price of noble metals has driven laboratory costs to unprecedented levels.
• Advances in materials and technology have resulted in the development of four ceramic systems that can be considered as economic alternatives to PFM, which provide good to excellent esthetic results and have demonstrated adequate clinical longevity.
• Layered leucite-reinforced crowns provide excellent esthetic results on maxillary anterior teeth and premolars when etched and bonded in place.

SUMMARY & CONCLUSIONS: ALTERNATIVES TO PFMS

• Monolithic lithium disilicate crowns are indicated for premolars and first molars, whereas layered lithium disilicate crowns can be used with maxillary incisors.
• Layered zirconia cored crowns can be predictably used on anterior teeth and premolars.
• Monolithic zirconia crowns are best used for molars and mandibular anterior teeth.

ULTRA-HIGH DENSITY, PROCESSED THEN MILLED COMPOSITE/CERAMIC INDIRECT MATERIALS

 Advances in Composite Resin Technology
Steven R. Jefferies, MS, DDS, PhD

New Composite Developments
-NEW MONOMERS
-NANOTECHNOLOGY (NANOFILLERS)
**History**
- 1962 – Bis-GMA
  - stronger resin
- 1969 – filled composite resin
  - improved mechanical properties
  - less shrinkage
  - paste/paste system
- 1970’s – acid etching and microfills
- 1980’s – light curing and hybrids
- 1990’s – flowables and packables
- 2000’s – nanofills
- 2010’s – New monomers, low shrinkage

**Composition**
- Resin matrix
  - monomer
  - initiator
  - inhibitors
  - pigments
  - Inorganic filler
    - glass
    - quartz
    - colloidal silica
  - Coupling Agent

**Nanofill vs. Nanohybrid**
- Nanofills
  - nanometer-sized particles throughout matrix
- Nanohybrids
  - nanometer-sized particles combined with more conventional filler technology

**Nanofilled Composite**
- Filtek Supreme (3M ESPE)
  - Filler particles
    - filled: 78% wgt
    - nanomers: 0.02 – 0.07 microns
    - nanocluster
    - act as single unit
      - 0.6 – 1.4 microns

**CURRENT “NANO” COMPOSITES**

**Filter Improvements in Filtek Supreme Ultra Universal Restorative**

**Comparative Retention of Polish**
MICROSTRUCTURAL CHARACTERIZATION: FILTEK SUPREME VS. Z-250

- Fracture toughness, Flexural Modulus, Weibull Modulus, Characteristic Strength, and Critical Crack Strength – Very Similar.

OTHER IN-VITRO DATA: NANOCLUSTER REINFORCEMENT?

- Curing (nearly) without shrinkage.
- Bonding to enamel and dentin.
- Materials: Tetric Ceram, Ivoclar, NaFi.
- Conclusions: At the 3-year mark, no statistical difference in volume wear between the materials, but nanofill was lower.
- No statistical difference in volume wear between the materials, but nanofill was lower. 36.60 Month steady state vertical wear was lower for the nanofil (0.363 vs 0.486 microns per month).

CLINICAL DATA: NANOFILL VS. MICRO-HYBRID COMPOSITE

- Clinical data on performance of nanohybrid resins vs microhybrid resins in posterior teeth.
- Wear performance: No statistical difference in volume wear between the materials, but nanofill was lower.
- No statistical difference in volume wear between the materials, but nanofill was lower. 36.60 Month steady state vertical wear was lower for the nanofil (0.363 vs 0.486 microns per month).

CLINICAL DATA: NANOHYBRID VS. FINE PARTICLE HYBRID

- No difference in clinical performance between nanohybrid and fine hybrid.
- Success rate was 100% for both materials and no subject dropouts.

CLINICAL DATA: NANOFILL COMPOSITE – ANTERIOR TEETH

- Three year clinical examination of Nanofill and Z250.
- Conclusions: At the 3-year mark.
- 1) Surface wear, material removal from enamel.
- 2) No statistical difference.
- 3) Fracture toughness.
- 4) Flexural strength.
- 5) Weibull modulus.
- 6) Critical crack strength.
- 7) Clinical performance.
- 8) Good clinical evidence.

CLINICAL DATA: NANOFILLER COMPOSITE – CAD/CAM

- No statistical difference in volume wear between the materials, but nanofill was lower.
- 36.60 Month steady state vertical wear was lower for the nanofil (0.363 vs 0.486 microns per month).

CLINICAL DATA: NANOFILL VS. MICRO-HYBRID COMPOSITE

- Clinical data on performance of nanohybrid resins vs microhybrid resins in posterior teeth.
- Wear performance: No statistical difference in volume wear between the materials, but nanofill was lower.
- No statistical difference in volume wear between the materials, but nanofill was lower. 36.60 Month steady state vertical wear was lower for the nanofil (0.363 vs 0.486 microns per month).

CLINICAL DATA: NANOHYBRID VS. FINE PARTICLE HYBRID

- No difference in clinical performance between nanohybrid and fine hybrid.
- Success rate was 100% for both materials and no subject dropouts.

CLINICAL DATA: NANOFILL COMPOSITE – ANTERIOR TEETH

- Three year clinical examination of Nanofill and Z250.
- Conclusions: At the 3-year mark.
- 1) Surface wear, material removal from enamel.
- 2) No statistical difference.
- 3) Fracture toughness.
- 4) Flexural strength.
- 5) Weibull modulus.
- 6) Critical crack strength.
- 7) Clinical performance.
- 8) Good clinical evidence.
Increasing the size and molecular weight of monomers reduces overall shrinkage.

**“BULK FILL” RESTORATIVE COMPOSITE RESINS**

**DEFINITION - 2015:**
Light-cured composite resin materials for direct restoration of posterior teeth, which can be placed and cured in bulk increments of 4 – 5 mm thickness.

**BULK FILL Materials**

Advantages of “New Class” of materials:
- Saves Time?
- Easier?
- Better adaptation to tooth?
- Reduce chance for air entrapment
- Better conformity to cavity walls
- Better marginal integrity
- Less shrinkage stress?
- Greater Depth of Cure?
- 4-5 mm

**Why do we need bulk fill?**

- Why incremental filling?
  - Limited depth of cure
- Reduce shrinkage stress

**PRIMARY MODES OF FAILURE OF POSTERIOR COMPOSITES**

- SECONDARY CARIES
- RESTORATION FRACTURE

**OTHER FACTORS CONTRIBUTING TO FAILURE**

- MARGINAL BREAKDOWN
- RESTORATION WEAR
- INADEQUATE POLYMERIZATION
- PULPAL DEATH
- TOOTH FRACTURE

**National Institute for Dental and Craniofacial Research**

“...Studies have shown that dental resin composites have an average replacement time of 5.7 years due to secondary decay and fracture of the restoration.”

**Why incremental filling?**

- Limited depth of cure
- Reduce shrinkage stress
BULK FILL Materials

- Inadequate physical properties
- Reduced bond strengths
- Increased breakdown at margins with use
- Decreased biocompatibility
- Potentially increased DNA damage due to leachates
- Increased bacterial colonization of resin

BULK FILL Materials
They are NOT all the same!
- Increment thickness - 4mm, 5mm
- Single increment use vs. “capping layer”
- Sculptable (paste-like) or flowable (syringe)

BULK FILL Materials
Questions / Concerns
- Depth of cure [degree of conversion]
- Adaptation – microleakage
- Strength
- Mechanical properties
- Wear
- Contraction force and rate
- Handling
- Durability – clinical performance over time

Thermal Manipulation of Composite Resin
- VISTA DENTAL
- Thermo-Flo Composite Warming Kit
- Benefits of HEAT:
  - Increased flowability
  - Improved polymerization
  - Reduced voids
  - Reduced curing time

Sonic Delivery of Composite
Kerr Dental (Danaher)

So Where Did the Idea Come From

SONICFILL – TECHNICAL DATA
According to the Kerr Product Manager

- Better color matching
- Better esthetics

Local and Generalized Simulated Wear of Resin Composites
Operative Dentistry, 2015, 40(3), 322-335
WK Barkmeier, TM Takamizawa, RL Erickson, A Tsujimoto, ML Latta, MM Miyazaki

Clinical Relevance
Wear is an important property to consider in resin composite materials.

Are there other options for bulk-fill restorations???
- Glass ionomers?? Maybe— in selected situations?

ANOTHER CONCEPT IN BULK FILL RESTORATIVES: EQUIA
Self-Adhesive, Aesthetic Posterior Restorative
Clinical Case: Clinical images courtesy of Dr. Lassocinski & GC Dental

EQUIA PHYSICAL PROPERTIES
“Bulk fill, Self-adhesive, Rapid Restorative System”

GC’s New Product Description for Equia
**CONCLUSIONS:** Within the limitations of this study it can be concluded that EQUIA can be used as a permanent restoration material for any sized Class I and in smaller Class II cavities. However, results of ongoing prospective studies shall provide a more exact indication definition in Class II situations.

**SIGNIFICANCE:** Modern glass ionomer systems may not only serve as long-term temporaries, but also as permanent restorations in posterior teeth.

**What about interproximal contacts?**


**Objective:** The aim of this study was to evaluate the clinical performance of a glass ionomer restoration system compared with a microfilled hybrid composite in a four-year randomized clinical trial.

**Methods:** A total of 140 (80 Class 1 and 60 Class 2) lesions in 59 patients were restored with a glass ionomer restorative system (Equia, GC, Tokyo, Japan), which was a combination of a packable glass ionomer (Equia Fil, GC) and a self-adhesive nanofilled coating (Equia Coat, GC), or with a microfilled hybrid composite (Gradia Direct Posterior, GC) in combination with a self-etch adhesive (G-Bond, GC). Two independent examiners evaluated the restorations at baseline and at one, two, three, and four years postrestoration according to the modified US Public Health Service criteria.

**Results & Conclusions:** The use of both materials for the restoration of posterior teeth exhibited a similar and clinically successful performance after four years.
AFTER ALL THESE YEARS – TONS OF RESEARCH: WHY IS THE PERFORMANCE OF ADHESIVE RESIN MATERIALS IN QUESTION?

- Pulpal Biocompatibility? Pressure? Especially in areas with low remaining dentin thickness (RDT)?
- Stability of the “Hybrid Zone”?
- Absence of real bioactivity (ability to actively remineralize) biologically integrates with adjacent hard tissue?
- Different amounts of pathogenic bacteria underneath composite resin vs. amalgam? Ref. 2003, Quaint Int.
- Enzymatic Degradation of composite resins?

CURRENTLY AVAILABLE GENERATIONS

- Fourth Generation
  - Three-step Etch & rinse
- Fifth Generation
  - Two-step Etch & rinse
- Sixth Generation
  - Two-step Self-etch
  - One-step Self-etch
- Seventh Generation
  - One-step Self-etch
  - NS Plus

Currently Available Generations

- Three-step Etch & rinse
- Two-step Etch & rinse

CLASSIFICATION OF NEWER SYSTEMS

- Interaction with tooth surface
- Number of clinical application steps
  1) Etch & rinse (i.e., total-etch)
  2) Self-etch
  3) Resin-modified glass ionomer

Example:

- Optibond FL
- Scotchbond Multi-Purpose

ETCH & RINSE (THREE-STEP)

- Conditioner
- Primer
- Adhesive resin

Examples
- Scotchbond Multi-Purpose
- Optibond FL

PRIME & BOND NT – MODIFIED CLINICAL APPLICATION TECHNIQUE CAN IMPROVE BOND STRENGTH & CLINICAL PERFORMANCE

- 15 – 20 second enamel etch, 6-7 second dentin etch.
- Wet or Air Dry Dentin is Optional, Dry Dentin, Problematic (setures).
- Apply capillary amounts, let the products soak into the dentin, then “light” air dry.
- Cure for 20 seconds. Then repeat for a second coat and second cure.

Adhesive Categories

- Etch & Rinse
  - Three-Step
- Self-Etch
  - Two-Step

Examples
- Conditioner & primer, adhesive
- One-Step
- Conditioner & primer & adhesive
- Glass ionomer
  - Two-Step
  - Conditioner, resin-modified glass ionomer matrix

AN EMERGING CONCERN: BIOFILM-BACTERIAL CHALLENGE: SPECIFIC TO RESIN-BASED MATERIALS?

- “The enzymes in saliva degrade dental composites and may enhance tooth decay. Although much attention has been given to bacterial, chemical, and mechanical degradation of dental composites.”

Examples
- Eurocom, 2003
- “Tooth decay is the result of a series of reactions in the presence of bacteria, acid, and saliva.”

IS THE ORAL ENVIRONMENT EXCESSIVELY “CORROSIVE” TO RESINS & ADHESIVES?

Van Meerbeek, Oper Dent 2003

- Interaction with tooth surface
- Number of clinical application steps
- 1) Etch & rinse (i.e., total-etch)
- 2) Self-etch
- 3) Resin-modified glass ionomer
Questions About The Adhesive Resin Interface?

**Stability of the "Hybrid Zone"**


**Enzymatic Degradation**


NANOLEAKAGE BELOW & WITHIN THE HYBRID ZONE

- BUT THERE ARE OTHER THREATS TO MARGINAL STABILITY!
- Growing Evidence of the Role of Enzymatic Degradation?

PLUS – OTHER DEGRADATIVE ENZYMES FROM MULTIPLE SPECIES OF BACTERIA
PLUS – ACID DETERIORATION AT LOW pH

NANOLEAKAGE BELOW & WITHIN THE HYBRID ZONE NOW IS RECURRENT CARIES (I.E. – A GINGIVAL WALL LESION)

ANOTHER MAJOR CHALLENGE

- COMPOSITE RESINS MAY BE MORE PRONE TO BACTERIAL CHALLENGE /ENZYMATIC DEGRADATION.
- DENTIN BONDING IS STILL PROBLEMATIC.
- ANTIMICROBIAL RESINS AND COMPOSITES MIGHT BE USEFUL TO RESIST SECONDARY/RECURRENT CARIES.

Clearfil Protect Bond

**MDBP**
- ANTIMICROBIAL MONOMER

TOTAL ETCH/SELF ETCH?

- WHAT'S THE DIFFERENCE?
- TWO BOTTLE VS ONE BOTTLE?
- ADDED “SELECTIVE” ETCH FOR ENAMEL

Self-Etch Components

- Acidic monomers
- Crosslinking monomers
- Solvent
- usually water based

NEW “UNIVERSAL” ADHESIVES

- ONE BOTTLE
- SELECTIVE ETCH;
- TOTAL ETCH
- SELF ETCH
- IS IT POSSIBLE???

NEW UNIVERSAL ADHESIVES

- SCOTCHBOND UNIVERSAL
- XP BOND – NOW PRIME & BOND XP
- PRIME & BOND ELECT
What Do These Three Adhesives Share in Common That May Enhance Their Performance?

- OPTIBOND FL
- XP BOND – NOW PRIME & BOND XP
- SCOTCHBOND UNIVERSAL

They have combination adhesion promoters!

Scotchbond Universal

- Phosphate – MDP
- Carboxylic Acid – Vitrebond Co-polymer

XP Bond

- Phosphate – PENTA
- Carboxylic Acid - TCB

What Do These Three Adhesives Share in Common That May Enhance Their Performance?

- OPTIBOND FL
- XP BOND – NOW PRIME & BOND XP
- SCOTCHBOND UNIVERSAL

They have combination adhesion promoters!

Scotchbond Universal

- Phosphate – MDP
- Carboxylic Acid – Vitrebond Co-polymer

XP Bond

- Phosphate – PENTA
- Carboxylic Acid - TCB

Batalha-Silva, et al.

- "CAD/CAM MZ100 inlays increased the accelerated fatigue resistance and decreased the crack propensity of large MOD restorations when compared to direct restorations."
- "While both restorative techniques yielded excellent fatigue results at physiological masticatory loads, CAD/CAM inlays seem more indicated for high-load patients."

So, What Do We Do About the Gingival Wall Area in Tooth Colored Restorations???

- Preparation & Case Selection: Available Enamel & Caries Risk
- Adhesive Technique: Self-Etch w/ Enamel Bond, or Selective Dentin Etch ("Back to the Future")
- Control of Axial Wall Length/Depth
- Open Sandwich: But With What Material???
- Indirect Ceramic or Lab-Processed Composite: Maybe But Time & Expensive??
- Other Options?? Stiffer, Higher Modulus CR

Batalha-Silva, et al.

- "CAD/CAM MZ100 inlays increased the accelerated fatigue resistance and decreased the crack propensity of large MOD restorations when compared to direct restorations."
- "While both restorative techniques yielded excellent fatigue results at physiological masticatory loads, CAD/CAM inlays seem more indicated for high-load patients."

So, What Do We Do About the Gingival Wall Area in Tooth Colored Restorations???

- Preparation & Case Selection: Available Enamel & Caries Risk
- Adhesive Technique: Self-Etch w/ Enamel Bond, or Selective Dentin Etch ("Back to the Future")
- Control of Axial Wall Length/Depth
- Open Sandwich: But With What Material???
- Indirect Ceramic or Lab-Processed Composite: Maybe But Time & Expensive??
- Other Options?? Stiffer, Higher Modulus CR

Occlusal forces on Proximal Box

<table>
<thead>
<tr>
<th>AMALGAM</th>
<th>COMPOSITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS: 300 – 500 MPa</td>
<td>CS: 200 – 380 MPa</td>
</tr>
<tr>
<td>FS: 130 – 170 Mpa</td>
<td>FS: 90 – 150 Mpa</td>
</tr>
<tr>
<td>Modulus: 15 – 55 GPa</td>
<td>Modulus: 2 – 12 GPa</td>
</tr>
</tbody>
</table>

MORE EVIDENCE – WHY MODULUS MATTERS!

"Fatigue resistance and crack propensity of large MOD composite resin restorations: direct versus CAD/CAM inlays."

Batalha-Silva S, de Andrade MA, Maia HP, Magne P.

But is it really all about adhesives and adhesion to tooth structure??

- Or are there other factors??

Batalha-Silva, et al.

- "CAD/CAM MZ100 inlays increased the accelerated fatigue resistance and decreased the crack propensity of large MOD restorations when compared to direct restorations."
- "While both restorative techniques yielded excellent fatigue results at physiological masticatory loads, CAD/CAM inlays seem more indicated for high-load patients."

So, What Do We Do About the Gingival Wall Area in Tooth Colored Restorations???

- Preparation & Case Selection: Available Enamel & Caries Risk
- Adhesive Technique: Self-Etch w/ Enamel Bond, or Selective Dentin Etch ("Back to the Future")
- Control of Axial Wall Length/Depth
- Open Sandwich: But With What Material???
- Indirect Ceramic or Lab-Processed Composite: Maybe But Time & Expensive??
- Other Options?? Stiffer, Higher Modulus CR

Batalha-Silva, et al.

- "CAD/CAM MZ100 inlays increased the accelerated fatigue resistance and decreased the crack propensity of large MOD restorations when compared to direct restorations."
- "While both restorative techniques yielded excellent fatigue results at physiological masticatory loads, CAD/CAM inlays seem more indicated for high-load patients."

So, What Do We Do About the Gingival Wall Area in Tooth Colored Restorations???

- Preparation & Case Selection: Available Enamel & Caries Risk
- Adhesive Technique: Self-Etch w/ Enamel Bond, or Selective Dentin Etch ("Back to the Future")
- Control of Axial Wall Length/Depth
- Open Sandwich: But With What Material???
- Indirect Ceramic or Lab-Processed Composite: Maybe But Time & Expensive??
- Other Options?? Stiffer, Higher Modulus CR

More evidence – why modulus matters!

"Fatigue resistance and crack propensity of large MOD composite resin restorations: direct versus CAD/CAM inlays."

Batalha-Silva S, de Andrade MA, Maia HP, Magne P.
Closed vs Open Sandwich

Do we know if an open sandwich technique works clinically?
- Clinical Research of Professor Jan van Dijken:
- Moderate to Long-term Clinical Studies with:
  1) Glass ionomer
  2) Resin-modified Glass ionomer
  3) Compomer – Polyacid Modified Composite Resin

WHAT ABOUT SLOT PREPS?
WHAT'S THE EVIDENCE?
DOES IT WORK WITH LONGEVITY?

SOME IMPORTANT ANCILLARY PRODUCTS IN ADHESIVE DENTISTRY!! WHY THEY ARE IMPORTANT
PREVENTING DENTIN & ADHESIVE BOND DEGRADATION
MINIMIZING TOOTH SENSITIVITY

Chlorhexidine & Gluma
Consepsis® - 2.0% chlorhexidine gluconate solution used to clean/disinfect before bonding (a disinfectant)
Gluma® - 5% Glutaraldehyde, 35% HEMA, 60% Water (a collagen crosslinking agent)

Major Functions: Antimicrobial Activity & Inhibition of Metalloproteinases
- Reduces risk for recurrent caries?
- Reduces potential for post operative sensitivity caused by residual bacteria?
- Slightly higher bond strengths with many dentin bonding agents?
- Lower risk of bond strength compromise (Chlorhexidine hand soaps can adversely affect bond strength. Consepsis contains no surfactants or emollients that interfere with bond strength.)

ALDEHYDES & “CHX”

Final Thoughts – Adhesives/Dentin Bonding
- CHEMICALLY STABILIZING DENTIN WITH CROSSLINKING AGENTS (ALDEHYDES), ENZYME INHIBITORS, ANTIMICROBIALS;
- USE AN ADHESIVE THAT COMBINES A PHOSPHATE AND CARBOXYLIC ACID MONOMER;
- USE OF SELECTIVE ETCH OR “LIMITED” TOTAL ETCH MAY BE THE PREFERRED TECHNIQUE.

ALTERNATIVE METHODS TO FORM A BOND TO TOOTH STRUCTURE?
INTEGRATION TO TOOTH STRUCTURE WITHOUT USE OF ADHESIVE MONOMERS
NECESSITY? FEASIBILITY? BENEFIT?
Reducing New Bioactive – “Interactive” Materials to Practice

- New variations on the “classical” theme of the acid-base reaction cement may yield "unanticipated" benefits.
- Interactive materials, which are structurally more "analogous" to native mineralized tissue, may present new opportunities for restorative and prosthetic treatment in dentistry.

Examples of Ceramic Biomaterials

- **Traditional Ceramics**: Dental Porcelain, Leucite
- **Special Ceramics**: Al-, Zr-, and Ti-Oxides
- **Glass Ceramics**: Apatite-Melaminates
- **Chemically Bonded Ceramics**: Glass Ionomers

Compositions of Portland & calcium aluminates cements

CURRENTLY AVAILABLE BIOACTIVE MATERIALS

Calcium-Based, Bioactive Cements: The Potential

- Bioactivity via apatite formation at the cavity interface leading to true microstructural integration with the tooth substrate
- If above property is proven, potential to eliminate need for adhesive bonding agents.

Mineral Trioxide Aggregate (MTA) Composition

- Calcium Oxide
- Silicate Oxide
- Tricalcium Silicate
- Tricalcium Aluminate
- Bismuth Oxide

Torabinejad M, Hong CU, McDonald F and Pitt Ford TR. J Endod 1995; 21(7): 349-53

WHAT MAKES THESE CALCIUM-CONTAINING MATERIALS UNIQUE?

BIOACTIVITY
Bioactivity materials, when immersed in physiologic phosphate buffered saline solution, form calcium phosphate and hydroxyapatite. In-vivo, interaction with tooth structure is manifested through the precipitation of nanocrystals (<0.2 microns/200 nanometers) at the interface of the prepared tooth resulting in mechanical interlocking, and surface energy-based attachment of the hydrated cement nanocrystals with the tooth structure.

**Bioactivity:** Hydroxyapatite crystals on the cement surface

Ceramir® Crown & Bridge

- **Ceramir® C&B** is a material that combines class ionomer technology with Calcium Aluminate Chemistry.
- **The GI contributes to:**
  - Low initial pH, short duration
  - Flow and setting characteristics
  - Early strength
- **The CA contributes to:**
  - Increased strength and retention
  - Biocompatibility
  - Sealing of tooth material interface
  - Apatite formation
  - Sustained long term properties, no degradation
  - Basic end pH

**Micro CT Analysis – Surface Apatite Layer**

**Nano structural integration?**
- **Inherent properties of Bioactive Reactions**
  - Crystallites precipitate from solution, wetting and penetrating tooth surface;
  - As nano-sized crystallites and the gibbsite gel precipitates on the tooth interface and within the cement matrix, the cement integrates within the dentin and enamel matrix;
  - The material is constituted of nano-sized katoite crystals in a gibbsite gel matrix bonded together by means of surface energy and mechanical interlocking.

**Intended Use**
- **Ceramir® Crown & Bridge** is intended for permanent cementation of:
  - Porcelain Fused to Metal Crowns and Bridges
  - Metal (gold etc.) crowns and bridges
  - Gold inlays and onlays
  - Cast or prefabricated metal posts
  - Strengthened core Al-Zirconia, Al-Alumina, and Vitallium Distalloy (eMax) ceramic crowns and bridges

**Test program**
- The material is tested according to:
  - ISO 9917:2007, both internal and external tests, NIO Norway
  - FDA guidelines
  - Biocompatibility testing ISO 7405
  - External testing at Temple University, Prof Steven Jeffries
  - External testing with Prof C. H. Pameijer
  - Additional internal tests

**Integration vs Adhesion**
- A "seamless" interface, which could reseal itself over time – less risk of secondary caries?
- Basic pH (biocompatibility), chemical stability, and no shrinkage (unlike resin-based materials) gives a stable interface

**Intended Use**
- **Ceramir® Crown & Bridge** is intended for permanent cementation of:
  - Porcelain Fused to Metal Crowns and Bridges
  - Metal (gold etc.) crowns and bridges
  - Gold inlays and onlays
  - Cast or prefabricated metal posts
  - Strengthened core Al-Zirconia, Al-Alumina, and Vitallium Distalloy (eMax) ceramic crowns and bridges

**Test program**
- The material is tested according to:
  - ISO 9917:2007, both internal and external tests, NIO Norway
  - FDA guidelines
  - Biocompatibility testing ISO 7405
  - External testing at Temple University, Prof Steven Jeffries
  - External testing with Prof C. H. Pameijer
  - Additional internal tests

**Net setting time, compressive strength, and film thickness all conform to the International Standards Organization (ISO) values for water-based luting agents.**
CERAMIR MAY FILL A CRITICAL NEED FOR ALL-CERAMIC CROWNS/BRIDGES

BOND STRENGTH LEVELS TO ALUMINIA AND ZIRCONIA SUGGEST:
A POSSIBLE UNIQUE & NEW BONDING MECHANISM FOR CERTAIN BIOACTIVE, CHEMICALLY-BONDED CERAMIC CEMENTS (LIKE CERAMIR) TO HIGH-STRENGTH, POLYCRYSTALLINE SINTERED CERAMICS

Crown Retention Vs. Type of Cement
(all values in Kgs tensile force to displacement, using gold crown copings)
- Polycarboxylate: ~ 9 Kgs
- Zinc Phosphate: ~14 Kgs
- Glass Ionomer: ~24 Kgs
- RMGI: ~25 – 45 Kgs
- Resin Cement(w/DBA): ~30 – 60 Kgs
- Self Adhesive RC: ~16 – 45 Kgs
- ZOE or Non-ZOE Temp Cements: ~9 – ~9 Kgs

Clinical study
- The study is performed at Temple University Philadelphia by Prof Steven. R. Jefferies
- A total of 38 crowns and bridges were cemented in 17 patients of which 31 were on vital and 7 on non-vital teeth. There were 6 bridges cemented in the study, consisting of 13 prepared abutments (12 vital/1 non-vital).
- The clinical handling was part of the evaluation
- The study was made with a hand mixed version of the cement

Crown Retention
- Tests conducted by Professors Pameijer & Jefferies
- Gold or Zirconia crowns , 3mm prop height with 32 degree taper.

Clinical study
- Results of the clinical handling

<table>
<thead>
<tr>
<th>Cement Type</th>
<th>Mixing</th>
<th>Setting time</th>
<th>Working time</th>
<th>Complete Seating</th>
<th>Base of cement removed</th>
<th>Marginal Integrity</th>
<th>Marginal Discoloration</th>
<th>Sensitivity (Patient Perception)</th>
<th>Sensitivity (Categorical - Visual Analogue Scale (VAS))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emax Crown</td>
<td>Easy</td>
<td>2 minutes</td>
<td>4 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Yes</td>
<td>Not Tested</td>
<td>24.2 ± 3.8</td>
<td>24.2 ± 3.8</td>
</tr>
<tr>
<td>Zirkonia</td>
<td>Very easy</td>
<td>4 minutes</td>
<td>6 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Yes</td>
<td>Not Tested</td>
<td>26.6 ± 2.9</td>
<td>26.6 ± 2.9</td>
</tr>
<tr>
<td>Alumina</td>
<td>Easy</td>
<td>2 minutes</td>
<td>4 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Yes</td>
<td>Not Tested</td>
<td>11.3 ± 0.9</td>
<td>11.3 ± 0.9</td>
</tr>
<tr>
<td>Gold alloy</td>
<td>Easy</td>
<td>2 minutes</td>
<td>4 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>No</td>
<td>Not Tested</td>
<td>10.2 ± 0.8</td>
<td>10.2 ± 0.8</td>
</tr>
<tr>
<td>Resin Cement (w/DBA)</td>
<td>Easy</td>
<td>2 minutes</td>
<td>4 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Yes</td>
<td>Not Tested</td>
<td>22.3 ± 1.6</td>
<td>22.3 ± 1.6</td>
</tr>
<tr>
<td>Self Adhesive RC</td>
<td>Easy</td>
<td>2 minutes</td>
<td>4 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Yes</td>
<td>Not Tested</td>
<td>37.8 ± 4.3</td>
<td>37.8 ± 4.3</td>
</tr>
<tr>
<td>ZOE or Non-ZOE Temp Cements</td>
<td>Easy</td>
<td>2 minutes</td>
<td>4 minutes</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Yes</td>
<td>Not Tested</td>
<td>4.4 ± 1.0</td>
<td>4.4 ± 1.0</td>
</tr>
</tbody>
</table>

Measurement Parameters for Clinical Study

<table>
<thead>
<tr>
<th>CEMENT MEASUREMENT DATA</th>
<th>CLINICAL MEASUREMENT DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispensing</td>
<td>Sensitivity (Patient Perception)</td>
</tr>
<tr>
<td>Mixing</td>
<td>Retention</td>
</tr>
<tr>
<td>Working Time</td>
<td>Marginal Integrity</td>
</tr>
<tr>
<td>Complete Seating</td>
<td>Marginal Discoloration</td>
</tr>
<tr>
<td>Advance Tacte</td>
<td>Visual Analogue Scale (VAS) - Sensitivity</td>
</tr>
<tr>
<td>Ease of Cement Removal</td>
<td></td>
</tr>
</tbody>
</table>

Cement Removal & Clean-up

Clean-up and removal of Ceramir was deemed to be very easy. The cement reached a “crispy” state at the end of work-time at the marginal areas of the restorations, which facilitated easy and straightforward excess cement removal.
Porcelain Fused to Metal (PFM) Crowns

Clinical digital photograph of maxillary anterior, ceramic-metal restorations (right and left lateral and central incisors) cemented with Ceramir® at one year clinical evaluation.

CEMENTATION OF LITHIUM DISILICATE ALL-CERAMIC CROWN

Clinical study

Results

Clinical parameters followed in the study were:

- Sensitivity (Categorical)
- Retention
- Soft Tissue Reaction
- Marginal Integrity
- Marginal Discoloration
- Caries
- Visual Analogue Scale (VAS) - Sensitivity
- Gingival Inflammation Index (GI)

Results of cement performance up to three years recall have been excellent and quite clinically acceptable.

Summary Data & Conclusions from a field trial

1. Easy to use.
2. Robust seating procedure.
3. Low viscosity – easy seating.
4. Easy to clean up.

EVERYDAY ISSUES
What constitutes good handling in a luting cement?

SO WHAT DOES BIOACTIVITY DO FOR ME CLINICALLY??

UNIQUE PULPAL BIOCOMPATIBILITY & CAPACITY FOR REGENERATION

OK WHAT ELSE – ESPECIALLY FOR THE RESTORATIVE DENTIST??

DISCLOSURE

In the interest of full disclosure, this research was supported, in part, by Doxa Dental AB

Physical & Clinical Properties of an Experimental Bioactive Luting Cement

Physical & Clinical Properties of an Experimental Bioactive Luting Cement

Acknowledgments

David C. Appleby, DMD, MScD, FACP
Colin Galbraith, BS (MIT)
Daniel W. Boston, DMD
Cornells H. Pameijer, DMD, DSc, PhD
University of Connecticut School of Dentistry
Jesper Lööf, M.Sc.E, PhD
Doxa Dental AB

WHAT ARE THE NEW PARADIGMS?

- Bioactive vs. Inert
- Molecular Integration vs. "Physical – Chemical" Adhesion
- Nanomolecular Structure vs. Traditional, "Filler-Matrix" Composite Structure