Bioactive Direct Restorative Materials

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CATAPULT EDUCATION

Accredited Fellow, American Academy of Cosmetic Dentistry
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Member of The American Society For Dental Aesthetics
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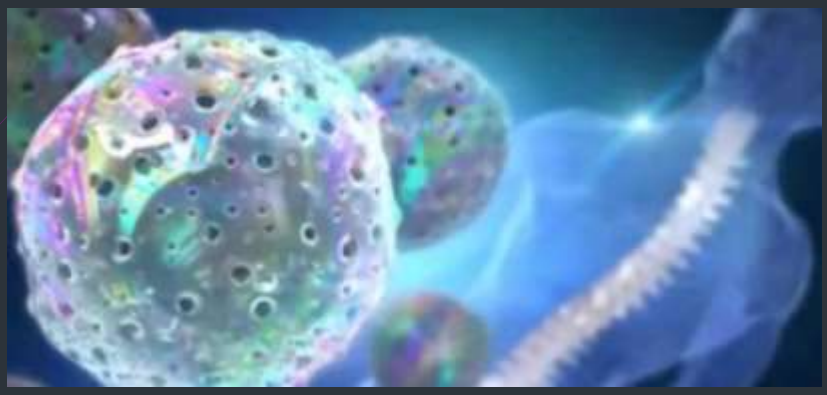


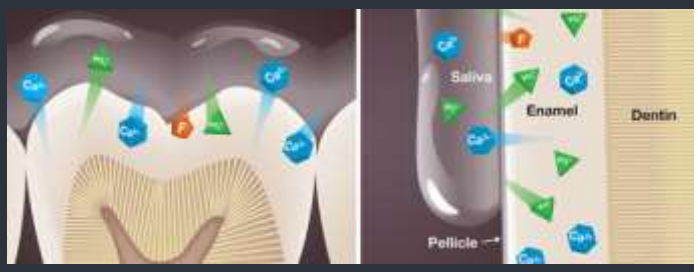
What are Bioactive Restorative Materials?

Fluoride release and the conversion of hydroxyapatite to its stronger form, fluorapatite.

Original Concept of Bioactivity

What are Bioactive Restorative Materials?

- Bioactive dental materials release compounds that help regenerate or maintain dental structures. In the past fluoride release was the only mineral that was in bioactive materials. Today we have materials that also release calcium and phosphate ions. Dentists use bioactive materials to remineralize dentin, repair bony defect, and maintain dental prosthetic margins. Bioactivity also includes the precipitation of apatite crystals on the surface of the material in the presence of moisture (saliva).



What types are currently available?

What types are currently available?

- *Bases & Liners*
- *Cements*
- *Restorative Filling Materials*

Why do dentists use bioactive materials?

Remineralization of dentin, repair of bony defects, and maintenance of dental prosthetic margins.

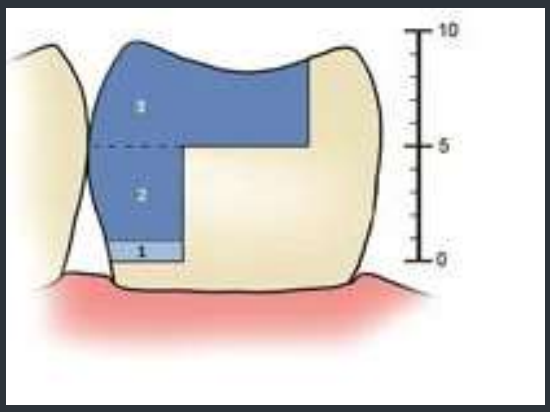
Material Composition

Classifications

- Primarily we have calcium silicates and calcium aluminates but the bioactive dental materials often contain some mixture of both. This only refers to the calcium releasing bioactive materials not the fluoride only materials.
- Calcium silicate materials similar to MTA (Portland cement)
- Calcium silicate with phosphate and without aluminum
- The calcium silicates with mostly tricalcium silicate
- Calcium aluminate
- Calcium aluminate and glass ionomer

Bioactive Liners

- Activa
- Biodentine
- CaOH Dycal
- TherCal LC
- Limelite
- MTA



Large sized Lesions (>2MM)

- Mostly dentin
- Dentin has more moisture and less substan
- Open and Closed defects
- Complications & Risks are higher
- Porous, Wet, Dentin Available
- Interproximal concerns
- Increased Occlusal Loading
- Remaining Tooth Structure

Pulpal Proximity

What are their advantages?

- Calcium Phosphate and Fluoride
- Easy to place
- Create a Reaction in the tooth.

Base/Liners

TheraCal™ LC

Resin-Modified Calcium Silicate Pulp Protectant/Liner

Seals & Protects the Pulp:

- For Direct & Indirect Pulp Capping
- Light-curable, Radiopaque Liner
- Significant Calcium Release:
  - Stimulates Hydroxyapatite & Dentin Bridge Formation.

Base/Liners

TheraCal™ LC

ACTIVA BioACTIVE-BASE/LINER (Pulpdent)

- Does not require a bonding agent
- Releases Calcium & Phosphate
- Resin component allows it to bond to other resin based materials

- **MTA mineral trioxide aggregate**
- MTA was the bioactive dental material that jump-started the interest in the field. It consists of Portland cement 75%, bismuth oxide 20%, and gypsum 5% and trace amounts of silicon dioxide, calcium oxide, magnesium oxide, potassium sulfate, and sodium sulfate. Portland cement is tricalcium aluminate, dicalcium silicate, tricalcium silicate, and tetracalcium aluminoferrite. The removal of tetracalcium aluminoferrite removes the gray color and creates White MTA.

Biodentine Septodont

- Tricalcium silicate material, which can be used as a bioactive build-up material where large areas of tooth structure are missing
- Used to treat pulp exposures
- Root perforations
- Sets in 10-12 minutes

Bioactive Cements

- Theracem
- Activa Bioactive
- Ceramir
- Biocem Universal

TheraCem by Bisco

- A self cure material made of tricalcium silicate cement and resins. It's all the similar resins as composite but also has polyethylene glycoldimethacrylate that allows mixing of resins and tricalcium.

Ceramir by Doxa

- Ceramir is a hybrid material consisting of calcium aluminate and glass-ionomer components.
- Ceramir does test higher than other cements for antibacterial properties.

Unosson Ceramir's ability to remineralize at the margin. Alhuwayrini tested it as acceptable retention. Jefferies J Clin Dent 2009 Jefferies 3 year test

Pameijer shows micro-leakage results of Ceramir

Calcium Aluminate/Glass Ionomer Hybrid Cement**

- Alkaline pH 8.5
- Moisture Tolerant
- Self Sealing
- Apatite Formation
- Insoluble/No Degredation
- Stronger with time
- Semi / Translucent
- Biocompatibility-Excellent
- Bioactivity-Apatite formation
- No silane, conditioning, bonding

Lithium Disillicate (eMax)

- Cleaning w/phosphate scavengers is not necessary
- Silane is contraindicated
- Tooth etching or conditioning is not necessary
- Bonding agent is not needed

Cementation Technique

Zirconia Restorations
- Cleaning w/ phosphate scavengers is not necessary
- Silane is contraindicated
- Tooth etching or conditioning is not necessary
- No bonding agent necessary

Cement Selection

A Bioactive Dental Luting Cement—Its Retentive Properties and 3-Year Clinical Findings

Steven R. Jefferies, MS, DDS, PhD; Cornelis H. Pameijer, DMD, DSc, PhD; David C. Appleby, DMD, MScD, FACP; Daniel Boston, DMD; and Jesper Lööf, PhD

ABSTRACT—A clinical validation study was conducted to determine the performance of a new bioactive dental cement

Three year recall data yielded no loss of retention, no secondary caries, no marginal discoloration, and no subjective sensitivity. All restorations rated excellent for marginal integrity.

recall examination included 14 single-unit full-coverage crown restorations, four three-unit bridges comprising eight abutments, and one two-unit splint. Three-year recall data yielded no loss of retention, no secondary caries, no marginal discolorations, and no subjective sensitivity. All restorations rated excellent for marginal integrity. Average visual analogue scale (VAS) score for tooth sensitivity decreased from 7.63 mm at baseline to 0.44 mm at 6-month recall, 0.20 mm at 1-year recall, and 0.00 mm at 2- and 3-year recall. Average gingival index (GI) score for gingival inflammation decreased from 0.56 at baseline to 0.11 at 6-month recall, 0.16 at 1-year recall, 0.21 at 2-year recall, and 0.07 at 3-year recall. After periodic recalls up to 3 years, Ceramir C&B thus far has performed quite favorably as a luting agent for permanent cementation of permanent restorations. In-vitro crown-coping retention studies were also conducted using this cement and various control cementation materials. Mean laboratory retentive forces measured for Ceramir C&B were comparable to other currently available luting agents for both metal and all-ceramic indirect restorative materials.

Keywords: dental cement, cementation, luting cement, bioactive, crowns, bridges, gold, PFM

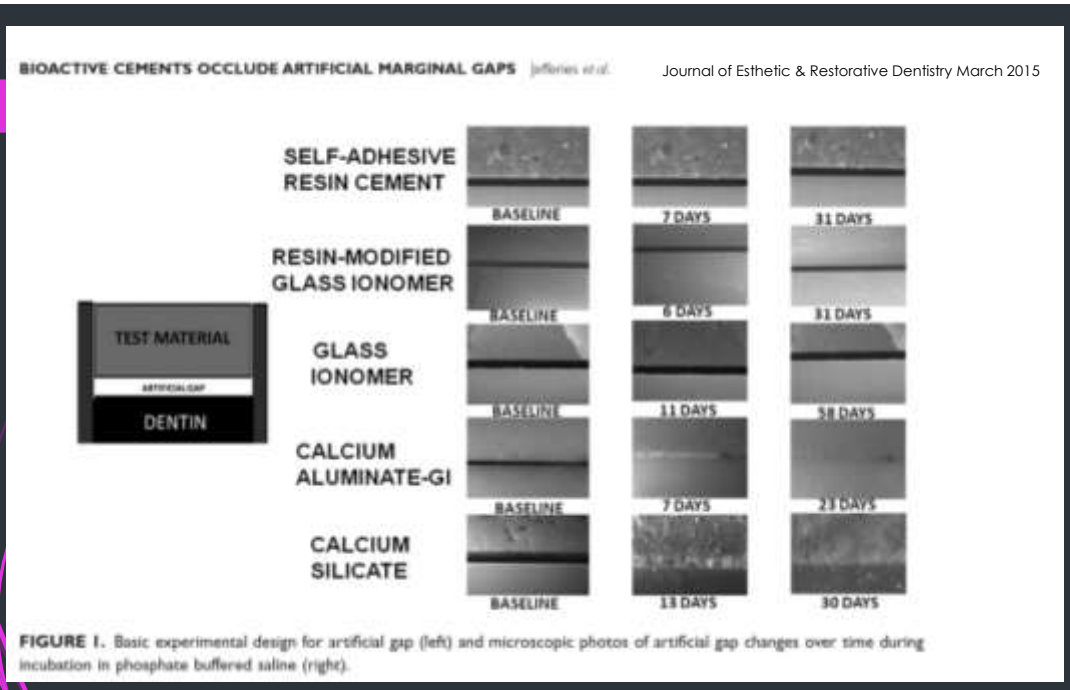


FIGURE 1. Basic experimental design for artificial gap (left) and microscopic photos of artificial gap changes over time during incubation in phosphate buffered saline (right).

ACTIVA BioACTIVE CEMENT (Pulpdent)

ACTIVA BioACTIVE CEMENT (Pulpdent)

3 Breakthroughs in Cement Technology

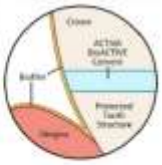
Traditional cements are designed to be passive: beyond securing a restoration, the only benefit they offer to the oral environment is that they won't harm the surrounding tissue. New bioactive materials play a dynamic role in the mouth, and behave favorably in the presence of moisture, laying the groundwork for remineralization. Check out these three breakthroughs in bioactive cement technology.

1. The bioactive difference
Do not confuse glass ionomers and fluoride-releasing composites with bioactive materials. Bioactive materials are moisture friendly and promote apatite formation and the natural remineralization process in the presence of water. ACTIVA BioACTIVE (Pulpdent) is a dynamic material that provides a continuous release and recharge of calcium, phosphate, and fluoride. It elicits a response that stimulates hydroxyapatite formation that knits the restoration and the tooth together and seals margins against microleakage—the primary cause of secondary caries and restoration failure. The bioactive resin matrix is resistant to acid and is ideal for the moist oral environment.

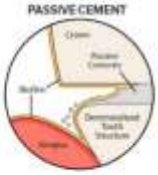
2. Versatile
ACTIVA BioACTIVE is ideal for all crown and bridge materials, including zirconia, CAD/CAM, lithium disilicate, PFMs, and glass ceramic materials. Its versatility and tissue compatibility means that dental offices can order just one cement. Not needing multiple cements for different substrates simplifies the dentist's clinical technique and makes inventory management and ordering easier for office staff. It handles easily, is light-cure and self-cure (dual cure), and is packaged in an easy-to-use auto-mix syringe.

3. Efficient
Bioactivity only occurs in materials that transport water. ACTIVA is a moisture friendly, self-adhesive cement and these properties simplify the clinical technique and the steps needed for a successful restoration. ACTIVA's patented rubberized-resin matrix is insoluble and absorbs shock, providing greater resistance to chipping and fracture. Excess material is easily removed after tack curing, allowing for fast clean-up. ACTIVA contains no Bisphenol A, no Bis-GMA and no BPA derivatives.

ACTIVA BioACTIVE CEMENT



PASSIVE CEMENT



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Dental Innovation Since 1947
www.pulpdent.com

HyperFIL HAp (Parkell)

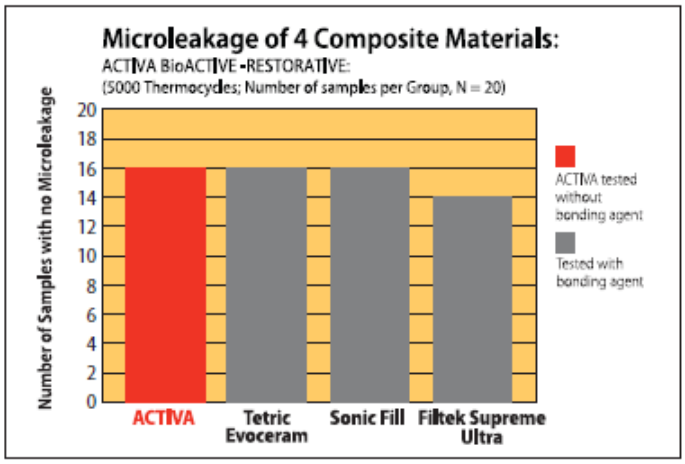
- couple of Universities testing the product. I have no results to share yet, as the testing is still underway.

HyperFIL HAp (Parkell)

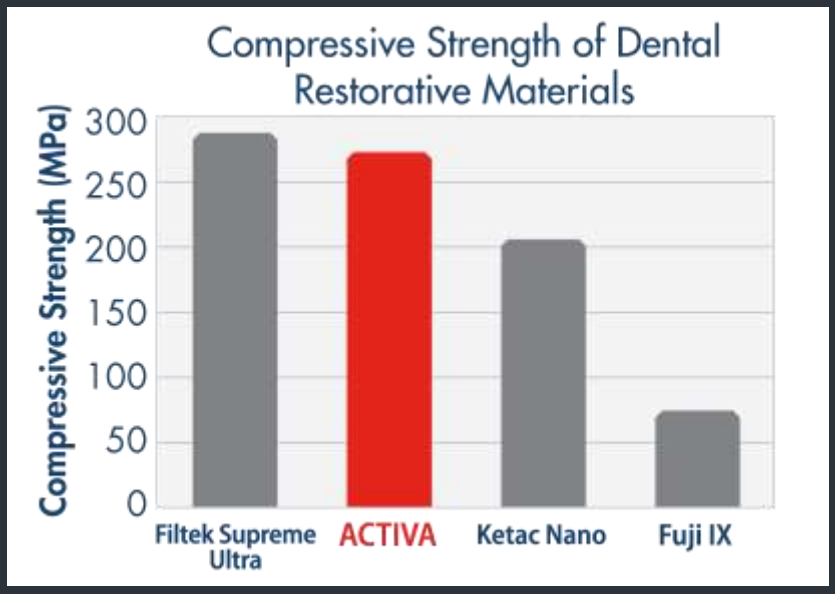
Bulkfill Self Cure Material

Releases/recharges calcium, phosphate and fluoride
Chemically bonds and seals tooth

- No Bonding agent necessary
- No layering bulkfill
- No polymerization stress
- Bioactive
- Bioavailable
- No sensitivity



Source: University testing[16] (see back page for trademark information)



DO Restoration Tooth #29

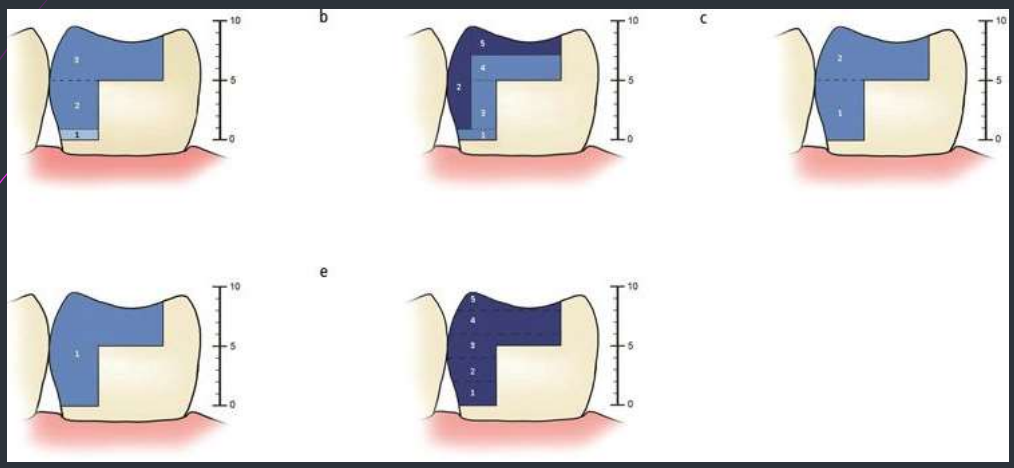
Class V and Class II Tooth #31

ACTIVA™

What are the indications for using each type?

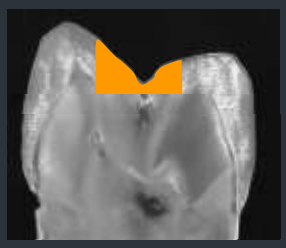
Direct Composite Restorations

PLACEMENT TECHNIQUES

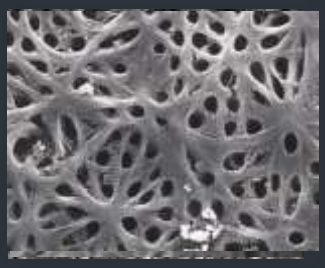


What substrate are we treating?

:Composite Preparation



Class I or II



3x Tubule Density Equals Higher Fluid & Increased Difficulty for Bonding
%30 Degrease in Bond Strengths with most bonding systems.

"Adhesive dentistry could be expressed as a simple relationship between bonds and stress. If the bonds can withstand the stress, the restorative technique will be successful."

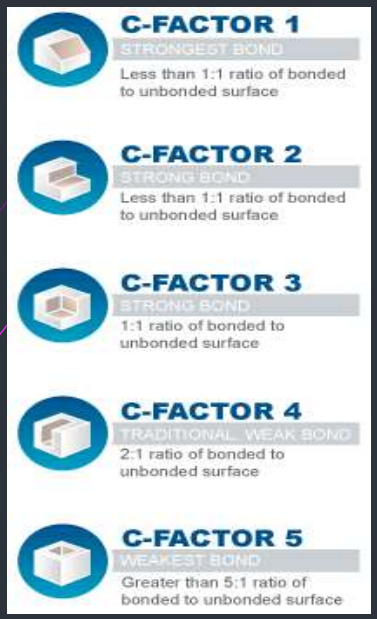
Unterbrink and Liebenberg (1999)

"C-Factor" Definition

Configuration Factor:

"The ratio of bonded to un-bonded (free) surfaces"

Feilzer, DeGee, Davidson (1987), Universtiy of Amsterdam, ACTA



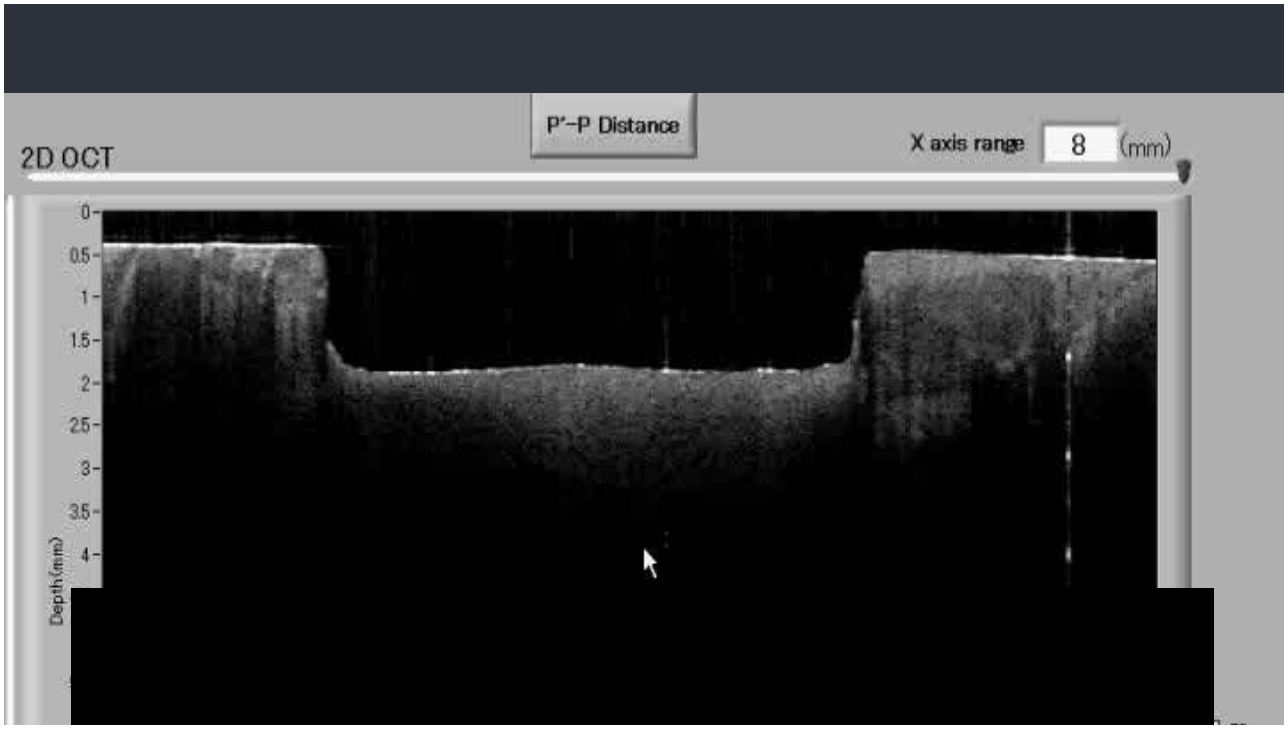
Lowest Stress

Low Stress

Medium Stress

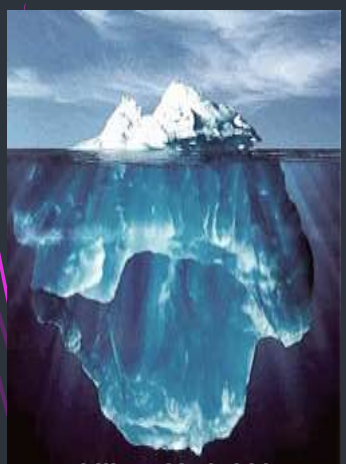
High Stress

Highest Stress



Factors that compromise bond durability in restorative dentistry

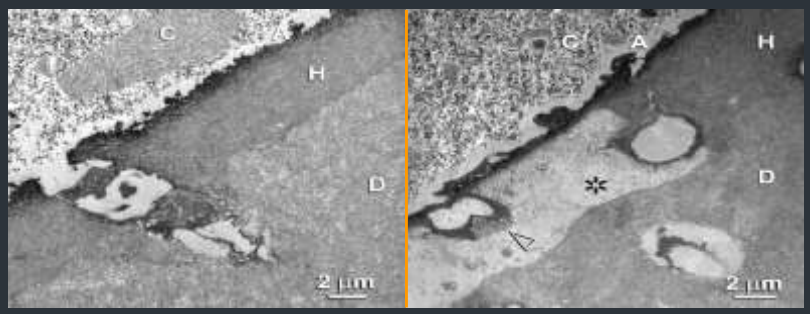
Hydrophilic dentin bonding (1956 -)



Instability of hybrid layers problem may be more severe than we realize

RESEARCH REPORTS
J Dent Res 2005; 4:741-746
J. Hebling[1], D.H. Pashley[2], L. Tjäderhane[3], and F.R. Tay[2,4*]

Chlorhexidine Arrests Subclinical Degradation of Dentin Hybrid Layers *in vivo*



Intact hybrid layers created by a simplified etch-and-rinse adhesive in caries-affected primary dentin partially disappeared after 6 months of intraoral function

Factors that compromise bond durability

Hydrophilic dentin bonding (1956 -)

RESEARCH REPORTS
J Dent Res 2004; 83:216-221

D.H. Pashley[1]*, F.R. Tay[2], C. Yiu[2], M. Hoshimoto[3], L. Breschi[4], R.M. Carvalho[5], and S. Ito[6]

Collagen Degradation by Host-derived Enzymes during Aging

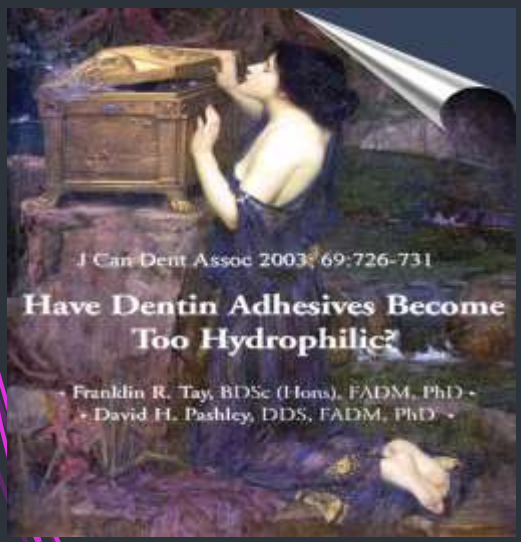
Demineralizing dentin is like opening the Pandora's box, releasing endogenous enzymes (Matrix Metalloproteinases - MMPs) that were trapped within the mineralized dentin matrix.

In the presence of water (such as that derived from water sorption or from adhesives, MMPs (2,8 & 9) can breakdown collagen fibrils that are not protected by intrafibrillar minerals

Sukala et al. (2007)
Mazzoni et al. (2007)

Factors that compromise bond durability in restorative dentistry

Hydrophilic dentin bonding (1956 -)



We challenged that current dentin adhesive designs that incorporate increasing concentrations of hydrophilic monomers are going in the wrong direction

Water sorption
Polymer swelling
Decline in mechanical properties
Leaching of hydrolyzed resin components

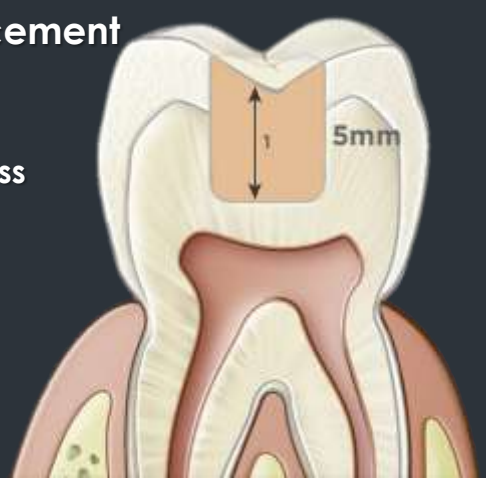
Bond Degradation

- Pashley DH, Tay FR, Imazato S. How to increase the durability of resin-dentin bonds. Compend Contin Educ Dent. 2011 Sep;32(7):60-4, 66.

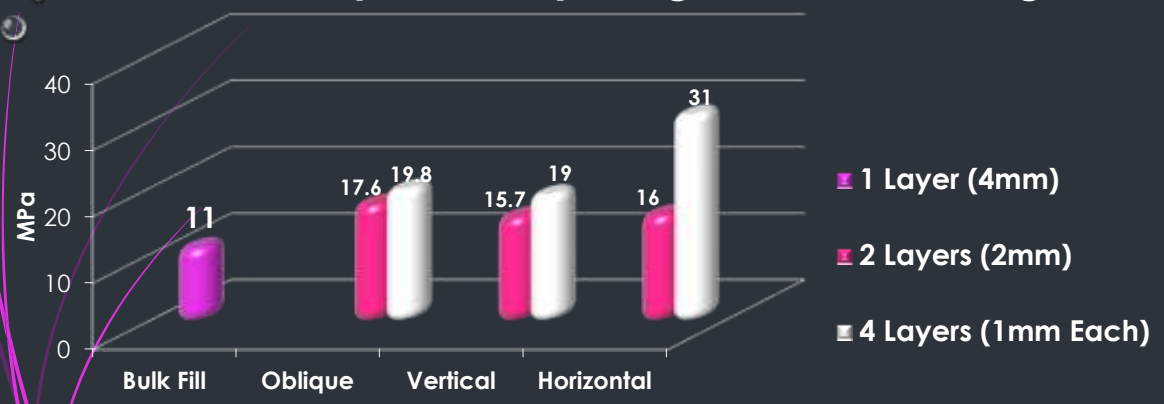
Resin-dentin bonds are not as durable as was previously thought. Microtensile bond strengths often fall 30% to 40% in 6 to 12 months.

BULKFILL COMPOSITES

- Long term research?
  - **Dentin & Enamel Replacement**
    - **Requires one layer**
    - **1.6%-2.4% vol. shrinkage**
    - **2.3-2.8mpa shrinkage stress**
  - **Self Cured BulkFill**



Effects of Composite Layering on Bond Strengths



Operative Dentistry

Today's resin-based composite materials are excellent. The bulk-fill concept is desired by many dentists; however, *CR research shows adequate depth of cure deeper than 3 mm remains questionable for most brands of resin composites and most resin curing lights.* Concepts for making Class II resin-based composites predictable and profitable were published in *Clinicians Report* February 2014.

These CRA research results agree with Dr. Tagami's results.
Tagami's research showed a prominent bulkfill cures to only 70% on bottom at 4 or 5mm depth of cure.

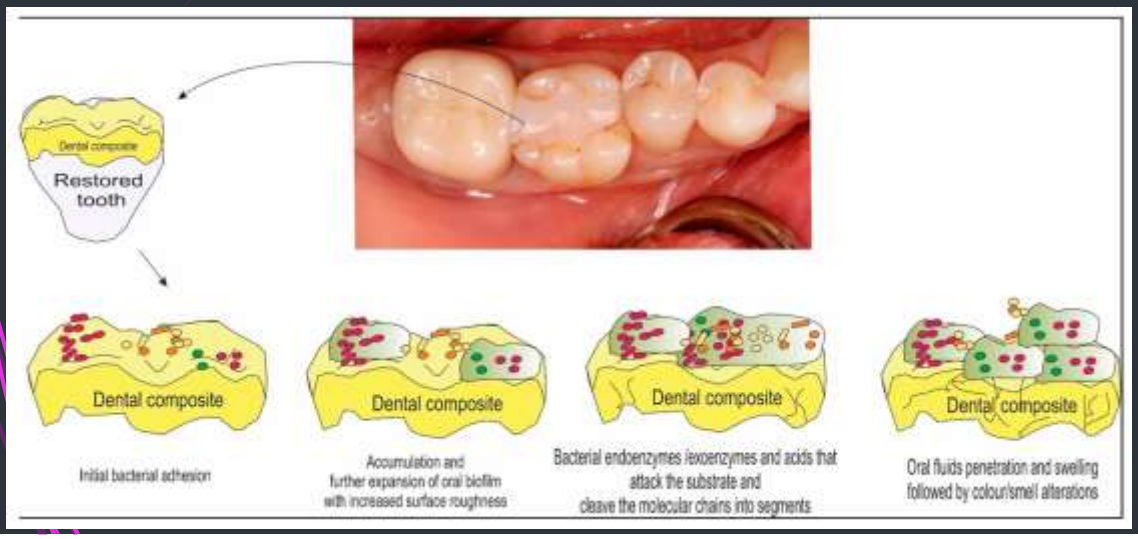
Internal (Polymerization) Stresses of Composites

"A Simple Pain-Free Adhesive Restorative System by Minimal Reduction & Total-Etching (1993)
Takao Fusayma DDS,
Tokyo Medical & Dental University

Resin Based Restorative Materials

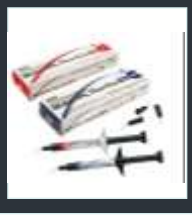
- Resin based adhesive materials absorb moisture over time which causes them to breakdown
- Leaching of mechanical properties
- Accumulation of oral biofilm causes degradation

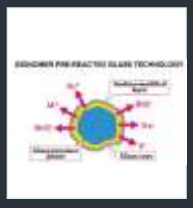
Oral bacteria Degradation of resin restorations



SHOFU
GIOMER PRODUCTS

- Utilizes Giomer Technology to provide antibacterial effect on the surface where it contacts the tooth.
- Less plaque accumulation





Drawbacks of Any Composite Resin

- Material placement techniques
- Variable substrate
- Polymerization stress & shrinkage
- Water absorption
- Hydrophobic bonding agents
- Decreased adhesive bond strength over time
- MMPs and Cathepsins
- Microleakage
- Light polymerization

Glass Ionomers

- Bioactive material
  - affinity to tooth structure. when placing a glass ionomer a weak acid or conditioner is used to aid in releasing calcium and phosphate ions from the tooth structure. These calcium and phosphate ions combine into the surface layer of the glass ionomer and form an intermediate layer called the interdiffusion zone. This bond layer can be very strong and significantly reduce the microleakage that would occur at the margins of the restoration.
- Very good fluoride and ion release helps remineralize tooth structure in the remineralization–demineralization process that naturally occurs in the oral cavity.
- They bond to enamel, dentin, and metals.

(RFA-DE-10-004)
"Tooth-colored resin restorations have an average replacement time of 5.7 years due to secondary caries precipitated by bond failure."

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3148178/

Van Meerbeek B, et al. Relationship between bond-strength tests and clinical outcomes. Dent Mater (2009), doi:10.1016/j.dental.2009.11.148

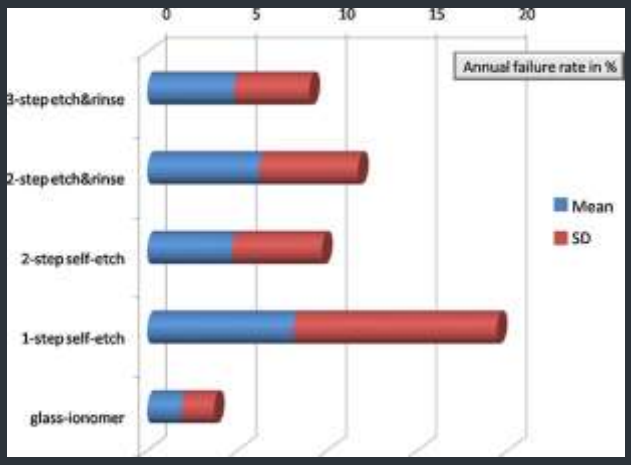
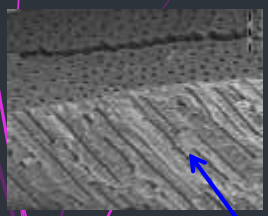
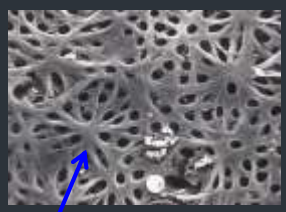


Fig. 15 – Graph representing the mean annual failure rates per adhesive class, determined according to a systematic review of Class-V clinical trials of adhesives during the period 1998–2004 [2].

Deep Preparations

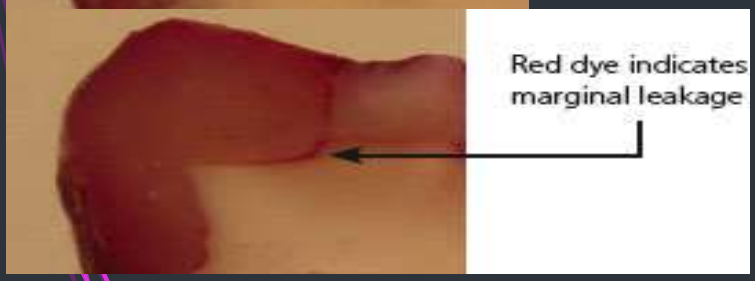
- Bonding Agent & Flowable composite
- Conventional Glass Ionomer or GI then Composite





- Fluoride Release
- High compressive strength
- Hydrophillic
- Insoluble
- True chemical adhesion
- Minimizes microleakage
- No sensitivity
- Acid Base Resistant Zone
- Decreased gap formation & C Factor
- Coefficient thermal expansion similar to dentin

Glass Ionomer Sandwich



•Class I, II, III & V posterior restorations
•Open & Closed Sandwich techniques
•Composite replacement
•Amalgam replacement
•High caries risk patients
•Pediatric patients
•Geriatric patients
•Special needs patients
•Long term resistance to microleakage

microleakage testing in vitro using three different bases under composites

T. DUONG, L. TRAN, R. PERRY , G. KUGEL, Special Issues of the Journal of Dental Research. ABSTRACT #0366
> *Tufts University School of Dental Medicine, Boston, MA, USA.*

abstract:

Objective: To compare Class II microleakage in vitro of three different bases placed under composite restorations.

Methods: Thirty-six extracted molars were prepared as Class II MO/DO: 2mm occlusal depth, 2mm axial box depth, 3-5mm gingival box width, and 1mm gingival margin below CEJ. Teeth were randomly divided into three groups of twelve (groups 1-2 = glass ionomer; group 3 = flowable resin): Group 1-Riva Light Cure GI (SDI), Group 2-Riva Self Cure GI (SDI), Group 3-Esthet-X Flow (DENTSPLY Caulk). All groups were primed with Clearfil SE Bond Primer and Bond (Kuraray). All samples were then restored using ICE nano-hybrid Composite (SDI), finished and polished. Restorations were thermocycled for 300 cycles between 5°C and 55°C with a dwell of 30 seconds and then placed in 0.5% aqueous basic fuchsin dye for 24 hours at 37°C. Samples were sectioned mesiodistally and scored independently by two evaluators for microleakage at the occlusal-cavo and proximal-cavo surfaces under a 40x stereomicroscope.
Dye penetration was evaluated using a scoring system:
0 = no penetration, 1 = penetration in enamel/cementum, 2 = penetration at the axial wall, 3 = penetration beyond the axial wall.

Results: A Kruskal-Wallis test revealed no statistically significant difference in microleakage between the three groups at the occlusal-cavo surface ($p>0.05$). Group 3 was found statistically different at the proximal-cavo surface. Group 3 yielded the most microleakage at both interfaces while Group 2 showed no axial wall penetration at either interface.

Conclusion: Both light-cured and self-cured glass ionomers were more resistant to microleakage than a flowable resin on both occlusal-cavo and proximal-cavo surfaces.

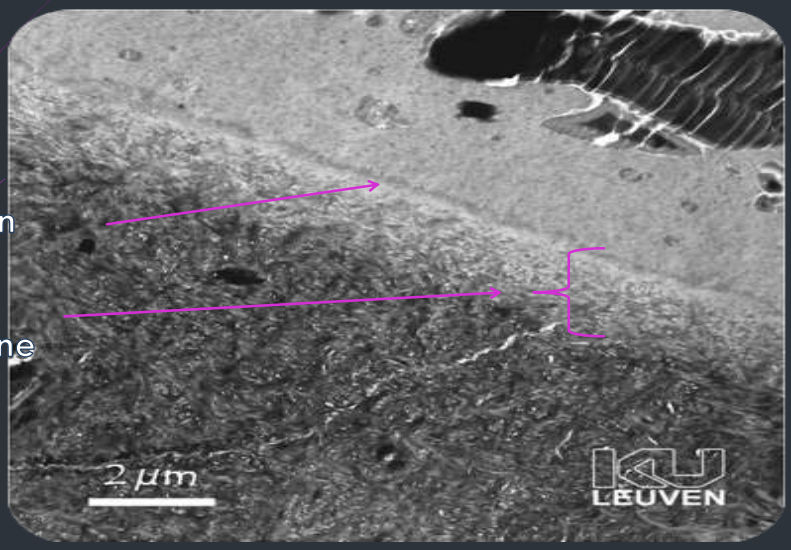
Glass Ionomer Materials

- Dentsply-ChemFil Rock Restorative
- SDI-Riva LC, light cure HV, Riva SC, self cure HV
- G.C. America-Fuji II LC, Equia Fil (Fuji IX)
- VOCO-Ionolux, Ionofil Molar AC
- 3M/ESPE-Ketac Nano, Photac Fil Quick, Vitremer, Ketac Molar Quick, Ketac Fil Plus
- Shofu- FX II

Glass Ionomer Interface

Dentin Margin

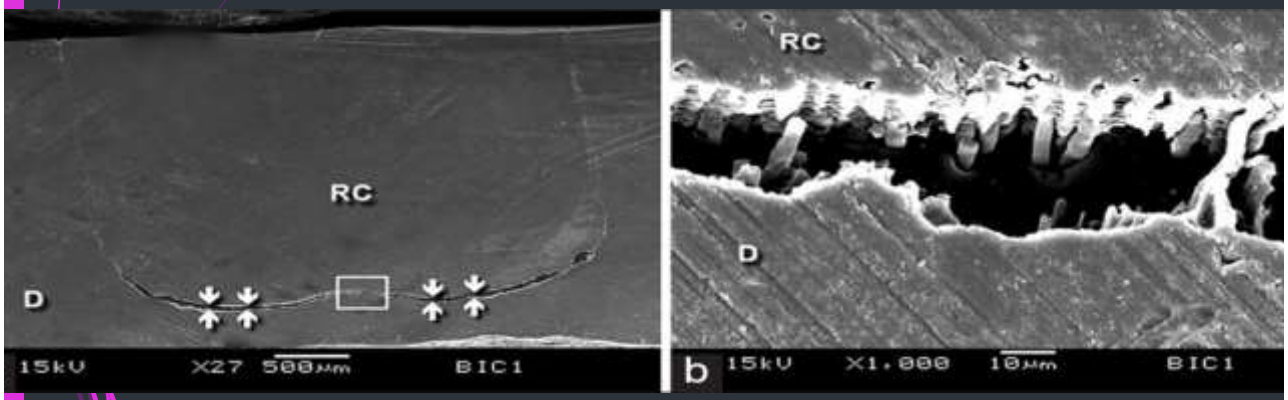
Acid Base Resistant Zone



Interface Analysis (TEM)

CARDOSO et al. J Dent 2010

Resin to Dentin Hybrid Zone



EQUIA FORTE

Caries control/quadrant dentistry

(Class II, III, V & core buildup)

Open Sandwich with glass ionomer & nanohybrid composite

How are you restoring

?

these different preparations

Bioactive dental material articles

Dental today article is very nice and so is this review article.

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