Clinical update on direct restorative materials.

Ian Meyers

6th September 2017
Direct Placement Tooth-Coloured Restorations

- The demand for tooth-coloured restorations is increasing worldwide and resin composite is the most commonly used material for direct placement in both anterior and posterior teeth.

- Resin composites are both technique sensitive and technique intensive and are therefore considered more time consuming and difficult to place.

- Modifications and improvements to glass-ionomers have made them viable alternatives and often the material of choice for many restorative situations.

- Selection from the range of available materials is complex.
Selection of the appropriate restorative material is influenced by each individual practitioner and the patient requirements and on an understanding of the benefits and limitations of the materials.
Adhesive Tooth Coloured Restorative Materials

- Composite Resins (Resin Composites)
- Glass-Ionomer Cements (GIC)
- Resin Modified / Reinforced Glass-Ionomer Cements (RMGIC / RRGIC)
  - ‘Light Cured’ Glass Ionomer Cements
- Glass-Ionomer Modified Resins
  - Polyacid modified resin composite (PAMRC)
  - Compomers
- Ceromers
  - Ceramic modified polymers
- Ormocer
  - Organic modified ceramic polymer
- Dentine Adhesive Systems
Composite Selection for Practitioners

• Practitioners are faced with ever-increasing composite choices that are designed to give better results during placement, and over the lifespan of the restoration.

• Ironically, the introduction of sophisticated materials designed to improve restorative procedures can have the opposite effect.

• Today’s clinicians can be easily confused about the subtle differences between the many available composite materials and may find it more difficult to make the correct decision about which material is best for each clinical situation.
Composite Selection for Practitioners

- Ideally, practitioners should rely on published reports and a careful review of a product’s physical properties when selecting a material. However, this level of review is generally not available for everyday providers.

- Dentists’ purchasing decisions may be based on cost, brand preference, and the “works best in my hands” argument, rather than a strict review of each product’s properties.

- Clinicians become more confident in their procedures and materials through repetition of use and clinical observations.
Composite Selection for Practitioners - Considerations

• What type of composite restorations do you most frequently do?
  • Anterior / Posterior
  • Smaller size / Larger size
  • Single shade / Multiple shade

• Do you have difficulty with shade matching?

• Do you have difficulty shaping the material?

• Does the material stick to your instrument?

• Do you have any concerns about long term stability of the restorations?

• Do you have other concerns or issues?
Composite Resins – Some Current Considerations

• Composition
  – Microfills / Nanofills / Microhybrid / Nanohybrid
  – bisGMA or non-bisGMA

• Aesthetics
  – Shade / Opacity Range
  – Polishability / Surface Finish / Gloss Retention

• Material Properties
  – Handling / Ease of Use
  – Viscosity
  – Rheology and Thixotropic Properties
  – Shrinkage Stress
  – Depth of Cure
  – Specific Mechanical Properties
  – Suitability for both Anterior and Posterior Use
Historical Composite Resin Classification

Posterior Restorations
Higher Strength
Lower Polish

Anterior Restorations
Lower Strength
Higher Polish

Universal Restorative
Moderate Strength
Moderate Polish
Fig. 1 – The development of RBC systems highlighting a general decrease in filler particle size.
<table>
<thead>
<tr>
<th></th>
<th>Microfill</th>
<th>Nanocomposite</th>
<th>Nanohybrid</th>
<th>Microhybrid</th>
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<tr>
<td>Particles</td>
<td>Sub-100nm particles</td>
<td>Sub-100nm particles</td>
<td>Sub-100nm to micron-sized particles</td>
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<tr>
<td></td>
<td>Discrete</td>
<td>Discrete*</td>
<td>Average particle size tends to be slightly lower for nanohybrids (though many exceptions)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-discrete (fused)</td>
<td>Non-discrete (fused)</td>
<td>Contain large amounts of ground particles</td>
<td></td>
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<tr>
<td></td>
<td>Pre-polymerized</td>
<td>nanocluster</td>
<td></td>
<td></td>
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<tr>
<td>Surface</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Retention</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>High</td>
<td>Intermediate to low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Low</td>
<td>low</td>
<td></td>
</tr>
<tr>
<td>Filler</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Loading</td>
<td>Low fillier loading</td>
<td>High filler loading</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

*Treated to bond to resin
Fig. 1 – Diagrammatic representation of the agglomerated zirconia/silica nanocluster filler particulate and individually dispersed nano-sized filler particles embedded in the resin matrix of the nanofill RBC systems.
The organic phase of resin composites consists of dimethacrylate resins, the most common monomers being;

- bisphenol A diglycidildimethacrylate (BisGMA),
- its ethoxylated version (BisEMA),
- triethylene glycol dimethacrylate (TEGDMA) and
- urethane dimethacrylate (UDMA).
Bisphenol A (BPA)

BPA is used in the production of epoxy resins and polycarbonate plastics, which are used to make many drinking bottles, food storage containers, dental polymers, adhesives, flame retardants and water supply pipes.

BPA is known to act as an oestrogen receptor agonist and thus may cause so-called ‘endocrine disruption’.

The primary source of BPA exposure for the general population is thought to be from BPA that leaches from food containers or drinking bottles.
Composites may contain BPA as an impurity from the synthesis process of BisGMA, and BPA may be released from composites following degradation of BisGMA.
The use of dental resin composites in dentistry is ubiquitous

Despite the fact that dental resin composites have improved their physico-chemical properties, the concern for its intrinsic toxicity remains high.

Some components of restorative composite resins are released in the oral environment initially during polymerization reaction and later due to degradation of the material.

The clinical consequences of biodegradation are still poorly understood.
Mastering anterior direct composite restorations is a necessity for the contemporary clinician who appreciates and understands the art and science of aesthetic dentistry.

In the aesthetic zone, composite bonding procedures are considered the most conservative and least invasive technique to return missing, diseased, and unsightly tooth structure to enhanced colour, form, and function.

Composites are the most versatile restorative material available to the dental professional, especially for the aesthetic-conscious patients, and can be provided at a reasonable fee.

To mimic natural tooth structure, the clinician must have a comprehensive understanding of the material science and techniques involved in direct bonding procedures.

Anatomical Form Defines Color: Function, Form, and Aesthetics

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Alvin Kobashigawa, BS**

Color Matching With Composite Resin: A Synchronized Shade Comparison

Douglas A. Terry, DDS*
Shade Selection

Selection by value instead of hue
• Difficulties with direct composite resins include shade matching, handling properties, premature setting under operatory lights, and the overall ease of use.

• Tooth colour, with its varying shades and translucencies, is difficult to achieve between composite systems.

• Resins based on the porcelain VITA Classical shade guide cannot achieve the desired results with consistency.

• Choosing the correct shade can be simplified by using a custom shade guide, which is made from original light-cured composite material.
Hue is the A, B, C and D colour shade
Chroma

Chroma is the 1, 2, 3., numbers – the amount of colour
The value represents the brightness of colour, the amount of light to dark in the colour.
If result from shade taking is not available on composite shades, always use the closest (in value) available.
Opacity is the 3D representation of value!

100% Opacity ← 100% Translucency
Optical effects

Opalescence

Fluorescence
Opalescence

Opalescence is a type of dichroism seen in highly dispersed systems with little opacity. The material appears yellowish-red in transmitted light and blue in the scattered light perpendicular to the transmitted light. The phenomenon is named after the appearance of opals.

The incisal third has a translucent area among the dentine mamelons - this area has a **bluish** effect under transmitted light. When light is reflected through the enamel, it appears **reddish orange**.
Opalescence
Fluorescent materials may appear one colour when bathed in visible light and another colour when exposed to other kinds of light such as Ultraviolet light.

Aesthetics and Function

• **Aesthetics**
  – Expectations of patient and dentist
    • Variability in satisfaction level
  – Conversation distance aesthetics Vs Photographic Magnification
  – Composite resin Vs Ceramic

• **Function**
  – Comfort and feel
  – Longevity
Layering with Direct Composite Resin Restorations

- In natural teeth, the colour comes from within, not from the surface
- Replace dentine with opaque ‘dentine composite’
- Replace enamel with translucent / transparent “enamel composite”
- Use subsurface characterisation
- This approach forms the basis of the layering concept for anterior restorations
Simple Layering

Multiple Layering
### Filtek™ Supreme XTE Universal Restorative

**Dentine** | **Body** | **Enamel** | **Translucent**
--- | --- | --- | ---
A1D | A1B | A1E | Clear
A2D | A2B | A2E | Amber
A3D | A3B | A3E | Blue
A3.5B |  |  | Gray
A4D | A4B |  |  
--- | --- | --- | ---
B1B | B1E |  |  
B2B | B2E |  |  
B3D | B3B |  |  
B5B |  |  |  
C1B |  |  |  
C2B |  |  |  
C3B |  |  |  
C4D |  |  |  
D2B | D2E |  |  
D3B |  |  |  
WD | WB | WE |  
XWB | XWE |  |  

**Opacity Differences**

Color is as much a subjective interpretation as it is a scientific manual on shade determination and matching does not exist. A visual shade guide is the only objective protocol that can meet others clinical needs. Although basic knowledge has been attained, it is not a position to devise individual perceptions and equipment. Color is a subjective interpretation of the esthetic success of a restoration. No matter how much clinical error might be noticed in the shade guide, the type, location, and components of color, it is necessary to be aware that color may vary. However, the harmony of the final result is strongly related to the harmony of the patient’s smile, facial shape, age, and characteristics of the ultimate space and aesthetic transformation. One allows more definition to the overall direction of the reflection gives a less visible shade. One shade has the same direction for the three-dimension. The matching armament indicates that the direction of the observer’s discrimination as close to a human observer is dependent on the relative positions of the lighting conditions. The object and observer.

### 3M ESPE Custom Shades

<table>
<thead>
<tr>
<th>A8B</th>
<th>B8B</th>
<th>WD</th>
<th>WB</th>
<th>XWB</th>
<th>WE</th>
<th>XWE</th>
<th>Clear</th>
<th>Amber</th>
<th>Blue</th>
<th>Gray</th>
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</thead>
<tbody>
<tr>
<td>Cervical Shades</td>
<td>Bleach Shades</td>
<td>Translucent Shades</td>
<td></td>
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</tbody>
</table>

www.3MESPE.com.au  www.3MESPE.co.nz

A polymer filled with nano-particles is clear and translucent, whereas one filled with macro-fillers is opaque.
Essentia™ recognises that the age of teeth determines shade

A dramatic simplification of shade design is possible if we observe the natural ageing of teeth. Younger teeth have little chroma and high opacity, while older teeth have high chroma and lower opacity. This intuitive observation is captured in the simplified Essentia™ shade range and is the foundation for the Essentia™ Universal composite system.

3 Dentine shades (Light, Medium and Dark) define shade “intensity” with increasing chroma and decreasing opacity to match the ageing of dentine.

2 Enamel shades (Light, Dark) define the subtle ageing of enamel and provide high reflection and translucency to complete the bi-layer Essentia™ restorations.
The range of dentine shades varies in both chroma and opacity, starting with a young and low chroma opaque dentine (Light Dentin), followed by a medium opacity medium chroma dentine (Medium Dentin) and ending with a higher translucent high chromatic dentine (Dark Dentin). Thus following the natural ageing of real dentine.

Enamel shades are naturally opalescent, with a more opaque, high value and low chroma enamel (Light Enamel) and a more transparent, low value and slightly chromatic enamel (Dark Enamel).

Universal is a body shade with incredible shade matching ability for small anterior cavities or single shade restorations in the posterior region.

Masking Liner is an opaque, heavily-filled injectable composite that will block discolouration without increasing value.
How many shades and opacities are needed?

- The majority of cases can be done with a limited range of shades
- Mixing and matching shades from different composite systems is ill-advised
- Composite shade should not be selected by placing a layer of uncured composite resin against the teeth as the composite may change after curing.
The majority of dental practitioners carry out large numbers of Class I and Class II restorations.

Dental amalgam has helped maintain dentitions for over a century, however its days appear to be numbered because of environmental issues, rather than any harmful effects to patients.

There is an ever increasing demand from patients for non-metallic and tooth-coloured restorations in their posterior teeth.
Guidance on posterior resin composites: Academy of Operative Dentistry - European Section.


- The AODES considers adhesively bonded resin composites of suitable composition and properties to be the “material of choice” for use in direct minimal intervention approaches to the restoration of posterior teeth.

- The application of modern, evidence-based approaches may be found to result in the safe provision of effective and predictable posterior resin composites.
Glass-ionomer materials have been available for over 40 years, but have generally not been indicated for loadbearing restorations.

Anecdotal evidence suggests that dentists are using the reinforced versions of this material in posterior teeth, possibly as a result of demands from patients to provide them with tooth-coloured restorations at a lower cost than resin composite.

Under certain circumstances these materials may provide reasonable service.
The importance of the tooth substrate and the ‘seal’ and ‘bond’ of the restoration
Enamel Demineralisation

Root Surface Demineralisation
Composite Resin and Dentine

• Composite resin does not bond directly to dentine
• Viscosity prevents adaptation to surface
• Regular unfilled resin is still too viscous
• A very low viscosity HYDROPHILIC resin (eg: Hydroxyethylmethacrylate (HEMA) ) as an intermediary layer is required for successful adhesion of composite resin to dentine
• Therefore use a Dentine Adhesive system for mechanical / chemical adhesion or use a Glass-Ionomer Cement (GIC) or Resin-Modified Glass-Ionomer Cement (RMGIC) to obtain chemical adhesion
Concerns with the ‘ALL’ Composite Resin Restoration

- Increased polymerisation shrinkage stress
- Reduced bond and seal to deep dentine
- No therapeutic benefit
- Poor access for photo-polymerisation
- Number of increments required
- Poor adaptation to cavity with high viscosity materials
Shrinkage Stress
“It’s a low-stress flowable composite you can bulk fill (4mm) and cure for faster and easier restorations. The pre-measured Compula® Tip allows you to simply dispense and cure, saving up to 40% in placement time.”
SDR Monomer - Polymerization

conventional monomer

\[
\text{X} \quad \text{O} \quad \text{R} \quad \text{O} \quad \text{X}
\]

+ 

SDR monomer with \textit{modulator}

\[
\text{X} \quad \text{O} \quad \text{Y} \quad \text{R} \quad \text{O} \quad \text{X}
\]

- High molecular weight
- Conformational flexibility

\[
\text{X} \quad \text{O} \quad \text{Y} \quad \text{R} \quad \text{O} \quad \text{X}
\]

- Lower stress build-up during polymerization
Filtek™ One Bulk Fill Posterior Restorative

- One-step placement, no additional capping layer
- Fast and easy procedure
- Excellent adaptation without additional expensive dispensing devices
- Stress relief to enable 5 mm depth of cure
- Better in vitro wear resistance than market-leading bulk fill materials
- Excellent handling and sculptability
- TRUE nanofiller technology and two innovative methacrylate monomers act to lower polymerization stress without compromising wear
Composition

Novel Stress Relieving Monomer System

AUDMA
High molecular weight dimethacrylate
– acts to lower volumetric shrinkage

AFM
Addition-fragmentation (AF) monomer
– Reacts into developing polymer network through terminal methacrylate bonds like other dimethacrylate monomers
– Central AF group can fragment and release stress
– Fragment may then polymerise into network in a lower stress orientation compared to its pre-fragmented state.
SonicFill™ System
The new, fast and easy Composite Filling System for posterior restorations.

Fill Faster with Sonic Energy
SonicFill uniquely combines the attributes of flowable and a universal composite. By activating the composite with sonic energy, fill and adapt at low viscosity, then press and sculpt at high viscosity.

- **Fast**: Time reduction with single-step fillings for up to 5mm increments
- **Reliable**: Predictable long-term restoration results due to improved adaptation and reduced shrinkage
- **Easy**: Convenient and precise delivery through cannula with small diameter and foot switch control
SINGLE-FILL™
THE TRUE SINGLE-STEP
BULK FILL UP TO 5MM

Traditional layering technique.
Several Layers.

Bulk fill flowable with universal cap.
Two Layers.

High viscosity bulk fill restorative with flowable liner.
Two layers.

SonicFill™ System
ONLY ONE LAYER
The highest rating (score 0, no dye penetration) was achieved by 93.33% of the restorations made of the SDR material, 90% of restorations of SonicFill system, 86.66% of restorations of the composite Filtek Bulk Fill, and 73.33% of restorations of the Tetric EvoCeram Bulk Fill.

The performed study showed that bulk-fill flowable or sonic-activated flowable composite restorations have better marginal sealing and lack of discoloration in comparison with bulk-fill paste-like composite.
The Aim is Bond, Adhesive Bond

- Does Newer Mean Better
THE ULTIMATE BOND

EVERYTHING OR NOTHING
Conclusion:
The increase in versatility of universal adhesives is not accompanied by technological advances for overcoming the challenges associated with previous generations of adhesives.
Evolution of Dentine Adhesive Systems

The Next Generation

- **1st** - Resin Tags (1960s NPG-GMA)
- **2nd** - Phosphorated Esters (1970s Phenyl P and HEMA)
- **3rd** - Physical/Chemical (1980s Smear layer modification)
- **4th** - Hybrid Layer (Multiple Bottle) (Early 1990s)
- **5th** - Single Bottle Prime and Bond (Mid 1990s)
- **6th** - Self Etching Primers (Late 1990s)
- **7th** - All in one systems (Early 2000s)
- **8th** - Dual cure self etch adhesives (Mid 2000s)
- **9th** - Selective etching (Currently preferred)
Selective Etch Technique
By first applying a 35% phosphoric acid to enamel margins, clinicians can help create a stronger bond to the enamel when using a self-etch material. **Applying the etchant only to the enamel areas** results in a localized deep etch, allowing the dentist to maintain the benefits of the **self-etch adhesive on dentine**.

http://www.dentallearning.net/articles/basic-properties-self-and-total-etch-adhesives
Dentine Adhesive Systems

- **A = Acid Etchant, P = Primer, B = Bond**
  - **A + P + B**
    - Scotchbond MultiPurpose Plus, All Bond 2, Optibond FL
  - **A + PB**
    - Single Bond 2, Prime and Bond 2
  - **AP + B (A ± AP + B)**
    - Clearfil SE Bond, Xeno III
  - **APB**
    - Prompt-L-Pop, Adper Easy Bond, G Bond, i Bond, XP Bond, Clearfil S3 Bond
  - **A ± APB**
    - Scotchbond Universal
    - G-aenial Bond / G-Premio Bond
    - Prime and Bond Elect
**Dentine Tubule Distribution**

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Number / mm²</th>
<th>Average Diameter (µm)</th>
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<tbody>
<tr>
<td>Near Pulp</td>
<td>45,000</td>
<td>2.5</td>
</tr>
<tr>
<td>Mid Dentine</td>
<td>29,500</td>
<td>1.2</td>
</tr>
<tr>
<td>Peripherally</td>
<td>20,000</td>
<td>0.9</td>
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There are no significant differences in distribution between young and old dentine

Garberoglio and Brannstrom 1976
The amount of secondary dentine is directly correlated with dentine age. As teeth age, dentine continues to be secreted, resulting in the dentinal tubules becoming narrower. This increased calcification is part of physiological aging (or physiological sclerosis), as well as a response to external stimuli such as attrition and caries.

Within the limitations of an in vitro study, the substrate age influenced the bonding ability of the three-step etch & rinse adhesive. The presence of a carboxylic-based polymer enhanced the bonding ability of the two-step etch & rinse adhesive.
‘Wet’ Surface Bonding

• Hydration maintains spaces between collagen fibres – avoids collagen collapse
• Hydrophilic monomer penetration requires displacement of moisture (Volatile solvent)
• Excess moisture results in voids and a weak bond
• How moist is moist enough or too much??
• Blot with cotton wool or sponge pellet
• 3-5 second moderate air dry – less predictable
Transmission electron micrographs of dentine bonded with an all-in-one adhesive, to demonstrate the presence of water-filled channels called “water trees” (pointers), extending from the hybrid layer (H) and passing through the cured adhesive layer. Such water trees do not form in self etching primer adhesives.

Matrix MetalloProteinases (MMPs)

Dentin Adhesion and MMPs: A Comprehensive Review

Jorge Perdigão, DMD, MS, PhD*, Alessandra Reis, DDS, PhD†, Alessandro D. Loguercio, DDS, MS, PhD‡

Optimizing dentin bond durability: Control of collagen degradation by matrix metalloproteinases and cysteine cathepsins

Leo Tjäderhane a,b,c,* , Fabio D. Nascimento d, Lorenzo Breschi e,f, Annalisa Mazzoni e,g, Ivarne L.S. Tersario h,i, Saulo Geraldeli j, Arzu Tezvergil-Mutluay k,l, Marcela R. Carrilho m, Ricardo M. Carvalho n, Franklin R. Tay o, David H. Pashley p
Dentine contains collagenolytic enzymes, matrix metalloproteinases (MMPs) and cysteine cathepsins, which are responsible for the hydrolytic degradation of collagen matrix in the bonded interface. Several approaches to prevent enzyme function either directly or indirectly have been proposed in the literature.

Chlorhexidine, a general inhibitor of both MMPs and cysteine cathepsins, applied before primer/adhesive application is the most tested method.

Enzyme-inhibiting monomers and antimicrobial compounds are being considered as promising alternatives that would allow more simple clinical application

Cross-linking collagen and/or dentine organic matrix-bound enzymes could render the hybrid layer organic matrix more resistant to degradation

Complete removal of water from the hybrid layer with solvents or biomimetic remineralization could eliminate hydrolysis of both collagen and resin components
A Few Key Points

• Consider the tooth substrate before choosing an adhesive.
• Whenever enamel is present use phosphoric acid etchant - with the time of application determined by the quality of enamel.
• Shallow cavities in young patients provide accessible collagen within the dentine for formation of predictable resin interpenetration (hybrid zone).
• Deep cavities produce weaker hybrid zones and GIC may be a better option.
• Older patients with sclerotic or heavily calcified dentine are more difficult to create hybrid zones, and GIC may be a better option.
• Do not over dry or dessicate dentine when using resin based adhesives or GIC
• You may need several different adhesive systems in your practice to maximise performance in all bonding situations.
• Certain adhesives can be used with different techniques, but at present no one system appears ideal for all situations.
Volatile solvent
- do not predispense
- dispense immediately before use
- directly onto brush

Resin component
- avoid contact with skin / eyes etc
- may be quite acidic
- HEMA vs non-HEMA
Gloves are porous
Sensitivity to resins
Irritation to skin
Some more Key Points

• Universal adhesives can result in good dentine bonding, in either Total Etch or Self Etch modes.
• The Selective-etch technique is recommended for enamel bonding.
• Some products require a Dual Cure / Self Cure Activator when used with a DC/SC resin composite or cement.
• Universal adhesives chemically bond to zirconia because they contain MDP (or an alternative organo-phosphate) but light-curing is required.
• Universal adhesives can function as a zirconia primer.
• Universal adhesives do not chemically bond to silica-containing ceramics, even when silane is added to the adhesive formula.
• Universal adhesives do not function as a porcelain primer.
• Please read instructions and follow manufacturers directions.
• Do not mix / swap different components from different manufacturers.
Glass-Ionomer Cement Classification

1. Traditional Glass-Ionomer *(Chemical Cure)*
   a) Type I: Luting Cement
   b) Type II: Restorative Cement
   c) Type III: Liners and Bases

2. Metal Modified Glass-Ionomer *(Chemical Cure)*
   a) Cermet cement

3. Resin Modified Glass-Ionomer (RMGI) / Resin Reinforced Glass-Ionomer (RRGI)
   *(Chemical Cure / Dual Cure / Tri Cure)*
   a) Type I: Luting Cement
   b) Type II: Restorative Cement
   c) Type III: Liners and Bases

4. Hybrid materials *(Light Cure)*
   a) Polyacid modified resins (PAMR) - Compomer
Glass-Ionomer Cement Products

- **Type I** - Luting
  - Fuji I, Ketac Cem, Riva Luting

- **Type II** - Restorative / Restorative Enhanced
  - Fuji II, Ketac Fil, Riva Self Cure, Ionofil Plus *(Original Formulations)*
  - Ketac Silver, Miracle Mix, Riva Silver, Argion *(Cermet Cements)*
  - Fuji IX, Equia Forte Fil, Fuji Bulk, Ketac Molar, Riva Self Cure HV, Ionofil Molar *(Reinforced)*
  - Fuji VII, Fuji VII EP, Riva Protect *(High Fluoride Release)*

- **Type III** - Lining
  - Fuji Lining Cement, Ketac Bond, Ionobond

The above are conventional GIC (no added resin) and set by chemical reaction only

- **Resin Modified / Resin Reinforced (RMGIC / RRGIC)** *(Chemical Cure, Dual Cure, Tri Cure)*
  - **Luting** - Fuji Plus, Fuji Cem, Vitremer Luting, Riva Luting Plus
  - **Restorative** - Fuji II LC, Fuji VIII, Photac Fil, Ketac Nano, Riva LC, Ionolux
  - **Lining** - Fuji Lining LC, Vitrebond, Ionoseal
<table>
<thead>
<tr>
<th>WHEN TO USE</th>
<th>OR</th>
<th>WHEN NOT TO USE</th>
</tr>
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<tbody>
<tr>
<td>High caries risk patients</td>
<td></td>
<td>High strength required</td>
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<tr>
<td>Disease reduction / stabilisation</td>
<td></td>
<td>Aesthetics a high priority</td>
</tr>
<tr>
<td>Aesthetics not a high priority</td>
<td></td>
<td>High functional load</td>
</tr>
<tr>
<td>Moderate functional load</td>
<td></td>
<td>Acidic oral environment</td>
</tr>
<tr>
<td>Compromised tooth substrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture control not ideal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic / Environmental restrictions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acidic oral environment</td>
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Glass Ionomers

Glass Ionomers in Contemporary Restorative Dentistry -- A Clinical Update

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Figure 9. Closed sandwich technique. Missing dentin in a Class II cavity is replaced with either a resin-modified or high-viscosity glass ionomer. Composite resin is used to replace enamel and seal the enamel margins surrounding the cavity (Adapted from Ferrari77).

Figure 10. Open sandwich technique. This modification of the closed sandwich is utilized in Class II cavities lacking enamel at the cervical margin. A glass ionomer is used in lieu of composite resin to restore the cervical aspect of the proximal box, imparting optimal resistance to microleakage and secondary caries along dentin margins (Adapted from Ferrari77).
### Effect of open-sandwich vs. adhesive restorative techniques on enamel and dentine demineralization: an in situ study.

Conventional GICs should be considered the materials of choice for lining of cavities not having all margins in enamel, particularly using the open sandwich technique.


### Cervical microleakage in Class II open-sandwich restorations: an in vitro study.

The use of glass-ionomer in the open-sandwich resulted in the least microleakage (after thermocycling) when the cervical margins of Class II restorations were placed in dentine.


### Inhibition of dentine demineralization adjacent to a glass-ionomer composite sandwich restoration.

Glass-ionomer liners in an open-sandwich restoration exhibited pronounced inhibition zones at the dentine margin and lowered the amount of mineral loss in the vicinity of 0.25 mm from the restoration interface.


### Durability of extensive Class II open-sandwich restorations with a resin-modified glass ionomer cement after 6 years.

It can be concluded that the modified open sandwich restoration showed an acceptable durability for the extensive restorations evaluated. An accelerating dissolution of the RMGIC was observed at the end of the study.

The results of this study suggest that class-II restorations made of Fuji IX GP are susceptible to loss of material on proximal surfaces. In location these defects show similarity with carious lesions.
Suggested technique:

It is suggested not to place the resin composite-GIC margin in the red zone but move it as far as practicable into the green zone.

Finishing the resin composite-GIC margin too close to the contact area (left) may predispose the GIC to dissolution in the area shown (right).

Moving the resin composite-GIC margin well into the embrasure area is recommended.
Keep GIC clear of a contact area.

Possibly because it is a potential area of plaque accumulation and therefore acid production, the contact area in Class II (approximo-occlusal) GIC restorations is vulnerable to dissolution.*

Tip: If using GIC in an approximal box in the ‘open sandwich’ technique keep the material well below the contact area to minimise the possibility of any localised loss of the material at this site.

* A long-term study (6 years) found that Class 2 Fuji IX (GC) restorations performed very well except at the contact area. Approximately 60% of the restorations showed some dissolution of material at this site. (Scholtanus JD, Huysmans MC. Clinical failure of class-II restorations of a highly viscous glass-ionomer material over a 6-year period: a retrospective study. J Dent. 2007;35:156-162).

Right top: In the ‘open sandwich’ technique place the resin composite-GIC margin in the green zone not in the red zone.
Right below: Illustration of the suggested amount of clearance from the contact area.
Effect of glass ionomer cement and fluoride varnish on the remineralization of artificial proximal caries in situ.


GIC promotes more remineralization of carious lesions on proximal surfaces than F-varnish.
<table>
<thead>
<tr>
<th>Product</th>
<th>Features</th>
<th>Primary indication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuji BULK</strong></td>
<td>• Rapid set</td>
<td>Any restoration where speed, acid resistance and bulk cure are priorities over aesthetics.</td>
</tr>
<tr>
<td>Conventional auto-cure GIC</td>
<td>• Acid resistance</td>
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<td></td>
<td>• Radiopacity</td>
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<tr>
<td></td>
<td>• 1 shade</td>
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<tr>
<td>Dr G Milicich, NZ</td>
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<tr>
<td><strong>EQUIA Forte™ Fil &amp; Coat</strong></td>
<td>• Strength</td>
<td>Proven system for occlusal restorations'</td>
</tr>
<tr>
<td>Conventional auto-cure GIC &amp; LC Coat</td>
<td>• Aesthetics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Wear resistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 8 shades</td>
<td></td>
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<tr>
<td>Dr G Milicich, NZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuji VIII gp</strong></td>
<td>• Easy to handle</td>
<td>Open and closed sandwich restorations</td>
</tr>
<tr>
<td>Resin reinforced auto-cure GIC</td>
<td>• Tough</td>
<td></td>
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<tr>
<td></td>
<td>• Quick setting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 3 shades</td>
<td></td>
</tr>
<tr>
<td>Dr J Smithson, UK</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuji II LC</strong></td>
<td>• Aesthetics</td>
<td>Class V restorations</td>
</tr>
<tr>
<td>Resin reinforced dual-cure GIC</td>
<td>• Light-cure</td>
<td></td>
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<tr>
<td></td>
<td>• Strong adhesion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 11 shades</td>
<td></td>
</tr>
<tr>
<td>Dr S Saito, Japan</td>
<td></td>
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</tr>
</tbody>
</table>
Fuji BULK strengthens and protects surrounding tooth structures

Fuji BULK was designed with hostile oral environments in mind, recognising the growing need for a bulk-cure, self-adhesive restorative that could provide a balance between restoring function and protecting surrounding and adjacent tooth surfaces.

Fuji BULK could be your first choice as a base in the sandwich technique, is perfectly suited to geriatric and paediatric restorations, and its speed of set makes it ideal for emergency, transitional or stabilisation procedures.

pH 4.0 lactic acid challenge*

Fuji BULK protects the tooth and restores function

Composite resin restores function, but gives no protection
<table>
<thead>
<tr>
<th>Product</th>
<th>Fuji BULK</th>
<th>EQUIA Forte Fil</th>
<th>Fuji VIII GP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing time (from IFU)</td>
<td>10″</td>
<td>10″</td>
<td>10″</td>
</tr>
<tr>
<td>Moisture critical time (from IFU)</td>
<td>2'00″</td>
<td>2'30″</td>
<td>3'00″</td>
</tr>
<tr>
<td>Compressive Strength [MPa]*</td>
<td>215±20</td>
<td>219±16</td>
<td>175</td>
</tr>
<tr>
<td>Flexural Strength [MPa]*</td>
<td>44±5.8</td>
<td>43±4.0</td>
<td>54</td>
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<tr>
<td>Flexural Energy [MPa]*</td>
<td>0.06</td>
<td>0.06</td>
<td>0.22</td>
</tr>
<tr>
<td>Wear resistance [µm]</td>
<td>27±3.8</td>
<td>20±5.4</td>
<td></td>
</tr>
<tr>
<td>- with EQUIA Forte Coat</td>
<td>12±7.6</td>
<td>11±5.3</td>
<td></td>
</tr>
<tr>
<td>Radiopacity [mm]°</td>
<td>3.3</td>
<td>2.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Shear Bond strength [MPa]#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Bovine enamel (1 day)</td>
<td>9.0±0.7</td>
<td>10.3±0.3</td>
<td>22.8±2.9</td>
</tr>
<tr>
<td>- Bovine dentine (1 day)</td>
<td>9.7±0.7</td>
<td>10.2±0.5</td>
<td>15.3±3.4</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>IDEAL FOR</td>
<td>GREAT FOR</td>
<td>HANDLING</td>
</tr>
<tr>
<td>---------</td>
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</tr>
</tbody>
</table>
| EQUIA® Forte Fil & Coat (Auto-cure GIC & LC Coat) | Restorations where occlusal wear resistance and aesthetics are priorities | • Occlusal, proximal and cervical restorations  
• Sandwich restorations - closed and open  
• Transitional restorations | Manipulation time  
Moisture critical time  
Finishing time | • Shades: A1, A2, A3, A3.5, B1, B2, B3, C4  
• Great translucency |
| Fuji® BULK (Auto-cure GIC) | Restorations where acid resistance, protection of surrounding surfaces and speed of bulk cure are priorities | • Selected occlusal, proximal and cervical restorations  
• Sandwich restorations - closed and open  
• Transitional restorations | Manipulation time  
Moisture critical time  
Finishing time | • 1 shade (A3 opaque)  
• High opacity |
| Fuji VIII GP (Auto-cure, resin-reinforced GIC) | Cervical and sandwich technique restorations where acid resistance, fracture toughness and speed of placement are priorities | • Sandwich restorations - closed and open  
• Cervical restorations  
• Transitional restorations | Manipulation time  
Moisture critical time  
Finishing time | • Shades: A2, A3, A3.5  
• Very good translucency |

Application time of resin bond for sandwich restorations:
- Immediate for hydrophobic resin bond, eg Stick Resin
- 3 min for hydrophilic resin bond eg G-sonic Bond.
KEY POINTS

**GIC Manipulation Time** includes an initial wet and glossy stage, which is essential for establishing chemical bonding to the tooth. This is followed by a short gel stage where contouring of the GIC is possible. The end of the manipulation time is reached shortly after the loss of surface gloss of the GIC.

**GIC Moisture Critical Time** is the period from start of mix where moisture contamination of the GIC should be avoided.
<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>IDEAL FOR</th>
<th>GREAT FOR</th>
<th>HANDLING</th>
<th>AESTHETICS</th>
</tr>
</thead>
</table>
| EQUIA® Forte Fil & Coat (Auto-cure GIC & LC Coat) | Restorations where occlusal wear resistance and aesthetics are priorities | • Occlusal, proximal and cervical restorations  
• Sandwich restorations - closed and open  
• Transitional restorations | Manipulation time  
Moisture critical time  
Finishing time | • Shades: A1, A2, A3, A3.5, B1, B2, B3, C4  
• Great translucency |
| Fuji VII (Auto-cure GIC) | Protection of “at-risk” surfaces, including erupting molars (fissure protection) and exposed root surfaces, and for caries stabilisation | • Fissure protection  
• Protection of root surfaces  
• Endo access  
• Caries stabilisation | Manipulation time  
Moisture critical time  
Finishing time | • Shades: White and Pink  
• High opacity |
| Fuji IX gp FAST (Auto-cure GIC) | General purpose “all rounder” GIC | • Selected occlusal, proximal and cervical restorations  
• Sandwich restorations - closed  
• Transitional restorations | Manipulation time  
Moisture critical time  
Finishing time | • Shades: A2, A3, A3.5, B2, B3, C4 |
| Fuji IX gp (Auto-cure GIC) | General purpose “all rounder” GIC | • Selected occlusal, proximal and cervical restorations  
• Sandwich restorations - closed  
• Transitional restorations | Manipulation time  
Moisture critical time  
Finishing time | • Shades: A2, A3, A3.5, B2, B3, C4 |
<table>
<thead>
<tr>
<th>Highest</th>
<th>Fluoride Release</th>
<th>Solubility</th>
<th>Aesthetics</th>
<th>Compressive Strength</th>
<th>Fracture Toughness</th>
<th>Moisture Critical Time</th>
<th>Radiopacity</th>
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<tbody>
<tr>
<td>Fuji 7</td>
<td>Fuji 7</td>
<td>Fuji 2 LC</td>
<td>Equia Forte Fil</td>
<td>Fuji 8</td>
<td>Fuji 8</td>
<td>Fuji 8</td>
<td>Fuji Bulk</td>
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<tr>
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<td>Fuji 7 EP</td>
<td>Fuji 8</td>
<td>Fuji Bulk</td>
<td>Fuji 2 LC</td>
<td>Fuji 7</td>
<td>Fuji 7</td>
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<td>Fuji IX Extra</td>
<td>Fuji IX Extra</td>
<td>Fuji IX Extra</td>
<td>Fuji Bulk</td>
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<td>Fuji IX Extra</td>
<td>Equia Forte Fil</td>
<td>Equia Forte Fil</td>
<td>Fuji 8</td>
<td>Equia Forte Fil</td>
<td>Fuji IX Extra</td>
<td>Fuji 7</td>
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<td>Fuji 8</td>
<td>Fuji Bulk ★</td>
<td>Fuji Bulk</td>
<td>Fuji 2 LC</td>
<td>Fuji IX Extra</td>
<td>Equia Forte Fil</td>
<td>Fuji 7 EP</td>
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<tr>
<td>Fuji 2 LC</td>
<td>Fuji 2 LC ★</td>
<td>Fuji 7 EP</td>
<td>Fuji 7</td>
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<td>Fuji Bulk</td>
<td>Fuji IX Extra</td>
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<td>Fuji Bulk</td>
<td>Fuji 8</td>
<td>★ Fuji 7</td>
<td>Fuji 7 EP</td>
<td>Fuji 7 EP</td>
<td>Fuji 7 EP</td>
<td>Fuji 2 LC</td>
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<td>Lowest</td>
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</table>

★ Test methods differ
Therapeutic, Biomimetic and Bioactive Materials

**Therapeutic:**
Materials that deals specifically with the treatment of disease and the art and science of healing, and the use of such materials and the method of their administration in the treatment of disease.

**Biomimetic:**
Often termed biomimicry, is the imitation of nature for the purpose of replacing or repairing lost or damaged human tissue. It can include physical, chemical, functional and aesthetic aspects.

**Bioactive:**
Materials that have an effect on a living organism, tissue or cell that may repair or replace lost and damaged tissue, and promote good health.
General Material Usage Rule

It is very difficult if not impossible for one restorative material to mimic both enamel and dentine, therefore consider;

- **Glass Ionomer** is a **dentine replacement** material
- **Composite Resin** is an **enamel replacement** material

Glass ionomer may be used as provisional restoration and cut back to a base for final restoration at a later stage.