Resin-modified glass-ionomer cement.

Two example products from the resin-modified glass-ionomer cement range (see below). Above: Fuji Plus (GC Corp). Above right: RelyX Luting Plus (3M Espe).

Resin-modified glass-ionomer cements are commonly used luting agents. They have the advantage of bonding to tooth structure, fluoride release and good biocompatibility. In addition, they have higher flexural and tensile strengths than conventional glass-ionomer cement and are not as susceptible to early water degradation.

Example products >>

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuji Plus</td>
<td>GC Corp</td>
</tr>
<tr>
<td>FujiCem</td>
<td>GC Corp</td>
</tr>
<tr>
<td>Meron Plus</td>
<td>Voco</td>
</tr>
<tr>
<td>Meron Plus AC</td>
<td>Voco</td>
</tr>
<tr>
<td>RelyX Luting Plus</td>
<td>3M Espe</td>
</tr>
<tr>
<td>RelyX Luting</td>
<td>3M Espe</td>
</tr>
<tr>
<td>Riva Luting Plus</td>
<td>SDI</td>
</tr>
</tbody>
</table>

Uses >>

These cements can be used to lute:

- Porcelain-fused-to-metal crowns and bridges.
- Metal crowns, bridges, inlays and onlays.
- Prefabricated metal provisional crowns.
- Zirconia- and alumina-cored all-ceramic crowns and bridges.
- Prefabricated or cast posts.

Early concerns were that, because of delayed expansion through water sorption, they could not be used for luting alumina-cored, all-ceramic crowns such as Procera AllCeram.

However, this proved unfounded and, as just shown, they can be used for luting both alumina- and zirconia-cored all-ceramic crowns and bridges.

Resin-modified glass-ionomer cement, in contrast to conventional glass-ionomer cement, can bond to resin composite and a silane layer on etched porcelain.

Clinical performance >>

Clinical trials have indicated a good clinical performance.

A trial comparing Fuji Plus (GC Corp) with Panavia 21 (Kuraray) for the luting of ceramic inlays showed an equivalent performance over 5 years.

When compared to zinc phosphate cement, it was found that resin-modified glass-ionomer cement retained crowns just as effectively over a period of 6.5 to 8.5 years. The crowns were either metal-ceramic or all ceramic with an alumina core.
Resin-modified glass-ionomer cement. (cont)

Clinical points >>

To obtain the optimum results with resin-modified glass-ionomer cements keep in mind that:

- It is best not to over-dry the preparation. If in doubt, apply just enough water with a microbrush to make the surface slightly glossy.
- The presence of air bubbles can be a problem in triturated or hand-mixed resin-modified glass-ionomer cement. (A technique for releasing any trapped air bubbles after mixing is shown opposite).
- Maintain pressure on the restoration until the cement has reached the gel stage. Excess material is best removed just after the initial gel stage.
- For situations where a longer working time is required, such as luting a post in a root canal, use a product such as Fuji Plus EWT (GC Corp).

Summary >>

A good standard luting cement for many applications including luting of metal crowns, inlays and onlays, and metal-ceramic crowns.  
Recently found to be by far the most popular luting agent for implant crowns and conventional bridgework used in US dental schools.  

Conventional glass-ionomer cement.

Conventional glass-ionomer cements have a long history of use as luting agents. They have the advantage of bonding to tooth structure, fluoride release and good biocompatibility.

Their main disadvantages are sensitivity to early moisture contamination, low tensile strength and some susceptibility to acid dissolution.
Conventional glass-ionomer cement. (cont)

**Example products >>**

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketac-cem</td>
<td>3M Espe</td>
</tr>
<tr>
<td>Fuji 1</td>
<td>GC Corp</td>
</tr>
<tr>
<td>Aqua Meron</td>
<td>Voco</td>
</tr>
<tr>
<td>Meron</td>
<td>Voco</td>
</tr>
</tbody>
</table>

**Uses >>**

- These cements can be used to lute:
  - Porcelain-fused-to-metal crowns and bridges.
  - Metal crowns, bridges, inlays and onlays.
  - Prefabricated metal provisional crowns.
  - Zirconia- and alumina-cored all-ceramic crowns and bridges.
  - Prefabricated or cast posts.

**Clinical performance >>**

One study of almost 1500 cast restorations placed in private practice over 5 years showed excellent retention of castings, good compatibility with the pulp and an exceptionally low rate of secondary caries.

**Clinical points >>**

The same points mentioned on the previous page for resin-modified glass-ionomer cements apply to conventional glass-ionomer cements.

- The preparation surface should be slightly moist and precautions taken to remove air bubbles from the freshly-mixed cement.
- Do not remove any marginal excess until the cement is fully set.

**Summary >>**

A traditional luting cement with many useful properties for various applications including luting of metal crowns, inlays and onlays, and metal-ceramic crowns.

Tends to have been surpassed by resin-luting cements because of their improved properties including better resistance to early moisture contamination.

---

**Zinc phosphate cement.**


Zinc phosphate cements have been used in dentistry for over 100 years. Despite this they still perform remarkably well and on equal terms to many of the newer materials.

Although they do not bond to either tooth structure or restoration, when freshly mixed they have a very low pH.
Zinc phosphate cement. (cont)

This acidity allows for excellent wetting of the tooth surface and the development of micro-mechanical interlocking between cement and tooth. 4

Example products >>

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hy-Bond Zinc Cement</td>
<td>Shofu</td>
</tr>
<tr>
<td>DeTrey Zinc</td>
<td>Dentsply</td>
</tr>
</tbody>
</table>

Uses >>

These cements can be used to lute:
- Porcelain-fused-to-metal crowns and bridges.
- Metal crowns, bridges, inlays and onlays.
- Prefabricated metal provisional crowns.
- Zirconia- and alumina-cored all-ceramic crowns and bridges.
- Prefabricated or cast posts.

Clinical performance >>

An examination of 1,314 cast-gold inlays placed 1 to 52 years previously found a 94.1% survival rate for restorations placed more than 40 years earlier. 8

All the restorations had been luted with zinc phosphate cement. Zinc phosphate cement was found to retain metal-ceramic and all-ceramic crowns as effectively as resin-modified glass-ionomer cement over a 6.5- to 8.5- year period. 3

A clinical trial begun in 2003 found that, after a mean period of 3.16 years, metal-based bridges were retained just as effectively with zinc phosphate cement as with a self-adhesive resin cement (RelyX Unicem - 3M Espe). 9

Clinical points >>

Mixing the material correctly is important.
- The glass-mixing slab should be cool to help dissipate heat from the exothermic reaction during mixing.
- The powder should be divided into around 6 increments and each increment mixed into the liquid for 15 seconds. It should take around 90 seconds to obtain the correct consistency.
- An indication of the correct consistency for luting being obtained is that a spatula placed into the mix can be withdrawn for over 2.5 cm without the attached string of cement breaking.
- Mixed correctly it has a long working time making it useful for cementing multi-unit bridgework.

Summary >>

A traditional luting cement with a long record of successful clinical use for various applications including luting of metal crowns, inlays and onlays, and metal-ceramic crowns. 7

To date, it has not been surpassed in clinical performance by some of the newer luting agents including one-step, self-adhesive resin cements.
Resin cements. (a) Three-step (total etch) type.

Two examples of the 3-step type of resin cements. Above: Variolink II [Ivoclar Vivadent]. Above right: Calibra [Dentsply]. A list of example products is shown below.

**Example products >>**

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variolink ll</td>
<td>Ivoclar</td>
</tr>
<tr>
<td>Dual cement</td>
<td>Ivoclar</td>
</tr>
<tr>
<td>Calibra</td>
<td>Dentsply</td>
</tr>
<tr>
<td>Comspan</td>
<td>Dentsply</td>
</tr>
<tr>
<td>RelyX Arc</td>
<td>3M Espe</td>
</tr>
<tr>
<td>TwinLook</td>
<td>Heraeus Kulzer</td>
</tr>
<tr>
<td>NX3 Nexus</td>
<td>Kerr</td>
</tr>
<tr>
<td>C&amp;B Cement</td>
<td>Bisco</td>
</tr>
<tr>
<td>Duolink</td>
<td>Bisco</td>
</tr>
<tr>
<td>Duo Cement</td>
<td>Coltene</td>
</tr>
<tr>
<td>Plus</td>
<td>Whaledent</td>
</tr>
<tr>
<td>PermaFlo DC</td>
<td>Ultradent</td>
</tr>
</tbody>
</table>

Details of uses, clinical performance and clinical points relating to this group are given on the next page. >>

**Summary >>**

As presented on the next page with the addition that this group is the most technique sensitive of all the resin cements.

Resin cements. (b) Two-step (self-etch) type.

**Example products >>**

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panavia F 2.0</td>
<td>Kuraray</td>
</tr>
<tr>
<td>Clearfil Esthetic and DC Bond</td>
<td>Kuraray</td>
</tr>
</tbody>
</table>

Left: An example of the self-etch type of resin cement (Panavia F 2.0 [Kuraray]).

Resin cements of the self-etch type utilise two steps: (i) application of a self-etching primer and (ii) placement of the resin cement.

They have good physical properties and, because they have one less step, are regarded as being less technique sensitive than the etch and rinse resin cements.

Users of Panavia F 2.0 should note that the radiopacity of the material is low and is similar to that of dentine. 18
Resin cements. Two- and three-step types. (cont)

Uses >>
These cements can be used to lute:
- Porcelain-fused-to-metal crowns and bridges.
- Metal crowns, bridges, inlays and onlays including crowns and bridges with reduced tooth structure and less-than-optimal resistance form.
- Maryland-type resin-bonded bridges.
- All ceramic and indirect resin-composite crowns, bridges, inlays and onlays
- Prefabricated or cast posts.

Clinical performance >>
Several clinical studies show excellent long-term clinical success of resin-bonded inlays, onlays, porcelain veneers and crowns. The materials have the highest physical properties of all the luting cements including:
- High compressive and flexural strengths.
- Good fracture toughness.
- Low solubility.

Clinical points >>
The major weakness of these materials is technique sensitivity:
1. Meticulous dryness is required to achieve good bonding and for minimising post-operative sensitivity.
2. Areas that are difficult to isolate, such as posterior molar areas, particularly in the lower arch, are the least suited to these types of luting agents.
3. Effective isolation must be maintained throughout each of the various steps involved, which can prove challenging.
4. It is easier to achieve the required degree of isolation in the anterior areas of the mouth.
5. If there is a marginal excess of polymerised material, particularly interproximally, it can be extremely difficult to remove.
6. Dual-cure versions are more technique sensitive than the light-cured alternatives.
Some techniques to minimise clean-up problems with resin cements are shown on pages 114 -115.

Summary >>
These resin luting agents have very good physical properties. However, the main disadvantage is a high degree of technique sensitivity.

Some techniques for minimising clean-up problems with resin cements.
One of the challenges that can be experienced when luting with two- and three-step resin cements in particular, is removing excess material from margins once the cement has polymerised. This can be particularly so in difficult-to-access approximal locations.
Some techniques to help minimise the problem are shown.

3-second ‘tack’ method.
With this method, the restoration is given a brief 3-second exposure to the curing light.
Some techniques for minimising clean-up problems with resin cements >> (cont)

1 3-second ‘tack’ method. (cont)

The partially-polymerised excess resin is removed carefully with a suitable instrument. A sharp H6/H7 sickle scaler or a no. 12 scalpel may be useful to remove excess from approximal-surface margins.

2 Brush and super-floss method. 10

Before any exposure to the curing light, a small brush is used to remove excess resin from accessible margins.

Holding the restoration in place, the firmer end of a length of super floss is introduced into the interproximal space. It is drawn through laterally to remove excess resin from the gingival margin area.

The restoration is then exposed to the curing light. The margins are then checked for any remaining material. A sickle scaler or scalpel as shown above can be used for any remaining minor clean-up of approximal-surface margins.

3 Light on - light off method. 11

A modification of the above techniques for dual-cure resins is to turn the operating light off and on at the appropriate times.

a and b. After the restoration is seated the light is turned off whilst gross excess is removed with a cotton roll.

c and d. The light is turned back on and as material starts to gel, excess at the gingival margin is gently removed with a probe.

After this the restoration is ‘tacked’ in place by a 5-second exposure to the curing light [from occlusal direction only]. Waxed floss is passed through the contact area to the gingival margin to remove any remaining excess cement.

The restoration is then given a prolonged exposure to the curing light. Any remaining excess is then removed as described as above.
Resin cements. Self-adhesive type.

Two examples of the one-step, self-adhesive type of resin cements listed below. Above: RelyX Unicem Cem (3M Espe). Above right: Maxcem Elite (Kerr).

Example products >>

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Product</th>
<th>Manufacturer</th>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>RelyX Unicem</td>
<td>3M Espe</td>
<td>G-Cem</td>
<td>GC Corp</td>
<td>Embrace</td>
<td>Pulpdent</td>
</tr>
<tr>
<td>MaxCem Elite</td>
<td>Kerr Dental</td>
<td>iCem</td>
<td>Heraeus Kulzer</td>
<td>MonoCem</td>
<td>Shofu</td>
</tr>
<tr>
<td>SmartCem 2</td>
<td>Dentsply Caulk</td>
<td>Set</td>
<td>SDI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BisCem</td>
<td>Bisco</td>
<td>Breeze</td>
<td>Pentron</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Uses >>

These cements can be used to lute:
- Porcelain-fused-to-metal crowns and bridges.
- Metal crowns, bridges, inlays and onlays.
- All ceramic and indirect resin-composite crowns, bridges, inlays and onlays.
- Prefabricated or cast posts.

Until more information is available on longer-term colour changes, it may not be advisable to use them for luting translucent ceramic restorations. These include porcelain veneers and pressed-ceramic crowns.

Clinical performance >>

A 3-year study found that RelyX Unicem (3M Espe) retained zirconia-core, all-ceramic crowns adequately.

A clinical trial begun in 2003 found that RelyX Unicem retained metal-based bridges as effectively as zinc phosphate cement.

The performance of both types of luting agent were equivalent after an average period of 3.16 years.

No longer-term clinical reports were found for other cements in this category.

Clinical points >>

Using RelyX Unicem as the example, it is easy to mix, has adequate working time and any marginal excess is simply removed at the gel stage.

Studies with this product indicate that:
1. For a strong bond to enamel, selective etching of the enamel, not dentine, with
2. After placement, the self-curing capacity of the cement is limited and, for a faster degree of polymerisation, exposure to a curing light is necessary.

If used for luting posts in root canals it is important not to use a Lentulo spiral for cement placement.

35% phosphoric acid is needed.
Resin cements. Self-adhesive type. (cont)

Two factors that can influence cement selection.

A suggested ‘rule-of-thumb’ for cement selection is to use the least technique-sensitive material wherever possible.

Two factors that can help in making a decision are:

1. **Degree of resistance and retention form.**
   - Ideally, a preparation has the resistance and retention form to minimise any dislodgement of the subsequent crown or inlay.
   - Lack of retention and resistance form is the major reason that restorations become uncemented.
   - If the preparation has questionable retention and resistance form, it may limit selection to one of the two- or three-step resin cements.

2. **Location of cervical margin.**
   - If the cervical margin of a preparation finishes sub-gingivally, meticulous dryness of the area is needed before the restoration is luted.
   - Any moisture can compromise the marginal seal, thereby increasing the possibility of microleakage.
   - If moisture control is going to be a problem, a cement with reduced moisture sensitivity, such as a resin-modified glass-ionomer cement, may be required.

*Left:* If a cervical margin finishes sub-gingivally any moisture can compromise the marginal seal of a luting cement. If achieving a dry environment is a difficulty, then a less moisture-sensitive cement such as resin-modified glass-ionomer cement may be necessary.

*Right:* A preparation with an optimal taper, adequate height and an anti-rotation feature, as shown above, has good retention and resistance form. In such cases, a straightforward, low-technique-sensitive luting agent can be used.

*Top:* To obtain a stronger bond with RelyX Unicem, enamel (not dentine) needs to be selectively etched with 35% phosphoric acid for 15 seconds.

*Right:*Expose newly placed RelyX Unicem to a curing light to hasten polymerisation as its initial self-curing capacity is limited.

Summary >>

This type of resin cement has addressed technique-sensitivity issues seen with the two- and three-step resin cements.

However, to date, they have not demonstrated any marked clinical superiority to the more traditional luting materials such as zinc phosphate cement.
Cement-selection guidelines for specific restorations.

The following guidelines, unless indicated otherwise, apply to preparations with good resistance and retention form. Although a variety of cements may be used for a particular type of preparation, the least technique-sensitive material with a good track record is chosen. Also it should be kept in mind that impressive results in laboratory testing do not necessarily translate into good clinical performance.

Porcelain-fused-to-metal crowns and gold crowns/inlays. Two cements with a good track record and low technique sensitivity for these type of restorations are:

- **Resin-modified glass-ionomer cement.** A good standard luting cement with useful physical properties. > User friendly. > Not as sensitive to early moisture contamination as conventional glass-ionomer cement.
- **Zinc phosphate cement.** Still a very good luting agent that, to date, has not been surpassed by the newer one-step, self-adhesive resins. > Has a long history of successful use. > Straight forward to use. > Has a long working time when correctly mixed and therefore most useful for multi-unit bridgework.

All-ceramic crowns with a zirconia core.*

- **Resin-modified glass-ionomer cement, glass-ionomer cement, zinc phosphate cement or self-adhesive resin cement** can be used. These are low-technique-sensitivity luting cements. All-ceramic crowns with a zirconia core have a non-etchable fitting surface. The above cements can also be used with alumina-coping-based crowns which also have a non-etchable fitting surface.** Not all the above cements have been tested in clinical trials. To date the longest trial, 3 years, showed that the self-adhesive resin cement, RelyX Unicem (3M Espe), performed adequately. 12

All-ceramic crowns, inlays and onlays with an etchable fitting surface.

Resin cements either light-cured or dual-cured are traditionally used for luting these restorations.

- **Light-cured resin cement.** Can be used in areas of aesthetic importance if the ceramic is not too opaque or too thick. It has been suggested that it can be used for ceramic restorations less than 3 mm in thickness. 15
Cement-selection guidelines for specific restorations. (cont)

All-ceramic crowns, inlays and onlays with an etchable fitting surface. (cont)

Although the majority of resin cements are now dual cured, if a light-cured material can be used it does have advantages. These include: > Increased working time. > Easier clean up of marginal excess. > Greater colour stability because there is no tertiary amine degradation. > Less porosity because no mixing is involved.

Tip: Excessive bulk of ceramic inlays and onlays can be avoided by building the tooth up with resin composite prior to tooth preparation, as reported in an earlier issue of Dental Outlook. This allows a ceramic thickness to be obtained that is suitable for light curing.

Porcelain veneers.

With porcelain veneers, aesthetics are of prime importance, therefore colour stability of the cement is a major consideration.

- Light-cured resin cement. Is the luting cement of choice as it is more colour stable than the dual-cured alternative. Using a heavier filled material makes clean-up easier. Some example products in this category are shown below.*

Bonded bridges.

The choice is between self-curing and dual-curing resin cements.

- Self-cured resin cement. Is the luting cement of choice for many situations as it eliminates concerns about adequate curing in remote sections of the metal-tooth interface. Example products in this category include Comspan (Dentsply) and C&B Cement (Bisco).

Posts in root canals.

The choice of cement for cementing posts in root canals depends on a number of factors including the type of post and whether it has distinct retentive features.

If bonding of the cement to the post and the root-canal walls is required then use of one of the resin cements is indicated.

- Resin-modified glass-ionomer cement, glass-ionomer cement or zinc phosphate cement can be used for luting, in a simplified approach, especially if the post has distinct retentive features and the walls of the post-hole are slightly roughened.

* Light-curing resin cements:

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Manufacturer</th>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>RelyX Veneer</td>
<td>3M Espe</td>
<td>Bisco</td>
<td>Choice 2</td>
<td>Ivoclar</td>
</tr>
<tr>
<td>Variolink Veneer</td>
<td>3M Espe</td>
<td>Bisco</td>
<td>Calibra</td>
<td>Bisco</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NX3 Nexus</td>
<td>Dentsply</td>
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<td></td>
<td></td>
<td></td>
<td>Clearfil Esthetic Cement</td>
<td>Kerr Dental</td>
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<td></td>
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<td>Kuraray</td>
</tr>
</tbody>
</table>
A useful tip for a faster clean-up of a preparation prior to crown cementation is to mix pumice powder with 3% hydrogen peroxide.

Rather than using a stiff, webbed prophylaxis cup, use a soft grey, ribbed type such as a Hawe Product No.1800/30 (Kerr).

References: