Resin luting materials

...majoring on self-adhesive resin cements
“I am not paid by any company to promote their products”

“Some manufacturers fund my research: I was involved in the early research on Unicem”

“I will try to be evidence-based rather than anecdotal”
What I plan to talk about:

- A brief history of luting materials
- Why resin cement is best
- The dentine-bonded all-ceramic crown
- Self adhesive resin luting
- Clinical evaluation of Unicem
Ideal requirements of luting material

Combe, Burke & Douglas, 1999

- Biocompatible
- Cariostatic
- Adhesive to tooth structure
- Prevent leakage
- Insoluble in the dilute organic acids found in plaque
Ideal requirements of luting material

- Resistant to water absorption
- Sufficient tensile & compressive strengths
- Available in a range of shades
- Facilitates easy removal of excess
- Low film thickness

Combe, Burke & Douglas, 1999
Factors in selection of luting materials

Combe, Burke & Douglas, 1999

- Type of restoration
- Resistance and retention form
- Available tooth tissue
- Risk of pulpal irritation
- Working time and setting time requirements
Trevor’s simple classification of luting materials

TODAY!

We need active

ACTIVE

PASSIVE

LUTING

LUTING
Review of properties of luting materials

Combe, Burke, Douglas, 2000,
Olio, 1991
Van Zeghbroeck, 1995
Rosenstiel et al., 1998
We thought that this was bonding!
The function of a traditional luting cement is to provide retention by interlocking the minor irregularities on the prepared tooth surface and the restoration surface.

Smith, Wright and Brown, 1986
“I was struck by the readiness by which the oxyphosphate cement laid hold of the amalgam.

This composite filling is suitable for all which are considered suitable for amalgam alone.”
## Zinc Phosphate

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of success</td>
<td>Post-op sensitivity</td>
</tr>
<tr>
<td>Adjustable working time</td>
<td>Long set time</td>
</tr>
<tr>
<td>High impact resistance</td>
<td>Mix technique</td>
</tr>
<tr>
<td>High rigidity</td>
<td>No measurable shear adhesion</td>
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<tr>
<td></td>
<td>High solubility</td>
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<td></td>
<td>Low compressive strength</td>
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<tr>
<td></td>
<td>Low diametral tensile strength</td>
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<td></td>
<td>Low fracture toughness</td>
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</table>

Lactic acid erosion test
Polycarboxylate cement

Soon became Poly-F
<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notable lack of post-op sensitivity</td>
<td>Clean up timing is critical</td>
</tr>
<tr>
<td>Long history of success</td>
<td>High solubility</td>
</tr>
<tr>
<td>Tolerant of mild contamination</td>
<td>Low compressive strength</td>
</tr>
<tr>
<td>Chemical adhesion to tooth</td>
<td>Low tensile strength</td>
</tr>
<tr>
<td>Appearance change at end of working time</td>
<td>Low fracture toughness</td>
</tr>
</tbody>
</table>
Glass-ionomer luting cements

**Advantages**
- Chemical adhesion to tooth
- F release
- Moderate compressive & tensile strengths
- Easy to mix

**Disadvantages**
- Low tensile strength
- Low fracture toughness
- Soluble in oral environment
- History of post-op sensitivity
- Clean-up time is critical
RMGI luting materials

**Advantages**
- Good compressive & tensile strengths
- Resistant to dissolution
- F release
- Reasonable working time
- Easy clean-up

**Disadvantages**
- Not very aesthetic
- Slight expansion on setting (some materials)

Performs well in lactic acid erosion testing
What I plan to talk about:
- A brief history of luting materials
- Why resin cement is best
- The dentine-bonded all-ceramic crown
- Self adhesive resin luting
- Clinical evaluation of Unicem
The retention of gold crowns on human dentine preparations — a comparison of eight cements

By S M BLACK BDS; and G CHARLTON BDS MDS FDSRCS; Department of Conservative Dentistry, University of Edinburgh, Old Surgeons' Hall, Edinburgh

Experiments were carried out to compare the retentive properties of eight dental luting cements, using gold crowns cemented onto human dentine. The order of retention of the cements was: 1 Composite (Panavia-Ex, J & S Davis); 2 Glass-ionomer (AquaCem, DeTrey); Glass-ionomer (Ketac-Bond, Cottrell); and Polycarboxylate (Bondalcap, Vivadent); 3 Polycarboxylate (Poly F Plus, DeTrey); Zinc phosphate (DeTrey); and Zinc phosphate (Phosphacap, Vivadent); and 4 Zinc oxide/eugenol, alumina, EBA (Opotow, Teledyne Getz).

has shown that recementation affects the retention of cement lutes.

Methods and materials

Eight cements were used as shown in Table 1. The crown preparations were made on extracted human teeth. Before preparation the teeth were kept in water at room temperature, and after preparation they were stored at 37°C and 100 per cent humidity. Fig 1 shows the dimensions of the
Resin-based cements: Is there a better way of luting restorations?  
Christensen, 1989
The Cement Effect  

Mitchell et al, 2000

Fracture Toughness

MN/m³/²

KetacCem
Fuji1
Vit Luting
SB resin
The Cement Effect  
Knobloch et al, 2000

![Graph showing fracture toughness in MPa/m^1/2 for various materials: KetacCem, Vit Luting, Advance, Enforce, and Metabond. The graph indicates that Metabond has the highest toughness, followed by Enforce, and so on.](image-url)
Some early resin luting materials

- 4-META based
- 10-MDP based
In comparison with resin composite restorative materials, the uptake of resin luting materials has been slow. 

Christensen 1990
WHY?

- Etching and bonding takes time and is technique sensitive
- Time = Money
- Clean-up is difficult
Which cement is indicated for luting all-ceramic restorations?
Are Adhesive Technologies Needed to Support Ceramics? An Assessment of the Current Evidence

F.J. Trevor Burke, Garry J.P. Fleming, Dan Nathanson, Peter M. Marquis

Abstract: Despite large variations in the reported fracture strengths of dispersion strengthened, glass infiltrated, castable, pressable and machinable ceramics utilised for the construction of all-ceramic crowns, the annual clinical failure rate reported for these materials in the dental literature is remarkably consistent at ca. 3%. These results emphasise that there may be little correlation between the average fracture strength and resultant clinical performance. Consequently, if ceramics are to be used for dental applications, then clearly more detailed information on the statistical variations in strength combined with the influence of cementation media are required.

The effect of adhesive technology has been examined in laboratory and clinical studies. The laboratory studies focused on the effect of cement lute on crown performance, whilst surface degradation and strengthening effects with different systems were examined utilizing conventional materials science techniques. Clinical studies focused on the failure rates of conventionally luted and adhesively luted crowns and inlays.

There would appear to be evidence from clinical studies that crowns luted with a resin cement and with the placement procedure incorporating a dentine bonding stage have enhanced rates of survival. It is therefore concluded that the available research strongly suggests that the use of resin as a luting material for ceramic restorations is indicated, given the research from these differing sources — laboratory fracture studies comparing restorations luted with resin vs other materials, clinical studies, and laboratory studies examining the surface sealing/strengthening effect of resin on ceramic. Laboratory studies also confirm the enhanced resistance to fracture of crowns cemented with an adhesive procedure.

J. Am. Dent. Assoc. 2002; 4:7-32. Submitted for publication: 20.12.01; accepted for publication: 03.02.02.
Resin cements

**Advantages**
- Not soluble in oral environment
- High compressive & tensile strengths
- Good fracture toughness
- Capable of bonding to tooth structure via DBA

**Disadvantages**
- Requires acid etch technique
- Requires dentine bonding
- Moisture control is critical
- Clean-up time is critical
- Technique sensitive
Take home message

Resin luting materials have excellent physical properties and are indicated for all-ceramic restorations.
Additionally……

resin cements may be used as part of an adhesive approach where preparation geometry is suboptimal.
18 luting materials

Extracted premolars

Standardised cone-shaped preparations with 33° taper

Gold copings made and cemented

Tensile force applied after 24h
Polycarboxylate cement produced lowest value
Ketac-Cem value was $X_2$ that of phosphate
Dentine bonding and resin produced highest values for retention

Think adhesive cementation!
Think adhesive cementation!
Zidan & Ferguson 2003

- Complete crowns prepared with three different tapers, luted with four different cements

- Retention of the adhesive resins investigated were 20% higher at 24-degree taper than the retentive values of conventional cements at 6-degree taper.
As the resin luting materials provided retention that was double the values of zinc phosphate or conventional cements, these results provide an overwhelming indication for the use of adhesive luting.

Zidan O, Ferguson GC  The retention of complete crowns prepared with three different tapers and luted with four different cements. J.Prosthet.Dent.2003:89:565-571.

Think adhesive cementation!
Systematic review including 18 studies
Most important factors for crown dislodgment were stump height, convergence angle and luting agent. Frequency of debonding was higher for restorations luted with zinc phosphate than all other types.
Heintze SD

In clinical situations with low mechanical retention, or situations with low stump height or high convergence angle, the adhesive properties of the luting agent are crucial for the prevention of debonding.

Think adhesive cementation!
Take home message

For the day (almost always!) when I cannot get an ideal taper ($6^0$ taper, Shillingburg 1995) I need (adhesive) resin luting!
Other advantages of resin luting
No risk of cement dissolution

Use a tooth coloured resin cement to avoid this
Today!
“Smart” resin cements

3M ESPE RelyX Ultimate Adhesive Resin Cement

Consultants’ Comments
- A very complete kit.
- This one kit does everything I need.
- Fewer steps than other cements I have tried.
- No post-operative sensitivity.
- No refrigeration required.
- Reduces the number of products I need to keep in the office.
- Great bond strength.
- Excess cement is difficult to remove once it is fully set.
- Add a glycerin gel to the kit to cover cement during self-curing.

Description
RelyX Ultimate is an adhesive resin cement used in combination with Scotchbond Universal Adhesive. It is dual curing and supplied in an automix syringe. It is used for the adhesive cementation of indirect restorations and is available in shades A1/Light, A3/Opaque/Yellow Opaque, B1/D/White, and Translucent. The cement can be used either in a "total

G-CEM LinkForce: one system, three base elements
That’s all it takes to create strong adhesion of your indirect restorations in all situations

G-Premio BOND Bonds with no compromises to ALL preparations (tooth, Core build-ups & abutments)
G-CEM LinkForce Provides a strong link in ALL indications
G-Multi Primer Bonding to ALL types of restorations
What I plan to talk about:
- A brief history of luting materials
- Why resin cement is best
- The dentine-bonded all-ceramic crown
- Self adhesive resin luting
- Clinical evaluations of Unicem
The dentine-bonded crown concept
The dentine-bonded crown

- Etchable (HF) ceramic
- Silane coupling agent
- Minimal film thickness
dentine bonding agent
- Dual-cure resin cement
Dentine-bonded crown – fracture resistance

Dentine-bonded crown-fracture resistance

When the ceramic and the tooth are bonded together using resin technology, the complex becomes synergistic.

No difference in fracture strength between teeth restored with dentine-bonded crowns and unrestored teeth.

Placement of dentine-bonded crowns

- Try-in paste
- Clean fitting surface and silanize
- Clean tooth with pumice, isolate
- Apply DBA
- Apply dual cure luting agent to crown
- Place with *gentle* finger pressure
- Remove XS luting material
- Light cure and finish margins
- Check occlusion and polish
It was necessary to apply the dentine bonding agent and light cure it prior to crown placement.

The big worry!
“A self-adhesive resin cement would solve these problems”
The incorporation of acid-functionalised methacrylate or related monomers is a critical component in self-adhesive resin cements.

The self-adhesive resin cements offer a reasonable degree of unassisted adhesion to dentine although bonding directly with enamel still presents a greater challenge.
Clinical relevance:
Etch with phosphoric acid needed if bonding with Unicem to enamel.
The fillers are combinations selected from barium fluoroaluminoborosilicate glass, strontium calcium aluminosilicate glass, quartz, colloidal silica, and other glass fillers.

The partial surface dissolution of acid-soluble glass serves to neutralise the resin acidity and is capable of delivering sodium, calcium, silicate and fluoride ions that part in the setting reaction.

The total filler content is typically in the range of 60–75 wt%.
Self-adhesive resin cements are two-part materials that require either hand mixing, capsule trituration or delivery by an auto-mixing dispenser. One component is comprised of conventional mono-, di- and/or multi-methacrylate monomers that are used in a variety of resin-based dental materials: Bis-GMA, urethane oligomers of BisGMA, UDMA, HEMA, glycerol dimethacrylate (GDMA), TEGDMA, etc.
Do you want to read more?
New monomers, FAS glass filler, new initiator systems

Self adhesive chemistry
Unicem: Intelligent chemistry: Transformation from hydrophobic to hydrophilic

- Radical polymerization + neutralization reactions
- Hydrophobic to hydrophilic
- Adaptation to tooth structure and moisture tolerance
- High mechanical strength, dimensional stability → Long term stability
Unicem: A neutralization reaction occurs upon polymerization.
Self adhesive resin cements: pH change

Complete Neutralization: from acidic to neutral for longevity

pH measurement. 3M ESPE internal data
Neutralisation reaction confirmed

Linlin HAN, Akira OKAMOTO, Masayoshi FUKUSHIMA and Takashi OKIJI

<table>
<thead>
<tr>
<th>Materials</th>
<th>Light cured</th>
<th>90 seconds</th>
<th>48 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-Cem</td>
<td>2.0</td>
<td>1.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Maxcem</td>
<td>2.2</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Smart Cem</td>
<td>3.6</td>
<td>3.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Relyx Unicem</td>
<td>5.0</td>
<td>2.8</td>
<td>7.0</td>
</tr>
</tbody>
</table>

“It is concluded that standardised ceramic crowns, luted with a new self-adhesive resin cement, had similar fracture resistance to those luted with a dentine bonding agent and conventional resin cement”
What I plan to talk about:

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Clinical evaluation of RelyX Unicem by the PREP Panel

12 UK general dental practitioners

Use Rely-X Unicem for 6 weeks

Complete questionnaire on handling of material

Variety of luting materials used pre-study

134 crowns cemented

Rated material on analogue scales
Clinical evaluation of RelyX Unicem by the PREP Panel

Ease of use of previous resin luting system

<table>
<thead>
<tr>
<th>Difficulty</th>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td></td>
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</tbody>
</table>

3.7

Ease of use of conventional luting system used prior to evaluation

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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</tbody>
</table>

4.2

Overall ease of use of RelyX Unicem

<table>
<thead>
<tr>
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</tr>
</tbody>
</table>

4.3
Clinical evaluation of RelyX Unicem by the PREP Panel

Was the flow of RelyX Unicem satisfactory when seating restorations?

No 1 5 yes

Viscosity of RelyX Unicem

Too viscous 1 5 Too thin

3.2

No reported incidence of post-op sensitivity
Clinical evaluation by the PREP Panel:

Comments

- Nurse thinks it’s great!
- Could be a godsend!
- No post-op sensitivity
- No adverse tissue reaction
- No need to etch is very advantageous (92%)
PREP Panel study of Unicem:

Summary

“the clinical handling of RelyX™ Unicem has been rated as being as good as conventional luting materials“

“…..the material takes away the technique sensitivity which is associated with etching, washing/drying and bonding“

The dentine-bonded (adhesive) crown concept lives on, using self adhesive luting materials (such as Unicem): ceramics have also improved.
Take home message

Resin cements have optimal physical properties, but, until the recent introduction of a self-adhesive material, have been technique sensitive.
Second take home message

...resin luting has become much simpler since the introduction of self-adhesive luting materials
Which way now For Unicem?
RelyX™ Unicem 2 Automix, 2011

- Additional monomer included
- New rheology modifier
- Optimised processing of the filler particles (improved delivery service)
- Better mechanical properties

The Automix syringe ensures consistency of mix quality
Evaluation of Unicem 2 by the PREP Panel

Flow of Unicem 2: Was flow satisfactory?

- NO 1: 4.9
- YES: 5

Ease of use of Unicem 2

- Difficult to use: 1
- Easy to use: 5

4.9
PREP Panel evaluation of Unicem 2

- “A definite improvement on RelyX Unicem Applicap”
- “Great advantage to only dispense the amount required”
- “The only issue is cross-infection control”
Unicem 2 Automix

**PREP** Panel evaluation

**Conclusion:** Results indicate that 3M ESPE have managed to further improve a successful material.
Unicem: Does it work?
Results at 15 years:
Categories evaluated at recall included: Lack of post-operative sensitivity, lack of marginal discoloration and retention. Each category was rated on a scale of 1-5: 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent.

Lack of Post-operative Sensitivity
From its inception RelyX Unicem has had very few reported and documented instances of post-operative sensitivity (Figure 3). The post-operative sensitivity was less than 1% of the seated restorations and even lower for restorations cemented with RelyX Unicem 2. Sensitivity usually occurred shortly after seating the restorations and often subsided within a couple of weeks after cementation.

Consultant’s Comments:
- “RelyX Unicem is still my first choice for self adhesive resin cement.”
- “Very retentive with very few debonds over the 15 years that I have been using it.”
- “Excellent esthetics overall; in very few cases, I have noticed some discoloration at the margin due to microleakage.”
- “After all these years RelyX Unicem has proven itself in my dental practice - good retention, good esthetics and almost no marginal discoloration.”
15-Year Clinical Performance

Lack of Marginal Discoloration

Ninety-five percent of the recalled restorations cemented with RelyX Unicem showed no marginal discoloration, while 98% of restorations cemented with RelyX Unicem 2 exhibited no discoloration at the margins (Figure 3). Discoloration was exhibited by graying at the margin of ceramic restorations. Graying was observed in 5% of the restorations. In half of these, the graying was minimal; in 1% the graying was moderate; and in the final 1.5%, the graying was more severe, requiring the replacement of about 35 restorations. It is important to note that the discoloration seemed to get worse with time. Less discoloration was observed when the restorations were cemented with RelyX Unicem 2.

Retention

One hundred and eight (4.8%) of the recalled restorations debonded over the 15-year evaluation period (Figure 3). In 90% of these debonds, the cement was in the restoration and not on the prepared tooth. It was not unusual to notice grey or black stain on many of the debonded restorations.

Summary:

RelyX Unicem Self-Adhesive Resin Cement has proven to be very reliable over the 15-year recall period. This product received a 96% clinical performance rating.
Five-year clinical evaluation of zirconia-based bridges in patients in UK general dental practices

F.J.T. Burke*, R.J. Crisp*, A.J. Cowan†, J. Lamb‡, O. Thompson‡, N. Tulloch‡

*Primary Dental Care Research Unit, University of Birmingham School of Dentistry, School of Medical and Dental Sciences, St. Chad’s Quarter, Birmingham B1 3DD, UK
†General Dental Practice, Barton, England, UK
‡General Dental Practice, Cumbernauld, Scotland, UK

A CASE SERIES OF ZIRCONIA-BASED BRIDGES LUTED WITH A SELF-ADHESIVE RESIN LUTING MATERIAL AT 12 YEARS, IN PATIENTS IN UK GENERAL DENTAL PRACTICES

ABSTRACT

Objectives: To report the results of a 5-year clinical evaluation of zirconia-based bridges, constructed using a yttria-stabilised tetragonal zirconium dioxide monolithic framework, placed in adult patients in UK general dental practices.

Materials and methods: Four UK general dental practitioners recruited patients who required fixed partial dentures and, after obtaining informed written consent, appropriate clinical and radiographic assessments were performed. The teeth were prepped and bridges constructed in accordance with the manufacturer’s instructions. Each bridge was restored annually within 1 month of the anniversary of its placement by a multi-centre examiner, together with the clinician who had placed the restoration, using modified USPHS criteria.

Results: Of the 41 bridges originally placed, 35 bridges were examined at 5 years. All Y-TZP frameworks were intact and no桥ule fixtures had been repositioned. Eight chipping fractures in the veneering ceramic were noted over the 5-year period. In five cases the patients were
Margins of 16 bridge retainers assessed:

12 Optimal ratings
4 satisfactory, none unsatisfactory
Contemporary UK dental practice 2016
Burke FJT, Brunton PR, Wilson NHF, Creanor S.

Questionnaire to 500 UK dentists, 2016
388 useable replies, response rate of 77%
13.1% of respondents are using a self-adhesive resin luting material
Contemporary UK dental practice 2016: Comparison with previous results

Self adhesive resin cements, 2002: 0%
Self adhesive resin cements, 2008: 9%
Self adhesive resin cements, 2016: 13%
Take home message

Resin luting materials have excellent physical properties and are indicated for all-ceramic restorations.
Self adhesive resin luting materials have simplified luting for the clinician.
Take home message

Unicem self adhesive resin luting material, and others in this class of materials, have excellent physical properties and may be used for (the easy) cementation of all indirect restorations. Conventional luting materials are fast becoming redundant.
Take home message

Unicem self adhesive resin luting material, and others in this class of materials, have excellent physical properties and may be used for the easy cementation of all indirect restorations. Conventional luting materials are fast becoming redundant.

Clearfil SA: Kuraray
Dentistry is changing!

Choosing the correct (adhesive) luting material is part of this process