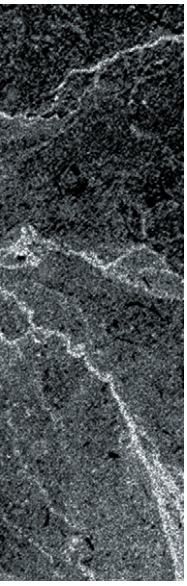

Critical Appraisal

SELF-ADHESIVE RESIN CEMENTS

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Regular readers will note that we depart from our normal Critical Appraisal *format in this issue of the* Journal. *This particular* Critical Appraisal *resembles an expanded* Ask the Expert *feature and addresses the topic of self-adhesive resin cements through a series of brief reviews of several clinically relevant issues.*

Resin cements can be classified according to their polymerization mechanisms into light-cured, chemical-cured, and dual-cured. However, this limited classification system does not categorize cements beyond their curing mechanism and does not describe the bonding or adhesive scheme of the cements. Therefore, we prefer to classify resin cements into the following categories: total-etch, self-etching, and self-adhesive. Total-etch cements use a phosphoric acid etchant and adhesive to bond the cement to the tooth. This category provides the highest cement-to-tooth bond but also requires the most steps to bond ceramic, composite resin, or metal to the tooth. The multistep application technique is complex, and consequently might compromise bonding effectiveness. Examples include RelyX ARC (3M ESPE, St. Paul, MN, USA), Variolink II (Ivoclar Vivadent, Amherst, NY, USA), Choice 2 (BISCO, Schaumburg, IL, USA), and Calibra (Dentsply Caulk, Milford, DE, USA). These cements and the adhesives used with them can be light- or dual-cured. Self-etching systems such as Panavia (Kuraray America, New York, NY, USA) and Multilink Automix (Ivoclar Vivadent) apply a self-etching primer to prepared tooth surfaces, and the mixed cement is applied over the primer. Bonds to tooth structure using this category of cements are almost as high as those of the total-etch cements. The newest resin cements are the *self-adhesive* dual-cured cements that require no etching, primers, or bonding agents to bond to the tooth surface. Bond strengths vary

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widely with these materials and in general are lower than total-etch cements (Table 1). Typical self-adhesive resin cements are RelyX Unicem (3M ESPE), BisCem (BISCO), Smart Cem 2 (Dentsply Caulk), Maxcem Elite (Kerr, Orange, CA, USA), and Speed-CEM (Ivoclar Vivadent). The newest material in this category is RelyX Unicem 2 Automix (3M ESPE), released in September 2010 in addition to Unicem.

WHAT ARE SELF-ADHESIVE CEMENTS?

Self-adhesive cements are dual-cured resin cements first introduced less than 10 years ago. These materials were designed to overcome limitations of both traditional and resin-based cements and simplify the bonding process. Because these cements are relatively recent developments and their composition continues to improve, complete information on their structure, adhesive properties, and clinical performance data is limited or lacking, with the exception of Unicem. Self-adhesive cements simplify bonding procedures, saving time and most importantly shortening the "window of contamination." Because total-etch cements require multiple steps (etching, priming, and bonding), each step represents a possible contamination point. By reducing the number of steps in the bonding procedure to zero, the risk of contamination is less and better adhesion can be achieved than with a contaminated total-etch cement. Self-adhesive cements reduce potential errors created by poor application of the bonding procedure.[1] Self-adhesive cements can bond to an untreated tooth surface that has not been micro-abraded or pretreated with an etchant, primer, or bonding agent; thus, cementation is accomplished in a single step.

WHAT ARE THE ADVANTAGES AND LIMITATIONS OF SELF-ADHESIVE RESIN CEMENTS?

Self-adhesive cements are improvements over conventional and resin cements. They simplify the bonding procedure by eliminating the multiple steps required for total etch cements. Bond strengths vary among specific cements, but total-etch cements generally provide the greatest retention, self-etching systems are intermediate, and self-adhesive cements can provide almost similar bond strength to self-etching systems.

Self-adhesive cements provide more retention than resin-modified glass ionomers,[2] and are particularly useful with high strength all-ceramic restorations. Preparations for these restorations require greater occlusal tooth reduction (2–2.5 mm) than metal restorations (1–1.5 mm), producing preparations that are less retentive. Self-adhesive cements improve retention and support ceramic restorations with a simple application technique. These materials have had a huge influence on dental practice because of their good dentin bonding and ease of use.

Some of the cements appear to be sensitive to overwetting and overdrying, which lowers their bond strengths. Self-adhesive cements can be used most efficiently when bonding to dentin; in fact, our data show that most of these cements bond better to dentin than to enamel. With most, if not all, cements in this category, the bond to enamel is improved when an etchant and bonding agent are applied. In contrast to enamel, our experience with one of these cements shows that when dentin is etched with phosphoric acid and a bonding agent is applied, the bond decreases.

HOW DO SELF-ADHESIVE CEMENTS BOND TO THE TOOTH?

Self-adhesive cements contain traditional fillers and an organic matrix with multifunctional phosphoric acid methacrylates or acidic monomers, which provide the mechanism for the cement's bond to hydroxyapatite. Like self-etching adhesives, the phosphorylated methacrylate in the self-adhesive cement has a low pH created when it contacts water or moisture on the tooth. This low

TABLE 1. COMMERCIALLY AVAILABLE SELF-ADHESIVE RESIN CEMENTS.

Cement/manufacturer	Working time/setting time	Number of shades	Curing time (seconds)	Delivery systems
RelyX™ Unicem Aplicap/3M ESPE	2 minutes/5 minutes after start of mixing (based on oral temperature)	5 shades—A1, A2 universal, translucent, A3 opaque, white Opaque	20	Capsules
RelyX Unicem Clicker™/3M ESPE	2 minutes/5 minutes after start of mixing (based on oral temperature)	3 shades—translucent, A2 universal, A3 opaque	20	Paste-paste system
RelyX Unicem 2 Automix/3M ESPE	2 minutes/6 minutes after start of mixing (based on oral temperature)	3 shades—translucent, A2 universal, A3 opaque	20	Automix tip and syringe
G-Cem capsules/GC America	2 minutes/4 minutes (based on oral temperature)	4 shades—translucent, A2, AO3, BO1	20	Capsules
G-Cem Automix/GC America		2 shades—A2 and translucent		Automix tip and syringe
Maxcem Elite/Kerr	Gel time is 2 minutes, set time is 3 minutes (based on oral temperature)	5 shades—clear, white, white opaque, yellow, brown	10	Automix tip and syringe
BisCem/BISCO	1 minutes/6 minutes (based on oral temperature)	2 shades—opaque, translucent	20	Automix tip and syringe
SpeedCEM/Ivoclar Vivadent	2 minutes, 30 seconds approx./5 minutes (based on oral temperature)	3 shades—transparent, yellow, and opaque white	20	Automix tip and syringe
SmartCem 2/Dentsply Caulk	2 minutes/2 minutes	5 shades—translucent, light, medium, dark, and opaque.	20–40	Automix tip and syringe

pH etches dentin more easily than enamel, which may account for the higher bond strengths in dentin compared with enamel. As etching continues, the cement penetrates the etched tooth surface, creating a micromechanical bond with the tooth when the cement polymerizes. The pH increases to neutrality during the setting reaction for Unicem, although some self-adhesive cements remain acidic for prolonged periods. Water is formed as the cement sets, which produces the cement's initial hydrophilicity and neutralizes the acid pH. Fluoride release is produced in some self-adhesive cements when acid reacts with the fluoride ion-releasing fillers. Because the water produced is consumed, a hydrophobic matrix is ultimately formed with low solubility, low expansion, and long-term stability. Some of these cements form a weak chemical bond with calcium in the

tooth in addition to the micromechanical bond.

ARE SELF-ADHESIVE CEMENTS CLINICALLY SUCCESSFUL?

As the first marketed self-adhesive cement, RelyX Unicem has undergone substantial *in vitro* and clinical testing whereas some other self-adhesive cements are still under early investigation. In large part, the initial success of Unicem was because of its capsule delivery system, which controlled the proportions of the mixed cement. As time passed, however, more convenient delivery systems such as hand-mixed paste–paste systems and automixing syringes evolved in addition to the capsule dispensing system.

Burke and colleagues conducted a practice-based evaluation of the handling of a new self-adhesive universal resin luting material. One hundred forty-four restorations were cemented using a self-adhesive resin luting material that was rated higher by the evaluators for ease of use, convenience, and handling than resin-based and conventional luting agents.[3] In general, our data indicate that the capsule mixing system produces a stronger bond and better retention than other mixing systems that may, in critical situations, influence clinical success. The exception to this finding is with the newly introduced Unicem 2 Automix, which produces bond strengths of 13 MPa to dentin and 16 MPa to enamel—a significant improvement to enamel.

Stanford and colleagues compared the clinical success of 95 ceramic inlays bonded with Unicem (self-adhesive) or Variolink II (total-etch). All inlays were rated clinically successful at the 3-year recall.[4] Geraldeli and colleagues subsequently reported equivalent performance of the same two cements at 4 years.[5] Behr and colleagues compared the clinical success of Unicem and zinc phosphate luted metal restorations in 49 patients over 38 months. Over that period, no restoration was lost or replaced with either cement. No sensitivity difference was reported.[6] A 2-year clinical study compared Empress inlays bonded with Unicem and Variolink II over a 2-year period. No significant differences were reported between the cemented restorations for color match or sensitivity.[7] Fasbinder and colleagues (unpublished data) compared 62 CEREC onlays and reported no debonding or fractures at the 2-year recall.

HAS POSTOPERATIVE TOOTH SENSITIVITY DECREASED WITH SELF-ADHESIVE CEMENTS?

Postoperative tooth sensitivity has been associated with the cementation process since the introduction of zinc phosphate cement and increased with the use of total-etch resin cements.[8] Self-adhesive cements contain acidic monomers that etch dentin without opening dentin tubules. During this process, the smear layer is incorporated into the shallow hybrid layer, which could reduce postoperative thermal sensitivity. The cement acidity needed to etch the tooth lasts only briefly, and near neutrality is achieved rapidly with most self-adhesive cements. Olms and colleagues reported postoperative sensitivity in 19 patients, with 60 full-coverage restorations retained with Multilink Sprint (Ivoclar Vivadent) self-adhesive resin cement.[9] The restored teeth were tested for subjective and objective clinical parameters and tooth vitality was examined with an ice test immediately after cementation, after 2 weeks, after 6 months, and then annually. Postoperative sensitivity was diagnosed immediately (7%) and 2 weeks (4.7%) after cementation, but none was observed at 6 months. This response was similar to the sensitivity with resin-modified glass ionomer cements. Taschner and colleagues evaluated the postoperative sensitivity of teeth containing IPS Empress inlays cemented with Unicem 2 after 1 year and reported no sensitivity.[10]

HOW WELL DO THESE CEMENTS BOND?

To retain a restoration, a cement must bond to the tooth and the restorative material while having enough flexural strength to prevent displacement of the restoration. Self-adhesive resin cements have better physical properties than conventional cements and their bond strengths have been measured.[11–13] Abo-Hamar and colleagues measured the shear bond of RelyX Unicem to dentin and enamel compared with a total-etch cement (Syntac/Variolink II), a self-etching cement (Panavia F2.0), and a glass ionomer cement, Ketac-Cem (3 M ESPE), with and without thermocycling, concluding that RelyX Unicem had lower enamel and dentin bond strengths than resin cements, but that Unicem could be an alternative to glass ionomers.[14] Kadam and colleagues compared the bond of seven self-adhesive cements to enamel and dentin, and showed that many of the self-adhesive cements had a greater bond strength to dentin than enamel.[15] Kiremitci and Altinci compared shear bond strength of self-adhesive and resin cements with dentin and reported bond strengths of 11.6, 8.8, and 6.0 MPa for G-Cem, RelyX Unicem, and Variolink II, respectively.[16]

Ghuman and colleagues compared the bond strength of seven self-adhesive cements with zirconia and concluded that G-Cem had bond strengths comparable with those of Unicem and Panavia, and a significantly higher bond strength than the other self-adhesive cements.[17] While in vitro data may show some cement bond differences among investigators, self-adhesive cements perform well clinically. Some are sensitive to over-wet and over-dry dentin, which lowers their bond strengths.[18] With most self-adhesive cements, the bond to enamel is improved when an etchant and bonding agent are applied.[18] In contrast to enamel bonding, some self-adhesive cements have a significant reduction in dentin bond when the dentin is etched with phosphoric acid or a bonding agent is applied.[18]

SURFACE TREATMENT: ROCATEC/COJET TECHNIQUE

Appropriate surface treatment of all-ceramic restorations can improve the bond of cement to the ceramic. The surface treatment of ceramics depends upon the composition and strength of the ceramic material. Depending on the type of ceramic, options with feldspathic, leucite-reinforced, and lithium disilicate ceramic materials include hydrofluoric acid-etching, on the intaglio surface prior to bonding. Sandblasting increases the surface area of the intaglio surface of the restoration and can improve bonding with high-strength ceramics. With high strength core materials such as zirconia, a light dusting of alumina particles of less than 50 psì (3 bar) for short periods (5 seconds) or the Rocatec/CoJet technique (3M ESPE) is recommended.

Rocatec Soft or Cojet Sand increases cement bond to high-alumina cores and zirconia core materials by applying a silica coating to the ceramic surface using a 30- or 110-micron silica particle coated with alumina.[19–22] Silane is then applied to this layer and dried thoroughly. The silane bonds cement to the silica-coated surface. By this mechanism, a high-strength nonsilica-containing ceramic restoration can be bonded to the tooth. An interesting finding when using the CoJet Sand in the micro-etcher is that the ceramic is strengthened by about 15% because of the silica coating. Blatz and colleagues reported the influence of surface treatments and simulated aging on bond strengths of four luting agents to zirconia.[23] Rocatec tribochemical silica/silane-coated surface yielded the highest shear bond strength for self-adhesive cements compared with untreated, or ground and polished surfaces. Nothdurft and colleagues compared the shear bond strength of adhesive-phosphate-monomer-containing (APM) and non-APM-containing (nAPM) luting cements with zirconia ceramic.[24] Using the

Rocatec system, a significant increase in bond strength was obtained with the nAPM cement to zirconia. The bond to the alumina and zirconia core materials may be improved by using the Rocatec/CoJet sand treatment.

EXPANSION

The dimensional stability of cement is important when cementing all-ceramic restorations because excessive expansion can fracture the restoration. Silmon reported that RelyX Unicem expands significantly less than the resin-modified glass ionomer materials Fuji Plus and Fuji Cem (both GC America, Aslip, IL, USA) at 3 months, but significantly more than RelyX ARC (total-etch resin cement).[25] Many authors have measured the expansion of self-adhesive cements and have demonstrated that self-adhesive cements have expansion rates less than resin-modified glass ionomers but higher than resin cements. Clinically, these materials may be used with weaker ceramic materials without the danger of fracturing the ceramic because of cement expansion.

POSTRETENTION

Bateman and colleagues evaluated the retention of quartz-fiber endodontic posts with RelyX ARC (a total-etch cement) and RelyX Unicem (self-adhesive cement) and reported no significant difference between the two.[26] Naumann and colleagues measured postretention with conventional and self-adhesive resin cements and reported that conventional nonadhesive postcementation is less reliable to withstand simulated functional forces than adhesive cements.[27] Naumann and colleagues reported the effectiveness of titanium and fiber posts bonded with Unicem in a 5-year randomized clinical trial.[28] Over this period, only one post debonded, providing good clinical evidence for the bonding of posts with a self-adhesive cement. Self-adhesive cements make postcementation easier by eliminating adhesive layers, providing good bond strength to dentin, and reducing the application time, which lowers the possibility of contamination.

CROWN RETENTION

Cakir and colleagues and Palacios and colleagues have measured crown retention on standardized preparations on extracted human molars.[29,30] Zirconium oxide copings were fabricated and sandblasted with aluminum oxide. Copings were cemented using a self-adhesive cement (Panavia F 2.0 and ED Primer A & B), a resin-modified glass ionomer cement (RelyX Luting), or a self-adhesive composite resin (RelyX Unicem). In the Cakir and colleagues study, seven self-adhesive cements were compared, with no thermocycling.[29] In the Palacios and colleagues study, specimens were thermocycled for 5000 cycles, with a 15-second dwell time. The copings in both studies were removed using a tensile load until failure.[30] In both studies, the highest retention was reported for the self-etching resin cement and the self-adhesive cement. The predominant mode of failure was cement remaining on the zirconia copings, demonstrating that the bond to the tooth was weaker than the bond to ceramic. An 18-month in vivo study, with 60 full-coverage restorations cemented with Multilink Sprint, reported no crown de-cementation.[9]

CLINICAL TIPS

Kramer and colleagues evaluated 60 Class I CEREC inlays cemented in vitro with RelyX Unicem (light-cured or dual-cured), Fuji Cem (resin-modified glass ionomer), Panavia F (self-etching cement), and Variolink II (total-etch) for wear and reported that Fuji Cem and RelyX Unicem (self-cured) had the greatest wear and dual-cured RelyX Unicem had the least.[31] Because self-adhesive cements bond to tooth structure, excess cement should be removed before setting to avoid damaging the weaker early bond. Self-adhesive cements are dual-cured, and like all dual-cured cements have reduced bond strengths, color stability, and wear resistance in the self-cure only

mode. Therefore, the clinician should light-activate all dual-curing cements at accessible restorative margins to improve marginal integrity and wear resistance and to reduce staining.

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THE BOTTOM LINE

Self-adhesive cements have been proven clinically effective for the cementation of indirect restorations including ceramic, composite, and metal-based inlays, onlays, crowns, fixed partial dentures, and posts. They are contraindicated for the cementation of ceramic veneers and resin-retained fixed partial dentures ("Maryland Bridge") because of the limited available shades and lower adhesion to enamel.[32] Most of these cements bond better to dentin than to enamel. Bonding to enamel is improved when an etchant and bonding agent are applied. In contrast to enamel, when dentin is etched with phosphoric acid or a bonding agent applied, adhesion decreases.

Editor's Note: We welcome readers' suggestions for topics and contributors to Critical Appraisal. Please address your suggestions to the section editor:

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