Self-adhesive Resin Cements: A Literature Review

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Purpose: To summarize research conducted on self-adhesive cements and provide information on their properties, based on the results of original scientific full-length papers from peer-reviewed journals listed in PubMed.

Materials and Methods: The search was conducted using the term "self-adhesive cement OR (trade names of currently available products)".

Results: Only in vitro studies that investigated two commercially available self-adhesive cements have been published so far. The results were summarized into the following categories: adhesion to tooth substrates (enamel, dentin, root dentin), adhesion to restorative materials (endodontic posts, ceramics, titanium abutments), marginal adaptation, microleakage, mechanical properties, biocompatibility, chemical adhesion and fluoride release, and ratings in clinical use.

Conclusion: The majority of available literature data is based on studies that investigated one of the self-adhesive cements that are currently available to clinicians. According to the in vitro results, self-adhesive cement adhesion to dentin and various restorative materials is satisfactory and comparable to other multistep resin cements, while adhesion to enamel appears to be a weak link in their bonding properties. Long-term clinical performance of these materials needs to be assessed prior to making a general recommendation for their use.

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The clinical success of an indirect restorative procedure depends in part on the cementation technique used to create a link between the restoration and the tooth. The different luting cements that are available to clinicians have been categorized into five main classes: zinc phosphate cements, polycarboxylate cements, glass-ionomer cements, resin-modified glass-ionomer cements, and resin composite cements.[17] Although each of the five classes has been widely investigated, the correct clinical choice between them is not always clear.[42] None of the five cement types is suitable to be used for the entire broad range of indirect restorative procedures. Therefore, their proper application requires a thorough understanding and awareness of each material's advantages and disadvantages, taking into account the restorative material, moisture control, and preparation design (retentive or adhesive).[17]

Until recently, resin cements were divided into two subgroups according to the adhesive system used to prepare the tooth prior to cementation. One group utilizes etch-and-rinse adhesive systems (eg, Variolink and Variolink II [Ivoclar Vivadent; Schaan, Lichtenstein]; Calibra [Dentsply Caulk; Milford, DE, USA]; Nexus [Kerr; Orange, CA, USA]). In the other group, enamel and dentin are prepared using self-etching primers (eg, Panavia 21, Panavia F and Panavia F 2.0 [Kuraray Medical; Tokyo, Japan]; Multilink [Ivoclar Vivadent]). Self-adhesive cements were introduced in 2002 as a new subgroup of resin cements (eg, RelyX Unicem, 3M ESPE; St. Paul, MN, USA). These materials were designed with the in-

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tent to overcome some of the shortcomings of both conventional (zinc phosphate, polycarboxylate, and glass-ionomer cements) and resin cements, as well as to bring the favorable characteristics of different cement classes into a single product.

Self-adhesive cements do not require any pretreatment of the tooth surface. Once the cement is mixed, its application procedure is extremely simple. Application is accomplished in a single clinical step, similar to the application procedures of zinc-phosphate and polycarboxylate cements. According to the manufacturers' information, as the smear layer is not removed, no postoperative sensitivity is expected. Unlike zinc phosphate, polycarboxylate, and resin cements, self-adhesive cements are claimed to be moisture tolerant and to release fluoride ions in a manner comparable to glass-ionomer cements. Furthermore, they are expected to offer good esthetics, optimal mechanical properties, dimensional stability, and micromechanical adhesion, analogous to resin cements. Such a combination of favorable features of conventional and resin cements is claimed to render self-adhesive cements suitable for a wide range of applications. At the same time, the clinicians' demands for simplification of luting procedures are addressed, as the application procedure purportedly leaves little or no room for mistakes induced by technique sensitivity.

Self-adhesive cements are still relatively new and detailed information on their composition and adhesive properties is limited. Although the basic adhesion mechanism appears to be the same for all self-adhesive cements, features of RelyX Unicem (3M ESPE) are by far the most extensively explained by the manufacturer (3M ESPE product profile; RelyX Unicem). This cement was the first product from the class of self-adhesive cements to be introduced to the market. Its multifunctional monomers with phosphoric acid groups simultaneously demineralize and infiltrate enamel and dentin. The dominant setting reaction is the radical polymerization that can be initiated by light exposure or through the self-curing mechanism. This results in extensive cross linking of cement monomers and the creation of high molecular-weight polymers. Additionally, in order to assure neutralization of this initially acidic system, a glass-ionomer concept was applied, resulting in a pH increase from 1 to 6 through reactions between phosphoric acid groups and alkaline filler. Phosphoric acid groups also react with the tooth apatite. Water that is formed in these neutralization processes is claimed to contribute to the cement's initial hydrophilicity, which provides improved adaptation to the tooth structure and moisture tolerance. Subsequently, water is expected to be reused by reaction with acidic functional groups and during the cement reaction with ion-releasing basic filler particles. Such a reaction would finally result in an intelligent switch to a hydrophobic matrix. The adhesion obtained is claimed to rely on micromechanical retention and chemical interaction between monomer acidic groups and hydroxyapatite.

Several products are currently available on the market (Table 1). They differ in terms of delivery systems, working/setting times, number of available shades, and composition. According to the manufacturers, all currently available self-adhesive cements release fluoride ions. All these products are dual-curing radiopaque materials that are indicated for adhesive cementation of virtually any indirect restoration: ceramic, composite, metal, inlays (composite or metal), onlays, bridges, crowns, posts and screws (including fiber posts) made of metal, composite resin, and ceramic. The only procedure in which the use of self-adhesive cements is not indicated is the cementation of veneers. In this case, light-curing veneer cements are recommended, as the practitioners usually require longer working times that allow the positioning and adjustment of several veneers simultaneously, prior to light initiation of the cement polymerization.

The aim of this literature review was to summarize research conducted on self-adhesive cements and provide information on their properties, based on the results of original scientific full-length papers from peer-reviewed journals listed in PubMed. The search was conducted using the term: self-adhesive cement OR biscem OR breeze OR gcem OR wetbond OR maxcem OR monocem OR multilink sprint OR unicem.

LITERATURE DATA

RelyX Unicem is undoubtedly the most thoroughly investigated self-adhesive cement in the current literature. The vast majority of the articles published in Medline-cited journals investigated some of the properties of this cement. Limited information is also available on Maxcem,[7,22,24] while no studies that investigated other currently marketed self-adhesive cements have been published so far. One study assessed the handling properties of Relyx Unicem in clinical use through a practice-based evaluation.[12] All the other published articles are based on in vitro investigations.

Adhesion to Tooth Substrates

Enamel

The adhesion of self-adhesive cement to ground enamel was assessed in several studies that evaluated bond strength[1,15,24,26] and cement-enamel interface micromorphology.[15,24] Bond strength of self-adhesive cements used for cementation of orthodontic brackets to unground enamel was also investigated.[7,8,46] In all the studies, self-adhesive cements were light cured.

Bond strength of RelyX Unicem[1,15,24,26] and Maxcem[24] to enamel was investigated using shear[1] and microtensile[15,24,26] bond strength tests. Shear bond strength of RelyX Unicem to enamel was evaluated prior to and after thermocycling.[1] Before thermocycling, this cement produced a bond strength of 14.5 MPa, which was significantly lower than the bond strengths of other resin luting systems investigated, which ranged between 17 and 32 MPa. Moreover, its shear bond strength to enamel was significantly lower after thermocycling, in contrast to other resin cements that were not influenced by the same aging condition.[1] However, since the bond strength of RelyX Unicem was higher than the bond strength of a glass-ionomer cement both before and after thermocycling, it was pointed out that this self-adhesive cement may be considered an alternative to glass-ionomer cement for cementation of high-strength ceramic or metal-

Table 1 Features of commercially available self-adhesive cements

Product	Delivery system	Working / setting time	Shades	Composition
BisCem (Bisco; Schaumburg, IL, USA)	Paste/paste dual syringe; direct dispensing through a mixing tip	1 min / 6 min at 22°C (72°F)	Translucent Opaque	Bis (hydroxyethyl methacrylate) phosphate (base), tetraethylene glycol dimethacrylate, dental glass
Breeze Pentron Clinical Technologies, Wallingford, CT, USA	Paste/paste dual syringe; direct dispensing through a mixing tip	(information not available)	A2 Translucent Opaceous White	Mixture of bis-GMA, UDMA, TEGDMA, HEMA, and 4-MET resins, silane-treated bariumborosilicate glasses, silica with initiators, stabilizers and UV absorber, organic and/or inorganic pigments, opacifiers
GCem GC; Tokyo, Japan	Capsules	2 min / 4 min (based on oral temperature)	A2, AO3 Translucent BO1	Powder: fluoroaluminosilicate glass, initiator, pigment Liquid: 4-MET, phosphoric acid ester monomer, water, UDMA, dimethacrylate, silica powder, initiator, stabilizer
Embrace WetBond resin cement (Pulpdent; Watertown, MA, USA)	Automix or standard syringe packaging	Completely autocures in 7 min	One shade	(information not available)
Maxcem (Kerr; Orange, CA, USA)	Paste/paste dual syringe; direct dispensing through a mixing tip	Gel time is 2 min, set time is 3 min (based on oral temperature)	Clear, White White Opaque Yellow Brown	GPDM (glycerol dimethacrylate dihydrogen phosphate), comonomers (mono-, di-, and tri-functional methacrylate monomers), proprietary self-curing redox activator, photoinitiator (camphorquinone), stabilizer, barium glass fillers, fluoroaluminosilicate glass filler, fumed silica (filler load 67% wt, particle size 3.6 µm)
MonoCem Shofu Dental; San Marcos, CA, USA	Paste/paste dual syringe; direct dispensing through a mixing tip	Unlimited working time. Completely autocures in 7 min in anaerobic conditions	Translucent Bleach	(information not available)
Multilink Sprint Ivoclar Vivadent, Schaan, Lichtenstein	Paste/paste dual syringe; direct dispensing through a mixing tip	Working time: 130±30 s, setting time: 270±30 s (based on oral temperature)	Transparent Yellow Opaque	Dimethacrylates and acidic monomers. The inorganic fillers are barium glass, ytterbium trifluoride and silicon dioxide. The mean particle size is 5 µm. The total volume of inorganic fillers is approx. 48 %
RelyX Unicem 3M ESPE; St Paul, MN, USA	Capsules (Aplicap: 0.01 ml; Maxicap: 0.36 ml)	2 min / 5 min at 22°C (72°F)	A1 A2 Universal Translucent White Opaque A3 Opaque	Powder: glass fillers, silica, calcium hydroxide, self-curing initiators, pigments, light-curing initiators (filler load 72% wt, particle size < 9.5 µm) Liquid: methacrylated phosphoric esters, dimethacrylates, acetate, stabilizers, self-curing initiators, light-curing initiators

based restorations. It was also suggested that RelyX Unicem may be used for luting conventional ceramic crowns with little or no enamel left, but that it might not be the ideal material for luting inlays and partial crowns, if a considerable enamel surface area is present.[1]

Similar results in terms of enamel bond strengths were reported in microtensile bond strength investigations. Enamel microtensile bond strengths of RelyX Unicem ranged between 10.7 MPa[24] and 19.6 MPa[15,26] and were significantly lower than the bond strengths of the self-etching cement Panavia F 2.0[15,24,26] and other resin cements,[26] which ranged between 25 and 49 MPa.[15,24,26] Microtensile bond strength of Maxcem to enamel was significantly lower compared to RelyX Unicem.[24] Conversely, RelyX Unicem microtensile bond strength to enamel was comparable to other resin cements when its application was preceded by phosphoric-acid etching.[15,26]

Morphological evaluations revealed that RelyX Unicem should be applied using some pressure in order to ensure its close adaptation to the cavity wall.[15] However, pressure twice as high as finger pressure had no effect on the microtensile bond strength of RelyX Unicem and other investigated cements (Maxcem and Panavia F 2.0) to flat ground enamel surfaces.[24]

The manufacturers did not include cementation of orthodontic appliances in the indications for use of self-adhesive cements. Nevertheless, the shear bond strength of orthodontic brackets cemented to unground enamel with RelyX Unicem[8,46] and Maxcem[7] was assessed in order to evaluate the potential benefits of self-adhesive cements in orthodontic clinical procedures. Both cements revealed significantly lower bond strengths in comparison to conventional orthodontic resin adhesive systems that utilize phosphoric-acid etching of the enamel surface.[7,8,46] However, the lower bond strength of orthodontic brackets cemented to enamel by RelyX Unicem was thought to be clinically acceptable.[46]

Dentin

The adhesion of RelyX Unicem[1,2,15,19,24,26,36,47,52] and Maxcem[24] to coronal dentin was evaluated by bond strength[1,2,15,19,24,26,36,47,52] and morphological investigations.[2,15,24,51] The retentive strength of zirconia crowns cemented with RelyX Unicem was also assessed.[18,34] In the majority of the studies, the self-adhesive cements were light cured,[1,15,19,24,26,34,47] while in two studies, materials were left to autopolymerize.[2,52] The effect of curing mode on shear bond strength to dentin of dual-cured resin cements, including RelyX Unicem, was assessed in one study.[36] Light curing resulted in higher bond strengths and was therefore recommended for clinical procedures.[36]

Bond strength studies were conducted using shear,[1,36] tensile,[2] and microtensile bond strength tests,[15,19,24,26,47,51] and the recorded bond strength values vary greatly depending on the applied test methodology. Nevertheless, the majority of the results obtained is consistent and demonstrates that in contrast to enamel adhesion, RelyX Unicem performs comparably to other multistep systems on coronal dentin. Its bond strengths were often compared to Panavia F, and no significant differences[1,2,15,24,26,36] or higher bond strength of RelyX Unicem were reported.[47] In comparison to resin cements that utilize etch-and-rinse adhesive systems, RelyX Unicem bonded equally effectively when compared to Variolink II (Ivoclar Vivadent),[1,26] Nexus 2 (Kerr),[26] RelyX ARC (3M ESPE), and Calibra (Dentsply Caulk).[36] Unlike previous findings, significantly lower microtensile bond strengths of RelyX Unicem to dentin compared to Panavia F 2.0,[19,51] Multilink,[19] and Variolink II[36] were also reported.

In contrast to the positive effect observed on enamel, acid etching was detrimental to RelyX Unicem dentin adhesion.[15,26] Its microtensile bond strength following acid etching was significantly lower than that obtained when the cement was used without any treatment of the dentin surface.[15,26] This was attributed to the self-adhesive cement's inability to infiltrate the collagen depleted by the etching step.[15] Although higher seating force had no effect on enamel adhesion, it improved microtensile bond strengths of RelyX Unicem and Panavia F 2.0 to dentin.[24] Conversely, the microtensile bond strength of Maxcem to dentin was significantly lower compared to that of RelyX Unicem, and was not influenced by the heavier seating pressure.[24]

The application of RelyX Unicem[2,15,24,51] and Maxcem[24] to coronal dentin does not result in the formation of a hybrid layer and resin tags. The morphological findings at the cement/dentin interface formed by self-adhesive cements were noticeably different in comparison to the interface formed with resin cements that require pretreatment of the dentin surface.[2,15,24,51]

Zirconium oxide crowns and fixed partial dentures may be cemented using conventional nonbonding cements due to their high fracture resistance. However, these restorations may also benefit from adhesive cementation.[11] Retention of zirconia crowns cemented with RelyX Unicem was investigated in two studies.[18,34] The retentive strength of Lava crowns (3M ESPE) luted with the self-adhesive cement was not significantly different in comparison to the other multistep resin luting agents tested.[18] Likewise, comparable retentive strengths of Procera AllZirkon copings (Nobel Biocare) were found between RelyX Unicem, Panavia F, and a resin modified glass-ionomer cement (RelyX Luting, 3M ESPE).[34]

Root dentin

Since root dentin is different in nature from coronal dentin and variations in its structure may affect bonding, the adhesion to this substrate is usually assessed separately.[21,33] The adhesion of RelyX Unicem to root dentin was investigated in light-curing mode when this cement was used for the cementation of fiber posts[5,9,25,44] and titanium dowels.[3] In order to evaluate the effectiveness of cementation, thin-slice push out tests,[9,25,44] retention tests,[3,5] and morphological evaluations of the cement/root dentin interface[25] were performed.

Similar to bond strengths on coronal dentin, the push-out strength of RelyX Unicem was comparable to Panavia F 2.0. However, both cements resulted in significantly lower push-out strengths compared to Variolink II cement in combination with an etch-and-rinse dual-curing adhesive Excite DSC (Ivoclar Vivadent).[25] Different results were reported in another investigation, where RelyX Unicem's push-out strength was significantly higher than the push-out strengths of Panavia F, Variolink II, and other resin cements investigated.[9] Moreover, its push-out strength was significantly higher after thermocycling. The authors speculated that the moisture tolerance of the self-adhesive cement purported by the manufacturer may partly explain its favorable adhesion in root canals.[9] A significant increase in RelyX Unicem's push-out strength was found after 24 h of water storage in comparison to immediate testing.[44]

Retention of quartz fiber posts cemented with RelyX Unicem was comparable to the retention obtained with the conventional resin cement RelyX ARC in combination with an etch-and-rinse adhesive.[5] When RelyX Unicem was used for titanium dowel cementation, it performed comparably to a zinc phosphate, glass-ionomer, and resin cement (Panavia 21).[3]

As with coronal dentin, no hybrid layer and inability to etch through the smear layer formed in the root canal were observed when RelyX Unicem was used for adhesive cementation of fiber posts.[25]

Adhesion to Restorative Materials

Endodontic posts

Only one study assessed the adhesion of RelyX Unicem to endodontic posts, using the thin-slice push out test after the tribochemically coated (CoJet, 3M ESPE) zirconia (CosmoPost, Ivoclar Vivadent) and fiber posts (FRC Postec, Ivoclar Vivadent) were cemented in artificial post spaces.[10] The push-out strength of RelyX Unicem was significantly higher to fiber posts than to zirconia posts. On both substrates, it performed comparably to the cements that resulted in the highest push-out strengths.[10]

Ceramics

Several studies investigated shear[29,30,32,38,40,41] and microtensile[35] bond strength of RelyX Unicem to different types of ceramic: high-strength cylindrical aluminum oxide,[38] leucite-reinforced,[38] lithium disilicate,[29,35,38] machinable feldspathic,[41] and zirconia ceramics.[30,32,40] The bond strength values varied in different studies, depending on the ceramic treatment and the aging conditions. However, the obtained results are in agreement, demonstrating that this cement achieves bond strength that is either higher or comparable to other investigated materials. In the majority of the studies, RelyX Unicem was light cured.[29,30,32,41,35] Two studies investigated the influence of curing mode on the bond strength of dual-curing resin cements to high-strength cylindrical aluminum oxide, leucite-reinforced, lithium disilicate,[38] and zirconia ceramics.[40] It was reported that light polymerization of the investigated dual-curing resin cements, including RelyX Unicem, significantly increased bond strengths in comparison to autopolymerization.[38,40]

In comparison with 10 cements from different classes, only RelyX Unicem resulted in high shear bond strengths after 14 days of water storage and thermocycling to all the investigated substrates: high-strength cylindrical aluminum oxide ceramic (following sandblasting), leucite-reinforced and lithium disilicate ceramic (following etching with hydrofluoric acid and silanization). Interestingly, water storage and thermocycling increased the bond strength of all resin cements and the self-adhesive universal resin cement.[38] In a study by Kumbuloglu et al, RelyX Unicem revealed lower shear bond strengths to lithium disilicate ceramics than the other resin cements investigated.[29] However, in this study, no pretreatment of the ceramic surface was performed, in contrast to the previous study in which the ceramic surface was etched and silanized,[38] following the manufacturer's directions (3M ESPE product profile, RelyX Unicem). Microtensile bond strengths of RelyX Unicem, Multilink, and Panavia F increased when a lithium disilicate ceramic (IPS Empress 2) was etched and silanized, compared with bond strengths to untreated ceramic surfaces.[35] RelyX Unicem's microtensile bond strength was comparable to Multilink following etching and silanization, and higher in comparison to Panavia F, regardless of the ceramic surface treatment.[35] High bond strengths that increased after thermocycling were also reported to etched and silanized machinable feldspathic ceramic.[41] This study reported that etching with hydrofluoric acid and silanization was the most effective treatment to gain a reliable bond strength to the majority of materials investigated, including RelyX Unicem.[41]

RelyX Unicem's shear bond strength to sandblasted (110-µm aluminum oxide) or tribochemically coated (Rocatec, 3M ESPE) zirconia ceramics (Lava, 3M ESPE) was investigated and compared with 10 luting cements from different material classes.[40] As in the previous study, using the same materials and methodology for different ceramic substrates,[38] the shear bond strength of this cement increased after 14 days of water storage and thermocycling. It was also the highest in comparison with other investigated materials regardless of the ceramic surface treatment.[40] High shear bond strengths, comparable to Panavia F, were also reported to zirconia ceramics with and without previous tribochemical treatment of the ceramic surface (Rocatec) and regardless of the aging condition.[30,32]

Titanium abutments

Retention forces of noble alloy castings cemented on titanium abutments with different cements were investigated.[50] The retention achieved using RelyX Unicem was comparable to retention achieved using polycarboxylate cement, and significantly higher in comparison to retention following the cementation with zinc oxide, zinc phosphate, and glass-ionomer cements.[50]

Marginal Adaptation

In vitro marginal adaptation of RelyX Unicem[6,22,43] and Maxcem[22] was evaluated following the cementation of all-ceramic MOD inlay restorations (IPS Empress, Ivoclar Vivadent)[22,43] and all-ceramic crowns (IPS Empress 2, Ivoclar Vivadent).[6] Marginal adaptation of all-ceramic MOD inlays was assessed in enamel and in dentin. One study reported over 90% perfect margins in RelyX Unicem specimens, which was comparable to resin cements Variolink and Panavia F both before and after thermocycling and mechanical loading. Marginal integrity deteriorated after loading for all the cements investigated, but a significantly lower percentage of perfect margin was recorded only for Variolink in dentin, at both tooth/cement and cement/inlay interface.[43] Another investigation reported that RelyX Unicem offers a tight seal at dentin margins, while Maxcem resulted in a significantly lower percentage of perfect margin.[22] However, it was pointed out that self-adhesive cements cannot compete with cements which utilize etch-and-rinse adhesives in terms of enamel bonding performance.[22]

Marginal adaptation of RelyX Unicem used for the cementation of all-ceramic crowns was assessed in dentin, before and after thermal and mechanical loading applied in order to simulate a five-year period of intraoral stress. Over 90% perfect margins were observed in RelyX Unicem specimens. Its adaptation was not influenced either by previous application of Prompt-L-Pop adhesive or by loading, and was comparable to Variolink resin cement.[6]

Microleakage

Microleakage of RelyX Unicem was evaluated subsequent to cementation of porcelain veneers,[27] all-ceramic inlay restorations,[20,43] all-ceramic crowns,[6] gold inlays,[20] and full cast crowns.[39] Porcelain veneer enamel microleakage was significantly higher when the self-adhesive cement was used in comparison to the resin cement Variolink combined with the etch-and-rinse adhesive Excite (Ivoclar Vivadent). However, in accordance with bond strength data,[15,26] enamel microleakage decreased to values comparable to Variolink if RelyX Unicem was used with the etch-and-rinse adhesive (Single Bond, 3M ESPE) or a strong self-etching adhesive (Adper Prompt-L-Pop, 3M ESPE).[27] Conversely, the application of these adhesives on dentin had a detrimental effect in terms of microleakage, while the self-adhesive cement used without any dentin pretreatment resulted in microleakage values comparable to Variolink.[27] When the self-adhesive cement was used for the cementation of all-ceramic MOD inlays, microleakage in enamel and dentin was comparable to resin cements Variolink[20,43] and Panavia F.[43] Microleakage of this cement following the cementation of all-ceramic crowns was investigated in dentin, and was significantly lower compared to Variolink.[6]

In a microleakage investigation of various cementing agents for full cast crowns, RelyX Unicem revealed the lowest microleakage both in enamel and in dentin.[39] Enamel microleakage was significantly lower compared to RelyX ARC resin cement used with the etch-and-rinse adhesive Single Bond and the zinc phosphate cement, and comparable to glass-ionomer cements and the self-etching cement Panavia F.[39] The authors speculated that the specific multifunctional phosphoric-acid methacrylates contained in this cement are able to react with the tooth surface in multiple ways, resulting in an effective seal. Apart from the formation of complex compounds with calcium ions, different kinds of physical interactions, such as hydrogen bonding or dipole-to-dipole interactions, were assumed to favorably influence self-adhesion.[39] In another microleakage investigation, RelyX Unicem performed significantly better than the zinc phosphate cement with gold inlays.[20]

Mechanical Properties

The mechanical properties of RelyX Unicem cement were assessed by surface microhardness,[31] degree of conversion,[31] compressive strength,[31,37] and flexural strength[37] investigations. Fatigue[4,45] and fracture resistance[13,28] of teeth restored using RelyX Unicem were also evaluated.

After 1 week of water storage, RelyX Unicem in light-curing mode had the highest values of hardness and compressive strength when it was compared with three other resin cements (RelyX ARC, Panavia F, and Variolink). However, in the same study it was reported that its degree of conversion was the lowest: 56% when the cement was light cured and only 26% when it was autopolymerized.[31] In another study, the same three resin cements had the highest flexural and compressive strengths, followed by RelyX Unicem, while all four materials were statistically significantly stronger than resin-modified glass-ionomer cements, glass-ionomer cements, and zinc phosphate cements.[37] This study also assessed the influence of curing mode on flexural and compressive strengths of dual-curing resin cements. No significant differences between the properties of light-cured and autopolymerized cements were found.[37]

Fatigue resistance of sandblasted (110-μm aluminum oxide) glass-infiltrated alumina ceramic (In Ceram Alumina, Vita) bonded to dentin was lower when RelyX Unicem was used in comparison to Panavia F.[4] Both cements were used in the self-curing mode.[4] In the assessment of load-fatigue performance of gold crowns luted with resin cements, RelyX Unicem survived fewer cycles than did C & B Opaque (Bisco; Schaumburg, IL, USA) and Calibra Esthetic resin cement (Dentsply Caulk), but behaved comparably to Panavia F and zinc phosphate cement.[45] The marginal areas in teeth where the crowns were luted with resin cements were light polymerized.[45] Fracture resistance of teeth restored with all ceramic crowns luted with RelyX Unicem in light-curing[13] and self-curing[28] mode was comparable to fracture resistance of teeth restored using the conventional resin cement Mirage ABS/FLC (Mirage Dental Systems; Kansas City, KS, USA),[13] and Super-Bond C&B (Sun Medical; Shiga, Japan).[28]

Biocompatibility

In a study by de Souza Costa et al, pulpal response to RelyX Unicem and Variolink II used to bond inlay restorations was investigated and compared.[16] Although slight tissue disorganization was observed in the RelyX Unicem samples after 7 days, no pulpal response was present in most of the samples evaluated at 60 days. Conversely, Variolink II associated with the adhesive system Excite demonstrated more aggressive effects to the pulp-dentin complex. A discrete to moderate initial pulpal inflammatory response was observed that persisted until the 60-day evaluation. The authors speculated that RelyX Unicem benefited from its chemical adhesion to tooth structure, low solubility, and a self-neutralizing mechanism during the setting reaction. These manufacturer-declared properties were assumed to prevent hydrolysis and diffusion of the cement's components across dentinal tubules. The mild inflammatory reaction that was observed at the 7-day examination was explained by the initially low pH of the cement.[16]

Chemical Adhesion and Fluoride Release

Until recently, chemical adhesion to hydroxyapatite was proven for glass-ionomer cements[49,53] and 10-MDP (10-methacryloxydecyl dihydrogen phosphate) and 4-MET (4-

methacryloxyethyl trimellitic acid) functional monomers used in some self-etching adhesive systems.[52] In a study by Gerth et al,[23] the potential for chemical interaction between RelyX Unicem and hydroxyapatite was investigated and compared to the resin cement Bifix (Voco; Cuxhaven, Germany) in combination with an etch-and-rinse adhesive system. It was reported that RelyX Unicem showed high chemical interaction with Ca ions derived from hydroxyapatite, which was enhanced in comparison to Bifix.[23]

The same authors investigated the exact composition of RelyX Unicem and Bifix and detected a fluoride content of 10% in RelyX Unicem and 2% in Bifix. Although fluoride release from restorative materials depends on their fluoride content, this process is also influenced by several other factors.[48] More importantly, a direct relationship between fluoride release from restorative materials and its actual anticariogenic effects has not been determined in vivo.[14] Therefore, the clinical significance of fluoride release from self-adhesive cements in terms of their cariostatic properties remains to be determined.

Ratings in Clinical Use

To date, no clinical studies that investigated self-adhesive cements have been published. However, some information on the handling properties of these materials is available. Product Research and Evaluation by Practitioners (PREP) Panel, a United Kingdom-based group conducted a practice-based evaluation of RelyX Unicem handling. The authors reported that this cement achieved ratings for ease of use that were superior to the pre-study resin-based and conventional luting materials in the practices of 13 United Kingdom dentists.[12]

CONCLUSIONS

Based on the in vitro data from the literature, adhesion of the most investigated self-adhesive cement to dentin and various restorative materials is satisfactory and comparable to other multistep resin cements. An interesting and clinically relevant concept is the possibility for dentin bond strength enhancement by the application of higher seating pressure. Light curing provided higher bond strengths than autopolymerization to dentin and to various types of ceramic materials. Some investigations have reported that artificial aging resulted in increased push-out strength to root dentin and increased bond strengths to various fixed prosthodontic restorative materials. Adhesion to enamel appears to be a weak link in bonding properties of self-adhesive cements. Although it may benefit from previous acid etching, this procedure is detrimental to dentin adhesion. Therefore, its potential employment would require extreme precision in applying the acid solely on enamel, which is difficult to achieve in clinical conditions. Chemical adhesion and fluoride release may play a role in durability and cariostatic properties of these materials, which remain to be determined in vivo.

Self-adhesive cements appear to offer a promising new approach in indirect restorative procedures. However, the available literature data are based on studies that investigated only one of the cements currently available to clinicians. More importantly, long-term clinical performance of these materials needs to be assessed prior to making a general recommendation for their use.

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