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1850s	Early 1900s	1900s	1972	1992
Zinc oxide eugenol	Zinc phosphate	Zinc carboxylate	Glass ionomers	Resin-modified glass ionomers

A Practical Guide To The Use Of Luting Cements

A Peer-Reviewed Publication

Written by John O. Burgess, DDS, MS and Taneet Ghuman, BDS

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Educational Objectives

Overall goal: The purpose of this article is to provide dental professionals with information on the selection and application of luting cements.

Upon completion of this course, the clinician will be able to do the following:

1. List the types of luting cements and their chemical composition.
2. List the physical properties that affect the performance of luting cements.
3. List the applications for the various luting cements currently available.
4. Describe the physical properties, chemistry and application of self-adhesive luting cements.

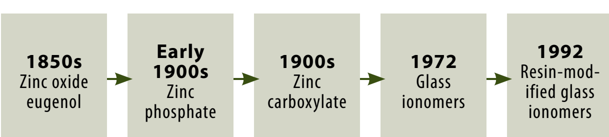
Abstract:

Dentistry uses a wide range of cements to retain crowns, posts and fixed partial dentures to tooth structure. Dental practitioners should have a good understanding of the properties and categories of dental cements to ensure the long-term clinical performance of cemented restorations. Classes of dental cements have evolved from zinc phosphate to glass ionomers, resin modified glass ionomers, resin cements and lastly to self-adhesive resin cements. Self-adhesive resin cements require no bonding agents and simplify the cementation procedure. Since metal, porcelain-fused-to-metal, resin and all-ceramic restorations are used today, an understanding of cement performance is needed before selecting a material to use in a particular situation. This article gives a brief review of cement performance and introduces a new material to the class of self-adhesive resin cements.

Introduction: History and Evolution of Dental Cements

Dental cements have evolved from humble beginnings. In the 1850s, the only cement available was zinc oxide eugenol.[1] This was followed by the successive development of zinc phosphate cements in the early 1900s, zinc polycarboxylate later in the 1900s, glass ionomer cements in 1972 and resin modified glass ionomer cements in 1992 (Figure 1).

Figure 1. Development of dental cements



Description and Properties

Zinc Oxide Eugenol Cement

Zinc oxide eugenol cement is mixed using zinc oxide-based powder and eugenol liquid. Originally introduced as a weak setting powder and liquid, two changes made this cement a clinical success. The first change increased the strength of the mixed material, allowing it to be used for permanent cementation, and the second produced an easy-to-mix paste-paste system for provisional cementation that is still in use today.[2,3] While the cement had an obtunding effect on pulp, its disadvantages, including a high film thickness, have limited its use.[4] The physical properties of dental cements appear in Table 1.

Zinc Phosphate Cement

Zinc phosphate cement has enjoyed widespread success as a permanent luting agent.[5] It is a two-bottle system composed of phosphoric acid liquid, and a mixture of zinc oxide and magnesium oxide powder.[6] The pH of the newly mixed zinc phosphate is less than 2.0 but rises to 5.9 within 24 hours and is neutral (pH 7.0) by 48 hours. The working time can be prolonged by mixing the material on chilled glass slabs.[7] Since zinc phosphate cement produces an exothermic reaction, mixing a small amount of the powder to the liquid and adding the remaining powder in small increments prolongs working time. A frozen mixing slab allows increased powder to be added to the mixture, which compensates for incorporating water collecting on the slab and increases working time without reducing cement strength.[8,9] Even though its use has declined dramatically, it has a significant amount of clinical success associated with its use. Zinc phosphate serves as the standard by which newer cement systems are compared.

Zinc Polycarboxylate Cement

Zinc polycarboxylate cement was the first cement to bond to tooth structure.[10] It consists of a powder containing zinc oxide and magnesium oxide, and a liquid composed of polyacrylic acid. Also known as zinc polyacrylate cement, its adhesive properties produce a bond to enamel and a weaker bond to dentin by a chelation reaction between the carboxyl groups of the cement and calcium in the tooth. Although still used, primarily by pediatric dentists and especially Durelon (3M ESPE, St. Paul, Minn.), its use has declined in recent years. Zinc polycarboxylate cement produces a mild pulpal reaction and forms a weak adhesive bond to the tooth. It has a short working time and greater solubility than other cements.

Glass Ionomer Cements

Glass ionomer cements were introduced as hybrids of silicate cements and polycarboxylate cements to produce a cement with characteristics of silicate cements (translucency and fluoride release) and polycarboxylate cements (chemically bond to tooth structure with a good seal).[11,12] They consist of fluoroaluminosilicate glass and a liquid containing polyacrylic acid, itaconic acid and water. The development of glass-ionomer cements was first announced by Wilson and Kent. Glass ionomer cements are waterbased, have low solubility in the oral cavity, good working time, intermediate mechanical properties and excellent translucency. They are among the most resistant to salivary contamination, but their handling and mixing characteristics make them difficult to use initially. The bond to tooth structure is significantly reduced when the tooth is excessively dried, which also contributes to post-cementation thermal sensitivity.[13] Although still used today, since they produce retention rates similar to zinc phosphate, their use has declined.

Resin Modified Glass Ionomer Cements

Resin modified glass ionomers were formed by replacing part of the polyacrylic acid in conventional glass ionomer cements with hydrophilic methacrylate monomers.[14] These dual- or tri-cured materials are popular luting agents and provide slightly greater bond strengths and release greater amounts of fluoride compared to conventional glass ionomer cements. However, a cement film of only 20–30µ is exposed at the marginal area after the restoration is cemented, and research has not shown reduced caries levels around restorations cemented with fluoride-releasing cements. The mechanical properties of all glass ionomers increase with time, which possibly contributes to their clinical success.[15] These cements bond to tooth structure[16], have low microleakage when mixed properly and when applied to moist dentin produce little post-cementation thermal sensitivity.[17]

Resin Cements

Resin cements vary in composition (paste-paste, single paste or powder liquid), curing mechanism (light cured, dual cured and chemically cured) and bonding mechanisms (total etch, self-etching). They are methacrylate-based and, depending on the curing mechanism, contain chemical and/or light initiators. Resin cements initially gained popularity due to their mechanical properties, the adhesion produced by the acid-etch technique to enamel and dentin, and their low solubility.[18]

The bonding agent used with a resin cement should be compatible with the cement chemistry to ensure an optimal bond. Sanares[19] first reported that the pH of a bonding agent could inhibit the polymerization of a chemically cured com-

Table 1: Physical Properties of Luting Cements

Property	Ideal	ZnOE	$ZnPO_4$	PCC	GI	RMGI	Resin	SAC
Film thickness (mm)	25	≤ 25	≤ 25	< 25	< 25	> 25	> 25	> 25
Working time (min)	Long	2–3	1.5–5	1.75–2.5	2.3–5	2–4	3–10	0.5–5
Setting time (min)	Short	4–10	5–14	6–9	6–9	2	3–7	1–15
Setting reaction	Acid-based	Acid-based	Acid-based	Acid-based	Acid-based	Light and/or chemical plus acid-based	Light and/ or chemical	Light and chemical
Retention	High	Low–moderate	Moderate	Low	Moderate	Moderate–high	high	Moderate–high
Compressive strength (MPa)	High	6–28	62–101	67–91	122–162	40–141	194–200	179–255
Tensile strength (MPa)	N/A	—	3.1–4.5	3.6–6.3	4.2–5.3	13–24	34–37	37–41
Elastic modulus (GPa)	Dentin= 13.7 Enamel= 84-130	5.4	13.2	4–4.7	11.2	—	17	4.5–9.8
Bond strength to dentin (MPa)		0	0	2.1	3–5	14–20* 10–12**	18–30*	5–12
Solubility in water (wt %)	Max. 0.2	0.04	0.06–0.2	< 0.05	1.25	0.07–0.4	0.13	< 1
Excess cement removal	Easy	Medium	Easy	Medium	Medium	Easy	Hard	Medium

*With bonding agent **Without bonding agent posite core material. Currently the best results are obtained with a dual-cured cement and a light-cured or dual-cured bonding agent, such as Prime and Bond NT (DENTSPLY/Caulk), which is supplied with a self-cured activator that makes it compatible with dual-cured resin cements and restoratives. Dual-cured cements should be tested to ensure that the chemical curing mechanism is still functioning. A simple test is to mix the dual-cured resin cement, place it in the dark for eight minutes and then break it between the fingers. If the material fractures with a snap, the chemical cure is intact; if it bends before fracturing, the chemical cure has weakened; if it is soft, the chemical curing mechanism has expired.

Although resin cements provide more retention than conventional cements, their use is associated with difficult cleanup and multiple steps for bonding. All-ceramic crowns require increased tooth preparation and have been associated with tooth sensitivity after cementation. Clinical surveys have reported that postoperative sensitivity within the first year after crown cementation with resin cements occurred in about 37 percent of patients.[20,21] Postoperative tooth sensitivity has been associated with cements and crown cementation since the use of zinc phosphate cement.[22] In the case of resin bonding cements, it appears that the reason for the sensitivity is failure to seal the dentinal tubules opened by phosphoric acid etching. It seems more likely that a combination of poor technique and lack of proper isolation has led to this increase in sensitivity rather than irritation associated with dental cements.

When using resin cements, properly bonded and sealed indirect restorations are retentive, long-lasting durable restorations. Bonded resin cements are particularly useful in clinical situations where retention of crowns or fixed partial dentures is compromised.

Applications

Zinc Oxide Eugenol, Zinc Phosphate Cements

The high film thickness of zinc oxide eugenol cements makes them unsuitable for the cementation of many contemporary indirect restorations. Use of zinc phosphate and polycarboxylate cements has also declined as cement options and types of indirect restorations, especially ceramic restorations requiring bonding, have increased.

Glass Ionomer Cements

Glass ionomer cements are used mainly to cement metal and metal-ceramic restorations with adequate retentive and resistance form. They are contraindicated for low-strength all-ceramic restorations.

Resin Modified Glass Ionomer Cements

Resin modified glass ionomer cements have a successful history of use for metal, metal ceramic and high-strength ceramic restorations (those with alumina and zirconia cores) as well as for metal and composite fiber posts. Although some reports[23,24] have indicated that resin modified glass ionomer cements may cause ceramic cracking, this is not the case. These cements are acceptable to use with high-strength ceramic restorations. Leevailoj et al.[25] measured the fracture incidence of In-Ceram and VitaDur Alpha porcelain jacket crowns cemented with five luting agents (Fuji I, Fuji Plus, Vitremer, Advance and Panavia 21) on prepared premolar teeth. During a two-month storage in saline, no cracks occurred with In-Ceram regardless of the cement used, demonstrating that resin modified glass ionomers can be used with high-strength ceramic materials. Resin modified glass ionomers provide inadequate retention with preparations with poor retention and resistance form. Table 2 lists indications for dental cements.

Table 2: Indications For Luting Cements

Restoration	ZnOE	$ZnPO_4$	PCC	GIC	RMGIC	Resin Bonding	SAC
Cast crown, metal-ceramic crown, FPD	✓	✓	✓	✓	✓	✓ Especially for low-retention preparations	✓
Crown or FPD with poor retention	✗	✗	✗	✗	✗	✓	✗
Metal ceramic crown with porcelain margin	✓	✓	✗	✓	✓	✓	✓
Pressed, high-leucite or feldspathic ceramic crown	✗	✗	✗	✗	✗	✓	✓*
Split cast alumina, alumina or zirconia core crown	✓	✓	✓	✓	✓	✓	✓
Ceramic inlay	✗	✗	✗	✗	✗	✓	✓*
Ceramic veneer	✗	✗	✗	✗	✗	✓	✗
Resin-retained FPD (Maryland Bridge)	✗	✗	✗	✗	✗	✓	✗
Cast post and core	✗	✓	✗	✓	✓	✓	✓
Composite fiber post	✗	✓	✗	✓	✓	✓	✓

✓: Indicated. ✗: Not indicated. *Some porcelain and ceramic manufacturers do not recommend the use of self-adhesive cements with flexural strengths lower than 250 MPa.

Resin Cements

Resin cements are the most versatile and widely used cements for nonmetallic restorations, resin-bonded fixed partial dentures, ceramic crowns and porcelain veneers, as well as ceramic and resin composite inlays and onlays.

Esthetic resin composite cements are used for veneers and are supplied in multiple shades, viscosities and esthetic try-in pastes. With thin ceramic veneers (0.4–0.8 mm), the shade of the veneer may be altered using these cements. A water-soluble try-in paste of the selected shade is used to verify the desired adjustment of the veneer's shade by placing the try-in paste into the veneer and temporarily seating it on the tooth. The correct shade is verified, and the same shade resin cement is used to cement the veneer.

Bonding of high-strength ceramic crowns will increase crown retention to teeth with short clinical crowns such as those that have been reduced more occlusally to provide space for ceramic posterior restorations.[26] Resin cements with a dentin bonding agent have provided a threefold increase in crown retention on teeth with short clinical crowns compared to using zinc phosphate cement. In the same study, retention was also improved using a resin cement for overtapered crown preparations compared to zinc phosphate cement.[27] Patients should be advised not to clench or grind their teeth immediately after restorations have been cemented with chemically activated resin cements, because early bond strengths are low and need 24 hours to fully mature.[28] Excess cement should be removed before resin cements set to avoid damaging the weaker early bond.[29]

When using a total etch cement, the enamel margins must be etched carefully before applying the etchant to dentin to prevent overetching. The primer or primer adhesive combination must be applied with agitation to moist dentin and then thoroughly dried. After drying, the tooth surface should appear shiny. If not, another layer of primer is applied and dried followed by a layer of unfilled resin. Since the adhesive layer must be light cured to achieve high bond strengths, a bonding agent producing a low film thickness (Prime and Bond NT (DENTSPLY/Caulk, Milford, DE) or Single Bond (3M ESPE) is recommended. Thorough light curing of this layer is critical before applying the mixed cement over it. Using self-etch cements (Panavia, Kuraray) reduces the number of steps compared to total-etch cements; however, using self-etching cements when bonding to unground enamel requires that the enamel be etched as a separate step.

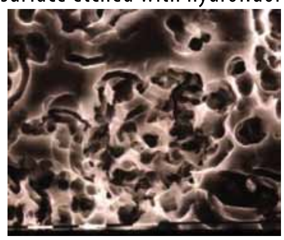
Surface treatment of ceramics prior to resin cement use

One area sometimes overlooked yet critical to the outcome of cementing indirect restorations is the surface treatment of the restoration itself. The surface treatment of ceramics depends upon the composition and strength of the ceramic material. Options include etching, sandblasting or the use of the Rocatec/Cojet technique (3M ESPE).

Etching

Etching is effective only for silica-containing materials (feldspathic porcelain and lithium disilicate- and leucite- containing ceramics). Care should be taken to use the appropriate etching time and etch correctly, as it is possible to overetch and reduce the bond of the cement to the ceramic.[31] The etching time (20 seconds to two minutes) is specific for each ceramic. For lithium disilicate (Empress materials), a 20-second etch time with 5 percent HF is recommended by the manufacturer (Ivoclar) and is supported by research.[30] Etching the intaglio (inner) surface increases the surface area available for bonding (Figure 2). An excellent review of preparing porcelain surfaces for bonding has recently been authored by Alex.[31]

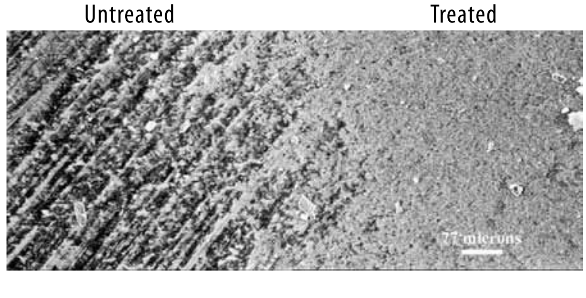
Figure 2. Intaglio surface etched with hydrofluoric acid



Sandblasting or treatment with the Rocatec system (3M ESPE) can be used on the intaglio surface prior to bonding high-strength ceramic materials such as Procera All Ceram (Nobel Biocare, Yorba Linda, Calif.), Cercon (DENTSPLY) or LAVA (3M ESPE). Sandblasting increases the surface area of the intaglio surface of the restoration. For high-strength core materials, a light dusting of alumina particles of less than 50µ for short periods (five seconds) is recommended. Sandblasting is not recommended for low-strength ceramics as it can weaken the restoration.

The Rocatec Soft or Cojet Sand system is an effective method for increasing the bond to high-alumina cores,[32] feldspathic porcelain[33] and zirconia core materials.[34] It coats the cementing surface of the ceramic restoration with silica (Figure 3) using a 30- or 110-micron silica particle coated with alumina.[35] Silane is then applied to this layer and dried thoroughly. The silane bonds to the silica coated on the ceramic, which bonds to the resin cement. By this mechanism a high-strength non-silica-containing ceramic restoration is bonded to the tooth.

Figure 3: Cojet Sand applied for 15 seconds on a non-silica-containing ceramic (Cercon)



Resin cements are also popular for metal and resin fiber post cementation. In one study, the use of resin cements with dentin bonding agents improved post retention when the length of the prepared post space was less than ideal.[36,37] A recent report by Hess et al.[38] on an in vitro short-term study found that fiber posts cemented with self-adhesive cements in endodontically treated teeth provide good retention.

Self-Adhesive Cements — A New Category

Self-adhesive cements are the newest category of resin cements. They are dual-cured and can be used most effectively when bonding to dentin. They are esthetically suitable for cementing all-ceramic crowns and porcelain inlays and onlays. Unlike resin cements, these materials require no intermediate steps to bond to enamel and dentin. A separate adhesive bonding agent is not required, saving time and simplifying the procedure.

Self-adhesive cements contain acrylic or diacrylate monomers and specific adhesive monomers that are sufficiently acidic to produce their self-adhesive properties. Self-adhesive cements leave the dentin smear layer and produce an intermediate bond to dentin compared with total etch cements. The cement acidity needed to etch the tooth lasts only briefly, and near neutrality is achieved over a short time period. Reports of reduced cold sensitivity after cementation using these materials have been recorded, while other studies have shown no difference between self-adhesive and total etch cements.[39,40,41]

Self-adhesive cements have been evaluated clinically and have a successful clinical history. Powers[42] reported that Unicem (3M ESPE), the first self-adhesive cement to appear on the market, has been evaluated over a four-year period in more than 4,400 restorations, with 1,560 available for recall. Less than 1.8 percent of the restored teeth had occasional temperature sensitivity, while marginal staining (graying at the margins) was seen in 4.2 percent of the cases.

Self-adhesive cements are dual cured, and it has been reported that dual-cured cements have reduced bond strengths in the self-cured mode. For this reason, it is prudent to light cure all dual-curing cements at accessible restorative margins. This practice should improve marginal integrity, amd nay increase wear resistance and reduce staining. Bond strengths to tooth structure seem to vary with the specific material. Some of these cements appear to be sensitive to overwetting and overdrying, which lowers their bond strengths. 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 the effects observed on enamel, it has been our experience with at least one of these cements that when dentin is etched with phosphoric acid or a bonding agent is applied, the bond decreases.

Crown retention values have been reported by Palacios et al.[43] and Cakir et al.[44] In both studies, standardized preparations were made on extracted human molars. Zirconium oxide copings (Procera All-Zirkon or Cercon) were fabricated and sandblasted with Al_2O_3. Copings were cemented using a self-adhesive cement (Panavia F 2.0 and ED Primer A & B), a resin modified glass ionomer cement (Rely X Luting) or a self-adhesive composite resin (Rely X Unicem). In the Cakir study, seven self-adhesive cements were compared, with no thermocycling. In the Palacios et al. report, the specimens were thermocycled for 5,000 cycles, with a 15-second dwell time. The copings in both studies were removed using a tensile load until failure. In both studies, the highest retention rates were reported for the self-etching resin cement and the self-adhesive cement. The predominant mode of failure was cement remaining principally on the zirconium oxide copings, demonstrating that the bond to the tooth was weaker than the ceramic bond.

Recent Developments

A new self-adhesive cement has recently been developed (SmartCem™2, DENTSPLY/Caulk). This cement contains resins that provide structural reinforcement of the cement and that also offer strong cross-link bonding following polymerization. It is based on Prime and Bond chemistry, containing the phosphoric acid modified monomer PENTA, which has been shown to bond chemically as well as mechanically by interacting chemically with the calcium contained in the tooth structure.[45] A unique initiator system with a patent pending promotes physical properties, enhances both shelf and shade stability and provides a gel phase during the setting reaction which results in easy clean-up procedures.

Figure 4a. Mechanical Micro-retention

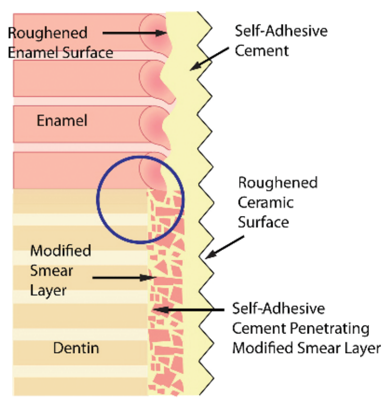
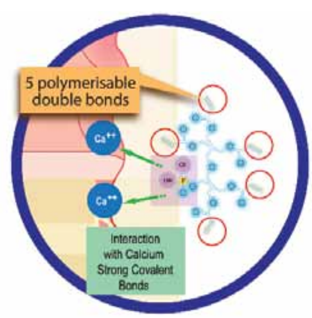


Figure 4b. Chemical Bonding (PENTA)



In vitro studies have shown the material to have high bond strengths to enamel and dentin; high retentive strength in crown-pull studies; and high bond strengths to indirect restorative materials including composite, base metal, noble metal and all-ceramic materials (Ceron and Finesse). Other studies have found no microleakage at either the enamel or dentin interface; minimal water solubility and sorption; and expansion over a six-month period in water storage of less than 1.0 percent.

Clinical Use of Self-Adhesive Cements — Case Studies

The following case demonstrates the use of self-adhesive cement (SmartCem™2) for the luting of zirconia crowns. The patient, a 32 year-old male in good overall health, presented complaining of the poor esthetic appearance of the porcelain-fused-to-metal crowns on teeth #7 and #8, and gingival recession (Figure 5a). After evaluation, radiographs and discussion with the patient it was decided to replace the crowns with ceramic crowns reinforced with a zirconium core. After preparation and and fabrication of the zirconia cores, a try-in was peformed to check their fit on the prepped teeth (Figure 5b).
The final crowns were seated using the self-adhesive cement (Figure 5c) and excess cement was removed while it was still in the gel phase prior to final set (Figure 5d). The completed case provided excellent marginal integrity and superior esthetics (Figure 5e).

Figure 5a. Poor esthetics and gingival recession at teeth #7 and #8

Figure 5b. Try-in of zirconia cores

Figure 5c. Seated crowns with excess cement

Figure 5d. Excess cement removed while in the gel phase

Figure 5e. Completed case

Summary

Over time, luting cements have evolved into stronger dental materials that are easier to use and can bond to tooth structure as well as the restorative material. Concurrently, indirect restorative materials have also evolved, offering a wider variety of materials and far more aesthetic solutions. With so many cements on the market and with new classes of materials emerging, it is critical to select a luting cement that meets the requirements of both the intraoral environment and the type of restoration. Perhaps the most versatile cements are the resin and self-adhesive resin cements since they are indicated for the widest variety of uses. Both provide bonding to tooth structure, and while self-adhesive cements offer extraordinary convenience, they should not be considered a substitute for traditional bonding cements in all situations. Just as self-

Table 3: Advantages & Disadvantages of Dental Cements

Dental cement	Advantage	Disadvantage	Precautions
ZnOE	Biocompatible, inexpensive	Low strength, solubility, hand mix	Use with retentive preparations
$ZnPO_4$	Successful clinical history	Leakage, hand mix, low retention	Exothermic reaction; need long parallel walls for retention
PCC	Biocompatible, weak bond to tooth	Low strength, solubility	P/L ratio
GIC	Translucency, bonds to tooth	Leakage, solubility	Avoid early moisture contamination and excessive drying; bond to moist tooth or bond drops
RMGIC	Low solubility, low leakage	Water sorption	May be used with high-strength restorations such as Cercon, LAVA, Procera; not for feldspathic porcelain
Total-etch composite resin cement	Low solubility, bond to feldspathic porcelain and pressables	Film thickness, number of steps, contamination sensitive	Requires bonding resin, moisture control, multiple steps; overetching of dentin possible
Self-etch composite resin cement	Fewer steps than total-etch cements; no etch and rinse steps required	Requires primer placement and drying steps	Unground enamel and sclerotic dentin etching with phosphoric acid
Self-adhesive composite resin	No bonding agent or bonding steps required; reduced postoperative cold sensitivity	Lower bond strengths than total- and self-etch resin cements	Requires enamel etch for optimal bond to enamel

etch adhesives have not replaced total-etch adhesives, neither should it be expected that self-adhesive cements will replace traditional bonding cements.

Table 3 presents the advantages and disadvantages of all classes of cements discussed in this article.

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Author Profile

John O. Burgess, DDS, MS

Dr. Burgess is the Assistant Dean for Clinical Research and the Director of The Biomaterials Graduate Program at the University of Alabama in Birmingham. He graduated from Emory University School of Dentistry and completed graduate training at the University of Texas Health Science Center in Houston. He completed a General Practice Residency and a General Dentistry Residency in the Air Force. He served as military consultant to the Surgeon General in General Dentistry and was Chairman of Dental Research and Dental Materials at Wilford Hall Medical Center. Dr. Burgess is a diplomat of the Federal Services Board in General Dentistry and the American Board of General Dentistry. He is a Fellow of the Academy of Dental Materials and the American College of Dentists, and an elected member of The American Academy of Esthetic Dentistry and The American Restorative Academy. He is a member of the Academy of Operative Dentistry, The American and International Associations for Dental Research, the Alabama Dental Association and the ADA. A dedicated researcher he has served as the principal investigator on industrial, foundation, state and national grants. Dr. Burgess is the author of over 300 journal articles, textbook chapters and abstracts and has presented more than 800 continuing education programs nationally and internationally. Dr. Burgess is an active investigator on clinical trials evaluating posterior composites, adhesives, fluoride releasing materials, impression materials and class 5 restorations. He maintains a part-time practice in general dentistry. He has been happily married to Patricia for more than 30 years.

Taneet Ghuman, BDS

Dr. Ghuman graduated with a Bachelor's degree in Dental Surgery from M.R. Ambedkar Dental College & Hospital, Bangalore, India in 2006. She is pursuing her Masters in Clinical Dentistry, specializing in Dental Biomaterials at UAB and will graduate in 2009. She is a graduate assistant with Dr. John O. Burgess, her advisor. She is a member of the Indian Dental Association, Dental Council of India, Bangalore Academy of Periodontology, American Association of Dental Research, International Association of Dental Research & Alabama Academy of Science. She is active in in-vitro trials on Dental cements, Bonding agents, Restorative Materials and Impression materials. Upon completion of her Masters, Dr. Ghuman intends to continue her work in the field of Dental Materials.

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The clinical case in this article contains clinical images courtesy of Dr. Amaury M. Silveira.

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Questions

1. In the 1850s, the only cement available was _________.
   a. zinc oxide ethanol
   b. zinc oxide eugenol
   c. magesium oxide eugenol
   d. none of the above

2. Resin modified glass ionomer cements were introduced in _________.
   a. 1972
   b. 1982
   c. 1992
   d. 2002

3. Zinc oxide eugenol cement _________.
   a. is the cement of choice today
   b. has an obtunding effect on the pulp
   c. has a high film thickness
   d. b and c

4. Zinc phosphate cement _________.
   a. is a two-bottle system composed of phosphoric acid liquid, and a mixture of zinc oxide and magnesium oxide powder
   b. produces an exothermic reaction
   c. has a significant amount of clinical success associated with its use
   d. all of the above

5. The first cement to bond to tooth structure was _________.
   a. zinc phosphate
   b. zinc polycarboxylate
   c. glass ionomer
   d. none of the above

6. The development of glass-ionomer cements was first announced by _________.
   a. Wilson and Dent
   b. Wilson and Kent
   c. Wilson and McIntosh
   d. none of the above

7. Glass ionomer cements have_________ .
   a. low solubility in the oral cavity
   b. excellent translucency
   c. good working time
   d. all of the above

8. Zinc polycarboxylate cement has a _________ than other cements.
   a. longer working time and lower solubility
   b. longer working time and lower solubility
   c. short working time and lower solubility
   d. short working time and greater solubility

9. Glass ionomer cements produce reten¬tion rates _________ zinc phosphate.
   a. similar to
   b. superior to
   c. inferior to
   d. none of the above

10. Resin modified glass ionomers were formed by replacing part of the _________ in conventional glass ionomer cements with hydrophilic methacrylate monomers.
    a. hydrochloric acid
    b. polyacrylic acid
    c. acetic acid
    d. none of the above

11. Resin modified glass ionomers release _________ conventional glass ionomer cements.
    a. less fluoride compared to
    b. more fluoride compared to
    c. the same amount of fluoride as
    d. none of the above

12. Resin cements _________ curing mechanism(s).
    a. all have the same
    b. vary in their
    c. each have multiple
    d. none of the above

13. Dual-cured cements should be tested to ensure that the _________ curing mechanism is still functioning.
    a. biochemical
    b. mechanical
    c. chemical
    d. all of the above

14. The range for the compressive strength of resin modified glass ionomer cements is _________.
    a. 30-131 MPa
    b. 40-141 MPa
    c. 40-141 Pma
    d. 40-151 Pma

15. The range for the compressive strength of resin cements is _________.
    a. 184-200 MPa
    b. 194-200 MPa
    c. 194-200 PMa
    d. none of the above

16. All-ceramic crowns require _________ tooth preparation and have been associated with tooth sensitivity after cementation.
    a. minimal
    b. increased
    c. decreased
    d. none of the above

17. Bonded resin cements are particularly useful in clinical situations where retention of crowns or fixed partial dentures is _________.
    a. superior
    b. compromised
    c. not required
    d. a and b

18. _________ is suitable for the cementation of feldspathic ceramic crowns.
    a. Zinc oxide eugenol cement
    b. Zinc phosphate cement
    c. Resin bonding
    d. all of the above

19. Glass ionomer cements are used mainly to cement _________.
    a. metal and all-ceramic restorations with adequate retentive and resistance form
    b. metal and metal-ceramic restorations with adequate retentive and resistance form
    c. metal and metal-ceramic restorations with poor retentive and resistance form
    d. none of the above

20. Resin modified glass ionomer cements _________ be used for high-strength ceramic restorations.
    a. can
    b. should not
    c. should always
    d. none of the above

21. _________ are used for veneers and are supplied in multiple shades, viscosities and esthetic try-in pastes.
    a. Esthetic resin composite cements
    b. Esthetic glass ionomer cements
    c. Esthetic zinc phosphate cements
    d. none of the above

22. Resin cements with a dentin bonding agent have provided a _________increase in crown retention on teeth with short clinical crowns compared to using zinc phosphate cement.
    a. twofold
    b. threefold
    c. fourfold
    d. fivefold

23. Sandblasting _________ .
    a. can be used on the intaglio surface prior to bonding high-strength ceramic materials
    b. is not recommended for low-strength ceramics
    c. increases the surface area of the intaglio surface
    d. all of the above

24. Etching is _________ silica-containing materials (feldspathic porcelain and lithium disilicate- and leucite- containing ceramics).
    a. never effective for
    b. effective mainly for
    c. effective only for
    d. none of the above

Questions

25. Self-adhesive cements _________.
    a. are the newest category of resin cements
    b. are esthetically suitable for cementing all-ceramic crowns and porcelain inlays and onlays
    c. require no intermediate steps to bond to enamel and dentin
    d. all of the above

26. It is _________ to light-cure all dual-curing cements at accessible restorative margins.
    a. unnecessary
    b. necessary
    c. prudent
    d. none of the above

27. A cement containing phosphoric acid modified monomer PENTA has been shown to _________.
    a. bond mechanically
    b. interact with the organic material at the tooth surface
    c. interact chemically with the calcium contained in the tooth structure
    d. a and c

28. Excess self-adhesive cement can be removed during the _________ phase.
    a. working
    b. hydrophobic
    c. gel
    d. none of the above

29. _________ requires enamel etch for optimal bond to enamel.
    a. Zinc phosphate
    b. Zinc carboxylate
    c. Glass ionomer cement
    d. none of the above

30. The selection of a luting cements must consider _________.
    a. the physical properties of the cement
    b. the esthetic properties of the cement for esthetic restorations
    c. the material and type of restoration being cemented
    d. all of the above

31. The intaglio refers to the _________.
    a. outer surface of a gold alloy
    b. outer surface of a cast gold crown
    c. inner surface of a feldspathic porcelain restoration
    d. all of the above

32. Resin bonding can be used for a _________.
    a. metal ceramic crown
    b. veneer
    c. Maryland bridge
    d. all of the above

33. A composite fiber post can be cemented using _________.
    a. polycarboxylate cement
    b. resin bonding
    c. zinc oxide eugenol
    d. a and b

34. A crown with poor retention should be cemented using _________.
    a. a glass ionomer cement
    b. resin bonding
    c. polycarboxylate cement
    d. a or c

35. _________ can be used prior to bonding high-strength ceramic materials.
    a. Laser roughening
    b. Sandblasting
    c. Cortication
    d. all of the above

36. In one study of self-adhesive cements, it was found that the bond to the tooth was _________ the ceramic bond.
    a. weaker than
    b. as strong as
    c. stronger than
    d. none of the above

37. Over time, luting cements have become _________.
    a. complicated
    b. weaker
    c. stronger
    d. a and b

38. Indirect restorative materials now offer _________.
    a. a wider variety of materials
    b. a narrower range of materials
    c. far more esthetic solutions
    d. a and c

39. Long parallel preparation walls are needed when using _________.
    a. resin bonding
    b. self-adhesive cement
    c. zinc phosphate cement
    d. all of the above

40. Zinc oxide eugenol has the advantage of offering _________.
    a. high bond strength
    b. biocompatibility
    c. water sorption
    d. all of the above

41. The disadvantage of zinc phosphate cement is its _________.
    a. low retention
    b. requirement for hand mixing
    c. low water sorption
    d. a and b

42. Total etch composite resin offers _________.
    a. low solubility
    b. opacity
    c. high refraction
    d. all of the above

43. Self-adhesive cement has a _________ compared to total etch cement.
    a. higher bond strength
    b. higher compressive strength
    c. lower bond strength
    d. a and b

44. Water sorption can be a disadvantage of _________.
    a. zinc oxide eugenol cement
    b. resin modified glass ionomer cement
    c. zinc phosphate cement
    d. all of the above

45. Total etch composite resin cement requires _________.
    a. only one step
    b. bonding resin
    c. moisture control
    d. b and c

46. Solubility is an issue with _________.
    a. zinc oxide eugenol cement
    b. glass ionomer cement
    c. polycarboxylate cement
    d. all of the above

47. Self-etch adhesives have replaced _________.
    a. resin bonding
    b. etch-and-rinse adhesives
    c. total etch adhesives
    d. none of the above

48. Self-etch adhesives contain _________.
    a. acrylic
    b. monomers
    c. eugenol
    d. a and b

49. Resin cements may be _________.
    a. paste-paste
    b. powder-liquid
    c. single paste
    d. all of the above

50. _________ has an acid-based setting reaction.
    a. Self-adhesive cement
    b. Resin adhesive
    c. Glass ionomer cement
    d. all of the above

ANSWER SHEET

A Practical Guide To The Use Of Luting Cements

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1. List the types of luting cements and their chemical composition.
2. List the physical properties that affect the performance of luting cements.
3. List the applications for the various luting cements currently available.
4. Describe the physical properties, chemistry and application of self-adhesive luting cements.

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Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

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____

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5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	31.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	32.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	33.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	34.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	35.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	36.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	37.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	38.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	39.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	40.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	41.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	42.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	43.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	44.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	45.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	46.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	47.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	48.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	49.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	50.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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