Reliable Protocols for Cementing and Bonding Today’s Restorations

by Franklin Shull, DMD, and Shashikant Singhal, BDS, MS

Abstract
This article provides readers with an overview of considerations for cementing and bonding today’s restorations. It particularly offers overall insight into cement classifications, preparation requirements for conventional vs. adhesive cementation, cement requirements based on restoration material, and surface treatment of the tooth and restoration. Finally, readers will learn to recognize and identify products for use when cementing and bonding certain types of restorations and why they are indicated for specific cases.

Educational Objectives
After reading this article, readers will be able to:
1. Identify various factors like restorative material, tooth preparation, isolation, etc., that influence cement selection.
2. Classification of cements.
3. Explain different techniques for cementation and bonding.
4. Discuss the types of products that can be used to efficiently and effectively cement and bond modern restorations.

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Multiple factors influence cement selection. These include the restorative material, preparation design, necessary bond strengths, isolation capability and desired aesthetic outcomes. Depending on the clinical requirements and material selection, dentists may place restorations using either conventional or adhesive cementation techniques.

Conventional cementation combines preparation design and resistance form to attach restorations to underlying tooth structure. Adhesive cementation, on the other hand, produces a micromechanical and chemical bond between the tooth structure and the restoration.

Dentists therefore need a thorough understanding of not only the restorative material used in the fabrication of the dental restoration, but also the cementation options and protocols in order to predictably place today’s restorations.

**Preparation Design and Restorative Materials**

Primary determinants for cement selection are preparation design and restorative material (Figs. 1-3).

Preparation design is significant in cement selection. In general, depending on the inclination/taper of the axial wall of the prepared teeth, tooth-preparation design is classified into retentive and non-retentive preparations. If the longitudinal axis of the prepared teeth is <4mm, tooth preparation is classified as short preparations.

Retentive preparations feature an inclination/taper of between four and eight degrees with a longitudinal axis of tooth. This feature provides additional retentive form, which facilitates cementation of a restoration either by adhesive or conventional cementation techniques. While adhesive cementation always provides the strong “bond” and the good marginal seal, the luting forces of conventional cement are sufficient for both retention and restoration support. On the other hand, non-retentive preparations feature an inclination/taper in excess of eight degrees and lack retentive features, hence conventional cements are not indicated in this clinical scenario. In these situations, or in “short preparations,” adhesive resin cements are recommended to achieve sufficient retention.1,2

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**Fig. 1: Preparation Requirements for All-ceramic Success**

**Fig. 2: Full-coverage Restorations**

**Fig. 3: Conventional Cementation Preparation**

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The other primary determinant for cement selection is the restorative material itself, which is chosen from among the following indirect restoratives:

- Metal and metal-based restorations (e.g., metal alloys and porcelain-fused-to-metal restorations)
- Intermediate-strength ceramic restorations (e.g., feldspathic, leucite-reinforced, and fluorapatite restorations)
- High-strength ceramic restorations (e.g., lithium disilicate, alumina, and zirconia restorations) (Figs. 4 and 5)
- Indirect composite restorations (e.g., reinforced composites)

Intermediate-strength glass ceramics (e.g., those with high glassy content) obtain additional support from adhesive bonding and must be adhesively cemented using resin cements. Therefore, feldspathic, leucite-reinforced and fluorapatite ceramic restorations should be seated with adhesive resin cements.

High-strength ceramics such as lithium disilicate materials (IPS e.max CAD (Fig. 6), IPS e.max Press), alumina and zirconia-based ceramics demonstrate good mechanical properties and can withstand occlusal loads in the absence of any additional support from adhesive resin cements. Therefore, high-strength ceramics to be cemented/luted with both adhesive and conventional cementation techniques. Although conventional cementation is permissible for these ceramics, the adhesive cementation technique offers multiple advantages and remains the material of choice (Fig. 7).

Cement Classifications

Cements are classified into three main categories: conventional cements, adhesive cements and self-adhesive cements.

Conventional Cements

Conventional luting cements connect restorations and underlying tooth structure by creating a hardened cement layer between the restoration and tooth. Conventional cements most notably include zinc polycarboxylate, glass ionomers, resin modified ionomers and zinc phosphate cements. These materials do not chemically bond with the tooth structure (except for glass ionomers and resin modified glass ionomers) and, hence, retentive preparation designs should be taken into consideration while using conventional cements. These cements are typically used by clinicians for luting high-strength ceramics, metal-based restorations and posts.

**Zinc Polycarboxylate Cement:** It was the first cement to bond to tooth structure. It consists of metal oxides and polyacrylic acid. The dry mixture is mostly used as a powder, which is mixed with water for processing. The complicated setting reaction takes place by the reaction of metal oxides with the polyacrylic acid. The comparatively high solubility of the cement and mild pulpal reaction is a substantial disadvantage.

**Glass-Ionomer Cement:** It consists of fluoroaluminosilicate glass and liquid containing polyacrylic, itaconic acid and water. They demonstrate the advantage of being able to release fluoride ions. Setting reaction takes place with the help of an acid-base reaction. Clinical experiences with glass-ionomer cements have been gathered for more than 20 years, however, it produces low retention rates and thus indicated for retentive tooth preparations.

**Resin-Reinforced Glass-Ionomer Cements:** These were formed by replacing part of polyacrylic acid in conventional glass inomer cements with hydrophilic methacrylate monomers. This group of luting agents includes a number of hybrid cements.
cements, the physical and clinical properties of which strongly vary depending on the composition of the individual components. Their adhesion to the tooth structure is often weak and when applied to moist dentin produce little post-cementation thermal sensitivity.

**Adhesive Resin Cements**

Adhesive resin cements are superior options for all-ceramic restorations. They are methacrylate-based and consist of monomers and inorganic filler particles. Their setting is based on a cross-linking of the polymer chains, which is initiated chemically and/or by light. Luting composites demonstrate high mechanical and physical properties with more wear resistance, more resistant to the oral environment, and offer outstanding aesthetics provided by the choice of several shades. In general, adhesive resin cements require tooth preparation to be etched and rinsed, then conditioned with an adhesive bonding agent and cured. Etching removes the smear layer and demineralizes the tooth surface, whereas a bonding agent forms an interpenetrating network with free collagen fibers, which is known as a hybrid layer. Adhesive resin cements have significantly superior mechanical properties however, when proper isolation can’t be achieved, conventional cements are recommended.

Adhesive cements are further classified according to curing options:

- **Self-cure resin cements (chemically cure)** [e.g., Multilink Automix (Ivoclar Vivadent, Inc.)] (Fig. 8).
- **Dual-cure resin cements (require light to initiate chemical reaction)** [e.g., Variolink II (Ivoclar Vivadent, Inc.), Calibra (Dentsply), Bifix, (VOCO), Nexus 3, (Kerr)] (Fig. 9).
- **Light-cure resin cements (light cure exclusively)** [e.g., Variolink Veneer (Ivoclar Vivadent, Inc.), RelyX Veneer (3M)] (Fig. 10).

Dual-cure and light-cure resin cements need light energy for complete polymerization of cement. However, restorations made of metals, metal alloys and opaque ceramics (e.g., zirconia oxide) are impervious to light, which contraindicate the use of dual cure and light cure resin cements for cementation, hence why self-cure resin cements are indicated in these clinical conditions.

Multilink Automix (Ivoclar Vivadent, Inc.) is a self-cure resin cement with an option of light cure to accelerate the setting reaction, which allows it to be indicated for cementation of indirect restorations (inlays, onlays, crowns, bridges and posts) made of all types of restorative materials like metal, metal-ceramic, ceramic or post and cores. Multilink Automix shares strong mechanical and physical properties with fast and easy application with clinical success of more than six years.

On the other hand, the cementation of highly aesthetic restorations such as veneers requires materials that ensure long-term color stability for high quality aesthetics. This requirement could be filled with amine-reduced resin cement, which is exclusively developed for light-curing Variolink Veneer (Ivoclar Vivadent, Inc.). Variolink Veneer is characterized by special shade mapping (shade value), which covers different opacities and colors and provides dentists a wide range of shades with try-in paste for cementation of highly aesthetic ceramic restorations.

**Self-adhesive Resin Cements**

Self-adhesive resin cements demonstrate some of the advantages of resin cements and the convenience of conventional cements, including moderate level bond strengths. These cements do not require the application of conditioners and bonding agents to the prepared tooth surfaces and hence make them easy to use and error-proof. However, because of compromised bond strength and mechanical properties, these cements are not indicated for low strength glass ceramics.

Some commercially available self-adhesive resin cements are Rely X Unicem 2 (3M ESPE), G-CEM (GC America) and MaxCEM Elite (Kerr Corp.).

One particular self-adhesive cement (SpeedCEM, Ivoclar Vivadent) can be used with high-strength ceramics to help maximize clinical efficiency. This self-adhesive, self-curing luting cement can be optionally light-cured and also offers an easy, quick and universal application. It offers the additional advantages of a composite, such as intermediate bond strength and translucency, as well as lower water solubility. SpeedCEM consists of an adhesive monomer with long chain methacrylate with a phosphate acid group that enables stable chemical bonds

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to zirconium oxide metal restorations. Therefore, it is suitable for cementing indirect restorations made of metal, metal-ceramics, lithium disilicate, oxide ceramics and fiber-reinforced resin composites.

**Surface Treatment of Restorations**

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 ceramic restorations depends upon the composition and strength of ceramic materials. It includes acid etching or sand blasting of an intaglio surface followed by an application of primer.

**Acid Etching:** This is indicated only for silica-containing materials like feldspathic ceramics, leucite-reinforced, and lithium disilicate ceramic restorations. Manufacturers’ recommendations should be strictly followed to achieve highest bond strength. For leucite glass ceramic (IPS Empress; Ivoclar Vivadent, Inc.), restoration surface should be treated with HF (<5% concentration) for 60 seconds and 20 seconds for lithium disilicate restorations (IPS e.max; Ivoclar Vivadent, Inc.). Etching generates retentive bonding surfaces on glass-ceramic restorations which enhances bond strength between cementation material and glass-ceramics.  

**Sand Blasting:** Sandblasting is indicated for high strength ceramic materials like Bruxir (Glidewell), LAVA (3M ESPE), Cercon (Dentsply), IPS e.max ZirCAD (Ivoclar Vivadent, Inc.) and contraindicated for intermediate-strength ceramic restorations. Sandblasting increases the surface area of the internal surface of the restoration and hence significantly increases bond strength between restoration and cements. Use of alumina particles less than 50 microns for short durations of time (five to 10 seconds) is recommended for sand blasting.

**Primer:** Adhesive luting protocols involve the use of resin cements, which are used in combination with dental adhesives.

In addition, a special primer is employed to establish a chemical bond to a restorative material. Depending upon the restorative materials, primer are classified as silane primer, zirconia primer and metal primer, indicated for glass ceramic restorations, zirconia restorations and metal or metal fused porcelain restorations, respectively. Research studies have shown a significant increase in bond strength of resin cements followed by the application of primers.  

It is very important for clinicians to follow the indicated primer with a particular restorative material, which often creates confusion. Monobond Plus (Ivoclar Vivadent, Inc.) is a universal primer that enables clinicians to achieve a strong and durable bond to any restorative material like glass ceramics, zirconia and metal or metal fused porcelain restorations. It consists of trialkoxy silane group for bonding with glass ceramics, phosphoric acid methacrylate for bonding zirconia restorations and disulfide methacrylate for bonding metal restorations.

**Cleaning of Restoration after Try-in**

Not all the dental practices are well equipped to carry out the etching and sand-blasting of restorations that allows dental labs to pre-treat the restorations. However, during the intraoral try-in of final restorations, contamination of pre-treated restoration surfaces from saliva and blood cannot be avoided. Phosphate groups from phospholipids and glycolipids present in saliva and blood bonds with the active sites of restorative surfaces, especially zirconia restorations, which have a high affinity towards a phosphate group. This blocks the active sites and further decreases bond strength between restorations and resin cements significantly. Various cleaning protocols have been proposed like cleaning with water, alcohol, phosphoric acid or corundum-blasted, however, none of these protocols are one hundred percent effective. Cleaning the restoration with phosphoric is the most common protocol followed by

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clinicians, however, it is contraindicated for zirconia restorations because of a high affinity of zirconia towards the phosphate group, which blocks the active sites and significantly decreases bond strength.8 Ivoclean (Ivoclar Vivadent, Inc.) is the newest universal cleaning paste available commercially. It is a concentrated zirconia oxide solution specifically designed for cleaning prosthetic restorations followed by intra-oral try-in. It is compatible with all types of restorations and ensures the integrity of bonding and cementation surfaces.

**Conclusion**

The quality and durability of restorations is predicated on the use of the correct placement protocols. Selecting the most appropriate adhesive and conventional cementation materials and techniques are critical to achieving successful results. The clinically proven Ivoclar Vivadent adhesive and conventional cementation materials have been thoroughly tried and tested for their respective indications. This article has outlined some key considerations related to cement and adhesive selection, as well as restoration placement.


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**Author Bios**

**Dr. Franklin Shull** is a native of South Carolina, earning his Bachelor of Science degree from the University of South Carolina and his dental degree from the Medical University of South Carolina. He then completed a general practice residency at Richland Memorial Hospital in Columbia, South Carolina.

Dr. Shull is a member and fellow of the Academy of General Dentistry, a member of the American Dental Association, American Academy of Cosmetic Dentistry and the Southeastern Prosthodontic Society. He is a member and past president of the South Carolina AGD and a member and past president of The Greater Columbia Dental Society.

Dr. Shull is on the teaching faculty at the L.D. Pankey Institute where he teaches the Aesthetics Continuum. He also holds faculty appointments at Palmetto Health Richland General Practice Residency, Georgia Health Sciences University School of Dentistry.

Dr. Shull has published multiple dental articles and lectures throughout the United States on aesthetics and dental materials, including adhesives, composites and ceramics, and dental photography. All of Dr. Shull’s lectures are based on current literature and are filled with clinical photography.

**Dr. Shashikant Singhal** graduated with a bachelor’s degree in dental surgery from College of Dental Sciences, India, in 2008. He then earned a Master of Science in Advanced Clinical Dentistry Program, with emphasis in Biomaterials, from the University of Alabama at Birmingham, AL in 2011. He was awarded a graduate fellowship award at the University of Alabama at Birmingham in 2010. Dr. Singhal is an active researcher and has presented his research studies at many scientific meetings. He is a member of the American Association of Dental Research, International Association of Dental Research and Academy of Dental Materials. Currently, Dr. Singhal works as a clinical specialist at Ivoclar Vivadent, Inc. In this capacity, he is responsible for university student’s research projects, educational and product training, and research developmental projects.

The authors declare that neither they or any member of their families have a financial arrangement or affiliation with any corporate organization offering financial support or grant monies for this continuing dental education program nor have any financial connection with any product or service mentioned.

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Ivoclar Vivadent has developed an online and mobile resource to assist dental laboratories and their dentists in making the right cementation choice for each indication.

The Cementation Navigation System – available as an app from the iTunes App Store and at www.cementation-navigation.com – is a multimedia application that guides viewers through the various cementation protocols.

Whether it’s natural tooth structure or an implant abutment, the Cementation Navigation System features detailed animation clips and step-by-step details for achieving an ideal cementation in each case.
Post-test

1. What are the factors that influence cement selection?
   a. Isolation capability
   b. Preparation design
   c. Bond strengths
   d. All of the above

2. Which of the following is not an advantage of self-adhesive resin cements?
   a. Ease of use
   b. Adequate bond strength
   c. No need for any surface treatment of the tooth
   d. Suitable for use with low strength glass ceramics

3. Sharp line angles or edges should be avoided when preparing all-ceramic restorations.
   a. True
   b. False

4. Which of the following is not a type of preparation design?
   a. Retentive
   b. Non-retentive
   c. Aggressive
   d. None of the above

5. Conventional cementation combines preparation design and resistance form to attach restorations to underlying tooth structure.
   a. True
   b. False

6. Which of the following facilitate bonding to dental alloys or ceramics?
   a. Monomers
   b. Primers
   c. Both a and b
   d. None of the above

7. Retentive and non-retentive preparations are determined by which of the following?
   a. Inclination/taper of the axial wall of prepared teeth
   b. Longitudinal axis of tooth
   c. Height of the prepared tooth
   d. All of the above

8. Restorations fabricated with which of the following materials must be seated with adhesive resin cements?
   a. Feldspathic porcelain
   b. Leucite-reinforced glass ceramic
   c. Metal substructures
   d. Both a and b

9. Conventional cements can be used for seating restorations fabricated with which of the following materials?
   a. Lithium disilicate
   b. Alumina
   c. Zirconia-based ceramics
   d. All of the above

10. A ceramic etching gel is used to achieve which of the following?
    a. Retentive bonding surfaces on all-ceramic restorations
    b. Enhanced bonding effect between the luting composite and ceramic bonding surface
    c. Reduced post-operative sensitivity
    d. Both a and b

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