Abstract
Clinical dentistry is filled with many processes and decisions that ultimately determine the fate and quality of the care provided. Cementation of indirect restorations is no exception, because several opinions exist in regard to adhesion dentistry. This article should help clinicians make better decisions when it comes to cementation and indirect restorative dentistry.

Introduction
Dental cementation has progressed dramatically since the introduction of zinc oxide eugenol in the 1850s. Manufacturers of dental materials have made minor changes with profound impacts in each generation of cements, which has created a highly diverse portfolio that can be confusing to decipher.1 With each generation of cement come new indications, directions, handling properties and techniques.

In addition to the diverse range of cements available, dentistry has also evolved to offer many options for indirect restorations. These restorations have evolved to a point that industry pioneers may have never imagined; however, failure can occur if the restorations are not handled and cemented properly. Even among materials, the type of restoration—crown, veneer, onlay, inlay, etc.—can have a profound impact on cement selection.

This article examines the most commonly used cements, in conjunction with the most commonly used restorations. The intent is to minimize stress in the decision-making process for dental cementation. Understanding the materials and cement selection is paramount for consistent predictable outcomes.

Cements
With variations in nomenclature, there are three main classifications of cements that are widely used and accepted in clinical practice: luting, self-adhesive resin and adhesive resin cements. Each has not only specific indications but also specific protocols to ensure success.

It should also be stressed that no specific cement satisfies all the requirements of every clinical situation; therefore, product knowledge is imperative.

<table>
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<tr>
<th>Resin-Modified Glass Ionomers</th>
<th>Self-Adhesive Resin Cements</th>
<th>Adhesive Resin Cements</th>
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<tr>
<td>Meron Plus, Voco</td>
<td>Bifix SE, Voco</td>
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<td>RelyX Luting Plus, 3M</td>
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Luting cements

A luting cement merely creates a seal between the restoration and the tooth. There is only a physical connection, no chemical connection (or bond).\textsuperscript{3}

Resin modified glass ionomer cements

Traditional glass ionomer (GI) cements have been utilized for more than 40 years; however, in the early 1990s, resin modified glass ionomer (RMGI) cements were introduced. RMGI cements represent an improvement over traditional GI cements with the addition of methacrylate monomers.\textsuperscript{4} They have an improved flexural strength, are biocompatible, and although they’re classified as luting cements, they provide a greater bond than traditional GI cements.

RMGI cements are attractive to clinicians because they release fluoride ions, don’t require additional bonding adhesives and have little or no postoperative sensitivity.\textsuperscript{5,6} They are indicated for multiple types of restorations, though reports indicate that leucite and feldspathic restorations have an incidence of fracture if luted with RMGI. It is imperative that proper retention and resistance form be followed for successful cementation with RMGI cements.\textsuperscript{1}

Resin cements

Resin cements are a general classification of cements, with many advancements creating subcategories. This general classification is the most widely used classification of cements in modern dentistry.\textsuperscript{1} The two categories that will be addressed here are adhesive and self-adhesive cements.

Adhesive resin cements

Adhesive resin cements have been around longer than self-adhesive cements. They have multiple indications, and each needs to be thoroughly investigated before use.

<table>
<thead>
<tr>
<th>Restoration</th>
<th>Cement Choice</th>
<th>Tooth Preparation</th>
<th>Restoration Preparation</th>
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<tr>
<td>Zirconia</td>
<td>Cement: Good retention only</td>
<td>Ensure clean preparation (pumice or scrub)</td>
<td>Air-abrade restoration (50–60µm aluminum oxide, ≤ 2bar); apply RMGI or SARC cement</td>
</tr>
<tr>
<td></td>
<td>Bond: Self-adhesive resin cement</td>
<td>Ensure clean preparation</td>
<td>Air-abrade restoration (50–60µm aluminum oxide, ≤ 2bar); apply silane primer; apply SARC cement</td>
</tr>
<tr>
<td></td>
<td>Bond: Adhesive resin cement</td>
<td>Ensure clean preparation; etch and/or bonding agent, according to manufacturer’s instructions</td>
<td>Air-abrade restoration (50–60µm aluminum oxide, ≤ 2bar); apply silane primer; apply bonding agent and ARC cement (dual cure)</td>
</tr>
<tr>
<td>Lithium silicate or disilicate</td>
<td>Bond: Self-adhesive resin cement</td>
<td>Ensure clean preparation</td>
<td>Etch restoration with 5% HF acid etch for 20 seconds; apply silane primer; apply SARC cement</td>
</tr>
<tr>
<td></td>
<td>Bond: Adhesive resin cement</td>
<td>Ensure clean preparation; etch and/or bonding agent, according to manufacturer’s instructions</td>
<td>Etch restoration with 5% HF acid etch for 20 seconds; apply silane primer; apply bonding agent; apply ARC cement</td>
</tr>
<tr>
<td>Leucite-reinforced ceramics</td>
<td>Bond: Adhesive resin cement</td>
<td>Ensure clean preparation; etch and/or bonding agent, according to manufacturer’s instructions</td>
<td>Etch restoration with 9.6% HF acid etch for 1 minute (max 2.5 minutes); apply silane primer; apply bonding agent; apply ARC cement</td>
</tr>
<tr>
<td>Hybrid ceramics</td>
<td>Bond: Adhesive resin cement</td>
<td>Ensure clean preparation; etch and/or bonding agent, according to manufacturer’s instructions</td>
<td>Air-abrade restoration (25–50µm aluminum oxide, 1.5–2 bar); apply silane primer for 60 seconds; apply bonding agent and ARC dual cure cement (verify with manufacturer’s directions)</td>
</tr>
</tbody>
</table>
There are self-cure, dual-cure and light-cure versions of this cement. A detailed bonding protocol may exist for success, including pretreatment of the tooth and the intaglio surface of the restoration.

In addition, dependent upon the type of adhesive, a silane coupling agent may be necessary for bonding to the restoration. Multiple shades are available, as well as corresponding try-in pastes (dependent upon the manufacturer).

**Self-adhesive resin cements**

Self-adhesive resin cements are often referred to as “universal cements.” With an initial pH of 2.1–2.3, they are acidic enough to “etch” the tooth, while their monomers enhance the bond strength without applying a separate priming or bonding agent (which isn’t recommended by most manufacturers). Most of these are dual-cure materials, and although the bond strengths aren’t as high as those of adhesive resin cements, the bond strength is increased when light initiates the set. The indications are vast: crowns, bridges, inlays and onlays of all materials. Veneers aren’t recommended as an indication by most manufacturers, because the long-term color stability can be an issue with these cements.

**Predominantly glass ceramics**

This type of ceramic is composed of feldspar minerals and aluminum oxides. These ceramics are generally referred to as “feldspathic” ceramics. They are highly aesthetic and can be used for porcelain jacket crowns, inlays, onlays and veneers.

Because of their low strength and fracture resistance, it’s recommended to cement these restorations with adhesive resin cements. To effectively bond these restorations, it’s recommended that the intaglio surface be treated with 9.6 percent hydrofluoric (HF) acid for a minimum of one minute (with a maximum of 2.5 minutes), followed by application of MDP primer (silane) for one minute, and then air drying.

**Particle-filled glass ceramics**

Particle-filled glass ceramics contain different types and amounts of particles in a glassy matrix. The strength of these materials corresponds to the amount of particles included and a lesser amount of glassy matrix. There are three commonly known variations: leucite-reinforced, lithium disilicate and glass-infiltrated alumina. The three rank in strength, lowest to highest, based upon filler content in the order presented. These materials may be used for crowns, veneers, inlays and onlays.

The three materials are recommended to be treated differently before cementation.

- For leucite-reinforced, a 5 percent HF acid etch for one minute is recommended along with adhesive cementation.
- For lithium disilicate, a 5 percent HF acid etch for 20 seconds is recommended.
- For glass-infiltrated alumina, air abrasion with either aluminum oxide or a silica coated oxide particle is recommended.

I believe that lithium disilicate and glass-infiltrated alumina are best cemented adhesively (with either adhesive or self-adhesive resin); however, it is possible to cement these two classifications with RMGI, and the use of a silane primer may not be indicated.
Polycrystalline

Polycrystalline restorations are either densely sintered aluminum oxide or zirconium oxide. According to Glidewell Laboratories, zirconium oxide restorations represent the predominant classification utilized by dentists. These restorations have numerous indications in dentistry, including full-coverage crowns. Both zirconia and alumina are non-silica-based, metal-free restorations and therefore need to be treated differently from conventional ceramics.

Retentive elements of the preparation play a role in cement choice. These may be cemented with conventional cements (RMGI) if the prep is retentive. There is also evidence to suggest that a bond is capable if treated correctly. Dr. Marcus Blatz has coined the “APC zirconia bonding concept.” The intaglio surface should be treated via sandblasting, with a 50–60µm aluminum oxide below two bars, followed by treatment with a primer suitable for zirconia or alumina. The final step is to use a dual- or self-cure resin cement. It’s important to not use a light-cure only cement, because the cement will not fully polymerize.

Hybrid ceramics

Hybrid ceramics, introduced in 2012, are the newest classification of indirect material. There are several materials, each made of a ceramic particle dispersed in a resin matrix, up to 86 percent filled. Each manufacturer lists different usages, but most hybrid ceramics are indicated for inlays, onlays, crowns, veneers and implant-supported restorations.

These materials are very attractive to CAD/CAM users because of their fast milling, and there is no need for post-firing. Each has a unique bonding protocol that’s critical for proper adhesion. Because of the varying compositions, it’s imperative to follow manufacturer’s recommendations for adequate bonding.

I recommend using a dual-cure adhesive resin cement (and corresponding adhesive) compatible with the material. In addition, sandblasting is recommended and HF acid is contraindicated for most restorations that fall under this classification.

Metal-based restorations

Metal-based restorations do not constitute a large percentage of dental restorations today (Glidewell Dental Laboratories, 2018). Although variations in metal composition exist, these materials can be cemented similarly to the alumina- and zirconia-based restorations. Either RMGI or dual- or self-cured resin cements can be used with success. If a resin cement is selected, the use of metal primers is debatable but does not provide an adverse effect.

Clinical case presentation

An IPS E.max-pressed restoration—particle-filled glass, lithium disilicate from Ivoclar Vivadent—was chosen to replace a failed PFM crown on tooth #13.

This restoration can be cemented using a luting RMGI, a self-adhesive resin cement or an adhesive resin cement. I prefer to bond most lithium disilicate restorations with adhesive resin cements, as opposed to zirconia-based restorations, to add increased adhesion, because of the lesser strength of the restoration.

The restoration was etched with 5 percent HF acid for 20 seconds, because this had not been previously done by the lab. The intaglio surface of the restoration was then cleaned with alcohol. Ceramic Bond from Voco was applied and allowed to air-dry for 60 seconds. Before cement application, oil-free air was blown for 5 seconds to ensure no pooling of adhesive (Fig. 1).

The tooth was anesthetized to decrease any sensitivity before and during cementation. After administration of infiltrated anesthetic, the tooth was cleansed with Consepsis 2 percent chlorhexidine rinse from Ultradent (Fig. 2). Although this step is optional, the product is antimicrobial and does not interfere with bond strength. Futurabond U from Voco was then applied for 20 seconds, then gently air-dried for five seconds (Fig. 3).
After preparation of the restoration and the tooth, Bifix QM cement from Voco was placed into the restoration, which was then placed on the tooth with gentle pressure (Fig. 4). Once it had been seated, a two-second tack cure was performed (Fig. 5). The excess cement was easily removed with an explorer (Fig. 6). The cement was then allowed to cure for three minutes. Lastly, the final restoration was polished (Figs. 7 and 8).

**Conclusion**

As presented, cementation of restorations presents the clinician with many possibilities. In clinical dentistry, the final decision is often based upon a practitioner’s preference. With many choices available, clinicians must look at the tooth and the restoration before making a decision. In the end, they must be confident they chose the best cement for that particular situation. Proper knowledge of our clinical armamentarium is paramount for clinical success.

**References**