The Role of Cements in Dental Implant Success, Part 1

Authored by Chandur P. K. Wadhani, BDS, MSD, and E. Ricardo Schwedhelm, DDS, MSD

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LEARNING OBJECTIVES
After participating in this CE activity, the individual will learn:
• How implants and teeth differ in terms of cemented restorations.
• Criteria to help select the proper cements to use when restoring implants.

ABOUT THE AUTHORS

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Disclosure: Dr. Schwedhelm reports no disclosures.

INTRODUCTION
Dental implants have achieved a high success rate that is almost unequaled amongst medical devices used in the human body. However, it should be remembered that these are specialized medical devices, and as such they behave very differently than the body part they replace, namely the natural tooth.

Failures in implant dentistry do occur and can be attributed to surgical technique, patient related health issues, and restorative factors such as occlusion. Placement of the restoration on the implant can also have an impact on the success of the implant. One reason for failure that has recently been described is the problems associated with residual excess cement (REC) that may be inadvertently extruded into the soft tissues surrounding the implant.

This 2-part series of articles explores some of the challenges that face the restorative dentist and helps provide guidance on cement selection criteria as well as controlling and preventing REC that may contribute to implant failure. Part 1 focuses on criteria for selecting the appropriate cement for implant restorations. Part 2 will focus on the relationship between cements and the implant abutment design, and how modifications in abutment design can influence cement flow.

CEMENT-RETAINED IMPLANT RESTORATIONS
The introduction of the cement-retained implant restoration as a replacement for the screw-retained restoration was in response to factors such as aesthetics, control of occlusion, cost, passive fit of the prosthesis, and reduced chair time. However, when these factors are scrutinized it would appear that the main reason that cement retention has become more popular than the screw-retained restoration is familiarity, with dentists and dental technicians alike fabricating cement-retained restorations for close to 100 years on the natural tooth. These are the techniques they have been taught, are well established, and are understood the best. Although it appears that dental professionals have a preference for cement-retained restorations for implants, it should be noted that when patients are surveyed, they do not appear to have a preference for the type of restoration (screw- or cement-retained) they will receive.
Although the major reasons for using a cement-retained implant restoration are cited as being aesthetics and occlusion, it has been documented that these factors can usually be as readily controlled with implant screw-retained restorations. A positive link has been established between peri-implant disease and residual excess cement (Figure 1). Unfortunately, as is the case with many diseases, the mechanisms of the peri-implant disease process are poorly understood and many of the risk factors remain unidentified. It should be understood that a mass of any foreign material adjacent to a dental implant could negatively impact patient health and implant survival. The disease process may also be specific to the material itself, cases. This suggests that cement selection for implants is based primarily on what is used to restore teeth and may in fact be arbitrary.

No ideal cement exists to date. The list of cements is diverse, with many different materials used. The cement choice should not be arbitrary, nor should it necessarily be based on what the clinician uses for tooth-borne restorations, but should be considered in light of the fact that implants are medical devices which anchor very differently to the human body (Figures 2a and 2b).

To explore the different requirements of the tooth and the dental implant, ideal properties for a luting cement for a natural tooth will be examined, then these properties will be compared and contrasted to the properties required of an implant restoration cement. According to Rosenstiel et al, cement properties may be divided into:

**Biological Properties**

In general, all cements should be biocompatible, with no or little interaction with body tissues and fluids. They should be nontoxic and have low allergic potential. Natural tooth tissues include enamel, dentine, pulpal tissue, and the periodontal supporting tissues—whereas with implant restoration with peri-implant disease. Residual excess cement is clearly visible in the tissues.

### Table 1. Definitive Cements Used for Implants and Conventional Fixed Restorations

<table>
<thead>
<tr>
<th>Cement Type</th>
<th>Implant Restorations</th>
<th>Conventional Fixed Restorations</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMGI</td>
<td>90</td>
<td>50</td>
</tr>
<tr>
<td>ZOE Based</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>ZP</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>PC</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>AU</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>OTHER</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

with cement selection having an impact on this process. It is highly likely that cements appropriate for use with natural teeth may not be suitable for the implant restoration.

A survey in 2010 of US dental schools reported on the selection of cements used with the restoration of dental implants (Table 1). The survey noted the same trend for department chairpersons as well as prosthodontics program directors to select the same cement used on natural teeth to be used for implant restorations, in most biological, mechanical, aesthetic, working properties and cost (Table 2).
restorations, there is the implant body, abutment, restoration, and peri-implant tissues. The cement used should not adversely affect any of these.

When restoring a natural tooth, there is often the ability to protect the periodontal tissues from effects of cements with barrier devices; for example, use of rubber dam isolation or retraction cord. In comparison, this is much more complex with implant restorations, where cement margins are frequently significantly deeper than their tooth counterparts. Retraction cord is not recommended, and has been shown to promote cement extrusion into the soft tissues as a result of the peri-implant tissues being far more delicate, with only a weak hemi-desmosomal attachment that is easily stripped form the implant surface (Figures 2a and 2b).

**Allergic responses**—There is some concern related to the use of resin-modified glass ionomers with implant restorations. Most of these cements contain 2-hydroxyethylmethacrylate, which is a particularly harsh chemical in its unset form. Contact dermatitis is a known issue, such that the instructions for use by the operator require the skin (hands and eyes) to be protected during handling of this material. This direction must also be considered relevant for the patient’s mucosa. Again, with the natural tooth, barrier protection is possible, but at 2 to 3 mm below the free gingival margin with an implant restoration,


### Table 2. Some Considerations for Material Selection Specific to Teeth and Implant Cemented Restorations

<table>
<thead>
<tr>
<th></th>
<th>Implant Restoration</th>
<th>Natural Tooth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Substructure</strong></td>
<td>Metal, ceramic, acrylic</td>
<td>Dentine, enamel</td>
</tr>
<tr>
<td><strong>Biologic tissue association</strong></td>
<td>Peri-implant tissues</td>
<td>Periodontal tissues, pulp</td>
</tr>
<tr>
<td><strong>Primary disease issue</strong></td>
<td>Peri-implant disease</td>
<td>Caries, pulpal, periodontal</td>
</tr>
<tr>
<td><strong>Restoration finish line</strong></td>
<td>One to 2 mm below the gingival crest—often deeper</td>
<td>One mm below in anterior aesthetic sites, often above free gingival margin elsewhere</td>
</tr>
<tr>
<td><strong>Cement margin</strong></td>
<td>May or may not follow scallop of gingival tissues</td>
<td>Preparation follows gingival tissue</td>
</tr>
<tr>
<td><strong>Need for cement seal</strong></td>
<td>Questionable</td>
<td>Desired (prevent caries)</td>
</tr>
<tr>
<td><strong>Anticaries agents</strong></td>
<td>May be detrimental</td>
<td>Desirable</td>
</tr>
<tr>
<td><strong>Corrosion</strong></td>
<td>Corrosive in contact with titanium</td>
<td>Not applicable</td>
</tr>
<tr>
<td><strong>Radiopacity</strong></td>
<td>Should be highly radiopaque</td>
<td>Similar to dentine</td>
</tr>
<tr>
<td><strong>Microbial challenge</strong></td>
<td>Bacteria found in peri-implant sites</td>
<td>Streptococci Mutans, Lactobacillus (caries producers)</td>
</tr>
</tbody>
</table>
this is likely impossible, potentially allowing cement chemicals to come in direct contact with the surrounding epithelium and other tissues.

**Caries**—This is a problem with the natural dentition, but a nonissue with implant restorations (Figures 3a and 3b). Many cements include fluoride or other antimicrobial additives to limit recurrent caries. Most if not all the cements found in Table 1 have been evaluated with respect to their protective activity against *Streptococci mutans* and *Lactobacilli*, essentially the bacteria that are problematic for the tooth. Cariogenic bacteria are not an issue for the implant restoration; caries does not exist, and neither *S. mutans* nor *Lactobacilli* have been implicated in peri-implant disease. Therefore, understanding the relationship of how a cement affects cariogenic bacterial growth is irrelevant for implant restorations. What should be a consideration when selecting an implant restorative cement is the potential disease producing bacteria found at and around implant depths where residual cement could be a potential problem, ie, 2 to 7 mm below the tissues. Bacteria found at these sites that may cause disease are *Aggregatibacter actinomycetemcomitans* and *Porphyromonas gingivalis*. To date, however, the authors know of no literature that supports the use of specific cements for implant restorations based on the bacteria which may be present at the implant site.

**Corrosion**—Fluoride-containing cements offer a definite advantage for the natural tooth restoration; however, they may have a negative impact on the implant restoration. Fluoride is commonly used in industry to condition titanium. Under the appropriate conditions, it will etch the surface, removing ions from the metal. Tarica et al reported that some 17% of US dental schools use polycarboxylate cement for definitive implant restoration. One of the most popular polycarboxylate cements is Durelon (3M ESPE). The instructions of use clearly state, “not suitable for use with titanium structures.” Further investigation revealed that this cement actually corrodes the titanium if the cement can be guaranteed not to be extruded beyond the implant restorative margin, this may not be a great concern. However, Linkevicius et al recently reported on the depth of implant restorative margins and REC in a clinical study. They found that even if the margin was placed as shallow as one mm below the gingival crest, cement will always be extruded into the gingival sulcus. In fact, he reported that cement excess was found on 100% of cemented implant restorations when the abutment margin was placed one mm to 3 mm below the gingival crest, with the amount of residual excess cement increasing relative to the margin depth. Metal corrosion is harmful to the body because it generates reactive oxidation species; any exposed titanium in contact with the tissues that has corrosion products forming on it will result in a destructive inflammatory response by the body.

**Microleakage**—Microleakage of organisms around natural tooth restorations has been implicated in adverse pulpal responses and caries, which are considerations with the natural dentition. Both these conditions do not relate to implants. Therefore, microleakage may be considered much less of an issue for cemented implant restorations.

**Mechanical Properties**
Compressive, tensile, and shear forces act on cemented restorations whether the foundation material is the natural tooth or an implant abutment. The need for the cement to withstand these forces under the conditions exhibited by the oral environment is a given. Most of the cements used today have proven their ability to exhibit these properties favorably over a period of years in clinical practice. Most restorations on teeth are cemented permanently with little concern for retrievability, even though materials fail (eg, porcelain fracture); this is a known complication. The discussion on whether to cement implant restorations
temporarily or permanently was primarily centered around the problems associated with screw loosening. This has been extensively studied and now considered a rare event, provided the restoration is torqued to the manufacturer’s directions and the components joined are geometrically matched correctly. Further, the incidence of prosthetic complications does not indicate a trend toward being greater with implant prostheses than with single crowns, fixed partial dentures, all-ceramic crowns, resin-bonded prostheses, and posts and cores. Therefore, there seems to be justification for permanent cementation of the implant restoration.

Many of the newer cements boast adhesive properties to materials such as titanium and zirconium dioxide (ZrO₂ [also referred to as zirconia]), gold and nonprecious metal alloys, acrylic, and porcelain, which is considered a positive property when considering the permanence of the restoration. However, this should also be countered by the degree of difficulty in removing residual excess cement from the material’s surface below the cement margin. Agar et al reported 16 years ago on the extreme difficulty of removing resin cements from a smooth titanium implant surface. Cements have been reformulated since that time to be even more retentive, implant surfaces are now predominantly rough in nature, and shapes now include platform switching (Figures 4a and 4b). All of these factors contribute to even more opportunity for residual excess cement to be lodged into the gingival sulcus (Figure 5).

In the authors’ opinion, it is a better option to use a nonadhesive cement where possible and allow for abutment design and modification (which is covered in more depth in part 2 of this series) to maximize the retentive properties of the cement. This allows for easier and more predictable cleanup, which if correctly carried out, minimizes the effects of REC.

Aesthetic Properties
The natural dentition exhibits unique aesthetic challenges. The conservation of tooth structure is a primary goal but may conflict with aesthetics, especially in the discolored tooth. The luting cement may be a bridge between these 2 factors, as it can be used as a means of modifying color, especially useful in the anterior dentition. However, implant abutment restorations are comprised of different materials such as titanium, zirconia, gold, and acrylic. In this case, the luting cement rarely has to compensate for the abutment material color.

Interestingly and rather surprisingly, it appears that some implant-specific luting agents are pink in color; this must be considered an error as well as a misunderstanding of the clinical needs when considering implant restorations. Removal of this type of cement is hindered by its aesthetic color match to the tissues from which it must be completely cleared, if an ideal outcome is desired.

Radiopacity
An ideal luting cement for the natural dentition should be radiopaque enough to enable the clinician to distinguish
between an open restoration margin and/or recurrent caries, but still allow for the detection of excess cement overhangs that can also occur with conventional tooth restorations.\textsuperscript{20} It is suggested that for teeth, the luting cement be slightly more radiopaque than dentine. Metal and zirconia implant components should be evaluated prior to cementation to confirm acceptance of fit of the restoration. After cementation, residual excess cement must be detected and removed.\textsuperscript{31} The sites where REC is most likely to be detected are interproximal, where an exaggerated effect noted on implants can enhance the radiopacity of the cement. This has been described as the peripheral eggshell effect.\textsuperscript{12,31}

For endodontic cement sealers, a minimum radiopacity is mandatory and dictated by the American National Standards Institute/ADA specification No. 57, stating, “the radiopacity of endodontic sealers must be not less than the equivalent of 3 mm of aluminum.” This is in contrast to luting cements indicated for restorations, where there is no minimum standard for radiopacity. Therefore, restorative luting cements can range from being completely undetectable on a radiograph to highly radiopaque in nature (Figures 6a and 6b).

**SUMMARY**

Peri-implant disease can be the result of residual excess cement. While there is no ideal implant restorative cement, the clinician must be aware that the material selection for implant restorations should not be based on properties which are more suited to restoration of the natural dentition. More appropriate criteria would be those unique to implants and the specific challenges these medical devices bring to the restorative dentist.

**REFERENCES**


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1. Dental implants are considered medical devices and have failures associated with them. Failures may be due to:
   a. Restorative factors—occlusal.
   b. Patient selection.
   c. Residual excess cement.
   d. All of the above.

2. Cement-retained implant restorations are preferred by the dental profession primarily because:
   a. Familiarity—clinicians are accustomed to cementing restorations to natural teeth.
   b. Patients have a preference for cemented restorations.
   c. Cement is easy to mix.
   d. Cement is inexpensive.

3. Aesthetics and occlusion when considering an implant restoration are:
   a. Impossible to do well unless a cemented restoration is used.
   b. Always a problem.
   c. Have been shown to be readily controlled even with screw-retained restorations.
   d. None of the above.

4. Peri-implant disease:
   a. Is well understood with all etiological factors known.
   b. Is poorly understood with many risk factors unidentified.
   c. Is an easily treated disease.
   d. Affects all implants.

5. A positive link has been established between peri-implant disease and residual excess cement. It is highly likely that cements appropriate for use with natural teeth may not be suitable for the implant restoration.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.

6. A survey of cements selected by US dental schools for restoring implants reported:
   a. No school cements implants—they are only screw retained.
   b. Everyone uses the same cement.
   c. Cement material selection is diverse, but in general the cements used for restoring teeth are the same used to cement implant restorations.
   d. The US schools only use implant-specific cements.
7. Biological issues related to cement selection must be considered, and they include:
   a. Retrievability.
   b. Allergic response.
   c. Microbiological factors.
   d. Both b and c.

8. Two hydroxyethylmethacrylate (HEMA) is commonly found in many cements. The following is true regarding HEMA:
   a. It is a bland chemical.
   b. It is a known cause of contact dermatitis.
   c. It is not a cause of concern.
   d. Both a and c.

9. Streptococci Mutans:
   a. Will cause caries in dental implants.
   b. Is a known cause of peri-implant disease.
   c. Is easily treated with amoxicillin.
   d. Is of no consequence to an implant.

10. Bacteria around an implant at the depth the cement may reach may be a problem. Knowing how the cement reacts with the environment would be of benefit.
   a. The first statement if true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.

11. Durelon is a polycarboxylate cement which contains stannous fluoride:
   a. The fluoride was added to prevent tooth decay.
   b. The stannous fluoride corrodes titanium.
   c. The instructions state it is not suitable for use with titanium.
   d. All of the above.

12. Corrosion products are known to cause inflammation in the human body:
   a. This statement is false.
   b. If titanium of an implant does corrode, then reactive oxidative species will result in an inflammatory response.
   c. This is a beneficial response.
   d. Both b and c.

13. Which of the following is true regarding location of the margin of a cemented implant restoration?
   a. The margin does not need to be controlled—place it as deep as possible.
   b. The margin should always be placed deep because aesthetics is the only concern—it should not be visible.
   c. Cement is always extruded out through this margin, and when subgingival, the cement must extrude beneath the implant soft tissues.
   d. The cement should be pink in case the margin becomes visible.

14. A pink or aesthetically shaded cement used for implant restoration:
   a. Hides an open margin.
   b. Is beneficial because of its pleasing color.
   c. Makes finding the cement for removal more difficult and must be considered a gross error by the manufacturer.
   d. Is okay if the margin lies above the gingival tissues because it can compensate for gingival recession.

15. Regarding radiopacity of cements used for restoring teeth and implants:
   a. Tooth restorations must be evaluated for caries radiographically, and caries is more readily detected if the cement has radiographic characteristics similar to dentine.
   b. Currently there is no minimum ADA standard requirement for cements used on teeth or implants.
   c. Implant cements should be as radiopaque as possible, far in excess of the radiopaque value for dentine.
   d. All of the above.

16. Peri-implant disease can be the result of residual excess cement. Cements used for the natural dentition may not be suitable for implant restoration.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.
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