Original Article

# Retention of Luting Agents Used for Implant-Supported Restorations: A Comparative *In-Vitro* Study

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**Abstract**

**Aims:** The aim of this study was to compare the retention of different luting agents used with implant-supported restorations. **Materials and Methods:** A total of 90 custom metal frameworks and copings were prepared and divided into six different luting agent groups ($n$ = 15/group): polycarboxylate cement (PC), resin-modified glass-ionomer cement (RMGIC), two self-adhesive resin cements (SARC), copper-ion zinc-phosphate cement (CZPC), and non-eugenol temporary resin cement (TRC). After sandblasting with 50 µm $Al_2O_3$, the copings were cemented on frameworks and stored in artificial saliva for 48 h at 37°C and thermocycled between 5–55°C for 37,500 cycles. Samples were subjected to tensile testing by a universal testing machine, and data were statistically analyzed. **Results:** The differences between the retention values of types of cement were significant ($P < 0.05$). The maximum retention value was calculated for CZPC (755,12 ± 55 MPa) while the lowest value was for TRC (311,7 ± 61 Mpa). **Conclusion:** Neither of the tested cement had superiority over another to ensuring retention. The types of cement presented were meant to be a discretionary guide for the clinician in deciding the amount of the desired retention between castings and abutments.

**Keywords:** *Cemented abutments, fixed prosthesis, restoration removal*

## Introduction

The success of implant therapy depends not only on the osseointegration of the implant fixture but also on maintaining the integrity of the connection between the prosthetic superstructure and the fixture. The choice between cement and screw-retained methods for implant-supported fixed prostheses has long been discussed, and there is still no consensus on the best method among practitioners.[1,2]

Both of them have their advantages and disadvantages compared to each other. In cases of limited interocclusal space, a screw is more favorable because abutment lacks the support of surface area and height. However, due to the absence of passive fit of screw-retained restorations, more stress accumulates around the implants.[3] The cement-retained prosthesis has become a choice for the implant restorations to overcome the limitations of screw-retained prostheses. Cemented restorations have superior esthetics, in some cases, as well as occlusion when compared to screw-retained restorations.[4] However, there are some disadvantages, such as the difficulty encountered while removing the excess cement results in a rough surface just at the implant-abutment junction line.[2] On the other hand, clinician's preference guided by the specific clinical situation is more effective than the scientific statements.[3]

Proper selection of luting agents is of great importance to maintain good retention, for the restoration, minimize

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the risk of saliva leakage and bacterial accumulation, and fill the gap between the abutment and the restoration. Therefore, a seal with a luting agent is a definite need for implant-supported restorations. An ideal luting agent should not only have enough retention to provide the restoration to stay in its place but also provide easy retrievability at the same time.[5]

If there is a demand to increase the retention (in case of a loose restoration, incorrect, or over-milling of the abutment) where an implant has ideally been inserted and the acting functional forces have been optimally directed; permanent luting agents may be preferred.[6] However, since each case is unique, temporary luting agents may also be used. The reasons for the preference of the temporary luting agents are the presence of a loosened-screw, ease of cleaning, periodical control of the tissues, and facilitating the repair of the restoration when necessary.[7,8] A cement-retained restoration should be removed easily when its removal is required for some purposes. Otherwise, both the restoration and the implant may be damaged causing a significant clinical problem. The retention strength data of particular cements helps the practitioner assess whether the degree of retention is sufficient to prevent debonding while facilitating retrieval if required. This point is especially important when the clinician must decide which type of cement (temporary or permanent) is to be used in the presence of the factors that may influence the retentiveness, such as parafunctional habits, the accuracy of the marginal fits of the crowns and number, height, surface area, and taper of the abutments.[9] Ideally, luting agent selection should be based on the specific needs of each clinical situation. Thus, every clinician should have knowledge of available options since there are no recommendations in the literature for any ideal cement that combines retrievability and sufficient retention strength to keep the restoration in place.[9,10] Therefore, the aim of this study was to determine the retention and retrievability of different luting agents used with implant-supported restorations.

The null hypothesis was that there would be no significant differences between the permanent and temporary luting agents used with cement-retained restorations in permanent cementation process. The second hypothesis was that there would be significant differences between the luting agents used with cement-retained restorations in permanent cementation process.

## Materials and Methods

The dimensions and configuration of the specimens were drawn [Figure 1] and a total of 90 ($n$ = 90) metal frameworks and copings, fully compatible with each other, were fabricated from Titanium-6 aluminum-4 vanadium (Ti-6Al-4V) rods, at custom lathe representing a single crown and abutment with a standard cement thickness of 0.05 mm. The cross-sectional image of the specimens are shown in Figure 2 and prepared titanium specimens are shown in Figure 3. All specimens were sandblasted with 50 μm $Al_2O_3$ and then ultrasonically cleaned in 96% isopropyl alcohol (Isopropyl alcohol; Sigma-Aldrich, St Louis, Mo) for 5 min. The specimens were randomly divided into 6 groups of 15 specimens each ($n$ = 15). Temporary and permanent cement tested in this study are listed in Table 1. A custom-made holder was prepared with an accurate fit for each sample [Figure 4]. All specimens were first placed on this holder to remain fixed and stable then cemented according to the manufacturer's instructions one by one by the same investigator. Neither the investigator nor the data analyst was aware which cement was being used and which group it belonged to (double-blinded).

A 5 kg pressure was applied to standardize the step during the setting time of the luting agents defined in the manufacturer's instructions [Figure 4].

Following cleaning of the excess cement, the samples were stored in artificial saliva for 48 h at 37°C and thermocycled between 5–55°C at 5 min dwell time for 37,500 cycles. Another customized holder that matched accurately with the specimen was prepared to keep the specimen fixed in place during tensile tests [Figure 5]. Tensile testing was applied by a universal testing machine (Shimadzu AGS-J, Japan) [Figure 6]. Cemented crowns were pulled off with a crosshead speed of 1 mm/min, and the maximum force to debond each crown was considered as retentive strength and recorded.

The maximum retention values of the luting agents were analyzed by SPSS version 23 software using the analysis of variance test (ANOVA) and post hoc tests (Dunnett T3).

## Results

The mean bond strength values and the standard deviations of the groups are shown in Figure 7. CZPC (Hoffman's) showed the highest retention strength (755,12 ± 55 MPa) while the lowest one was

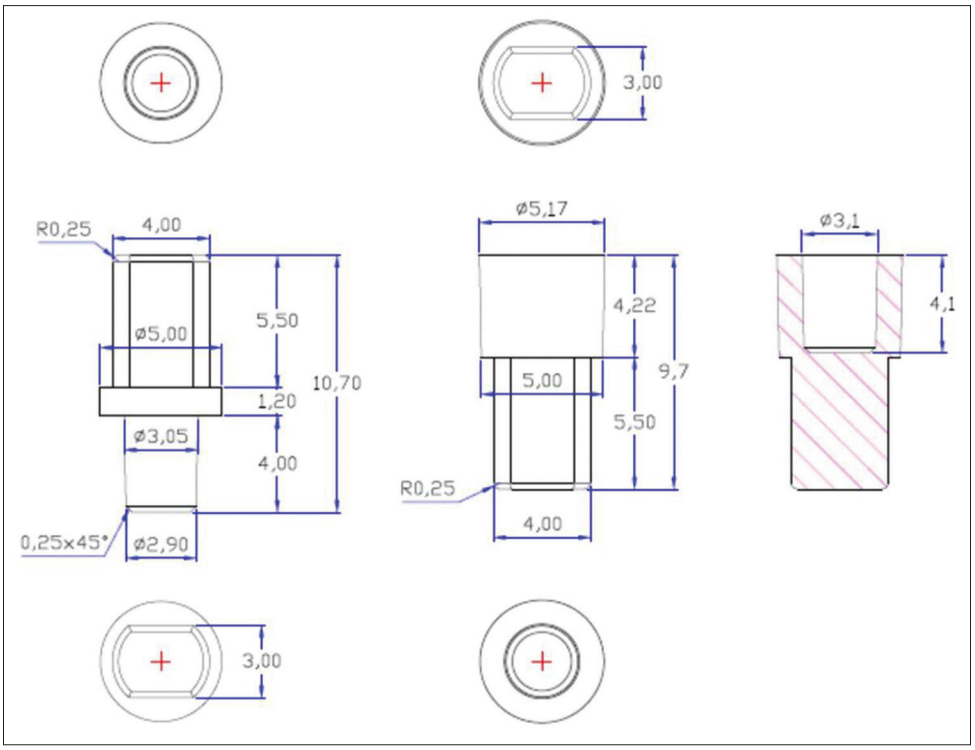


**Figure 1:** The dimensions and configuration of the specimen

**Table 1: Cement tested in this study**

| Cement | Manufacturer | Cementation type | Type |
|---|---|---|---|
| Premier | Premier Dental Company, USA | Temporary | Urethan-Based Non-Eugenol Temporary Resin |
| Poly-F Plus | Denstply/DeTrey, Konstanz, Germany | Permanent | Poly-Carboxylate |
| Hoffmann's Copper Cement | Hoffmann Dental Manufaktur, Berlin, Germany | Permanent | Copper-Ion Zinc Phosphate |
| Bifix SE | Voco, Cuxhaven, Germany | Permanent | Self-Adhesive Resin |
| Meron Plus | Voco, Cuxhaven, Germany | Permanent | Resin Modified Glass-Ionomer |
| RelyX U200 | 3 M ESPE, Neuss, Germany | Permanent | Self-Adhesive Resin |

**Table 2: Dunnett T3 multiple comparisons. Groups indicated with (*) were significantly different ($P$<0.05)**

| Cement type | | Mean (Mpa) | *P* |
|---|---|---|---|
| Premier | Poly-F | 281,36* | 0,000 |
| | Hoffmann | 443,42* | 0,000 |
| | Bifix SE | 230,30 | - |
| | Meron Plus | 190,63* | 0,011 |
| | Rely X U200 | 394,02* | 0,000 |
| Poly- F | Hoffmann | 162,05 | - |
| | Bifix SE | 51,06 | - |
| | Meron Plus | 90,73 | - |
| | Rely X U200 | 112,66 | - |
| Hoffmann | Bifix SE | 213,12 | - |
| | Meron Plus | 252,79* | 0,014 |
| | Rely X U200 | 49,39 | - |
| Bifix SE | Meron Plus | 39,67 | - |
| | Rely X U200 | 163,72 | - |
| Meron Plus | Rely X U200 | 203,39* | 0,016 |

non-eugenol temporary resin cement (TRC) (Premier) (311,7 ± 61 Mpa) ($P$ = 0.05). ANOVA revealed that the bond strengths differed significantly between all groups ($P$ = 0.00). Multiple comparisons computed with post hoc Dunnett T3, multiple range test, and results are listed in Table 2. The differences among non-eugenol TRC (311,7 ± 61 MPa) and polycarboxylate (PC [Poly-F Plus]) (593,07 ± 48 MPa), copper-ion zinc phosphate (CZPC) (755,12 ± 55 MPa), resin-modified glass ionomer (RMGIC [Meron Plus]) (502,33 ± 33 MPa), and self adhesive resin (SARC [RelyX U200]) (705,73 ± 45 MPa) were significant ($P$ < .05). The differences between Hoffmann and Meron Plus were significant ($P$ = 0.01). SARC (Bifix SE) (542 ± 33 Mpa) did not exhibit a significant difference between the RMGIC and the other SARC used in this study ($P$ > 0.05). Differences between the RMGIC and SARC were significant ($P$ = .016).

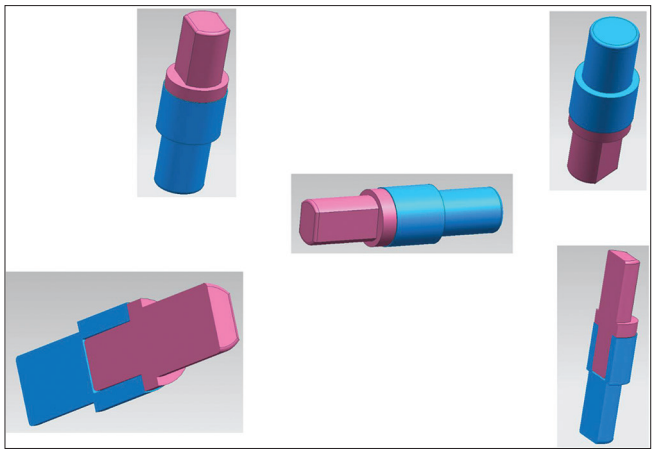

**Figure 2:** The cross-sectional image of the specimen

**Figure 3:** Specimen before cementation

**Figure 4:** A 5 kg pressure was applied to standardize the step during the setting time of the luting agents

**Figure 5:** Customized holder that matches accurately with the specimen to keep them in place


**Figure 6:** Universal testing machine used in this study

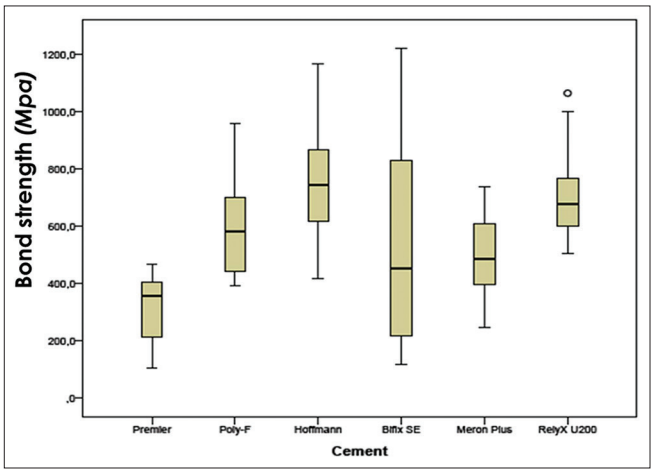


**Figure 7:** The bond strength values and the standard deviations of groups

## Discussion

The results of the present study showed that CZPC had the highest retentive strength followed by the SARC and the PC. Therefore, the null hypothesis was rejected. TRC showed significantly lower tensile strength values than the other permanent luting agents, thus the second hypothesis was accepted. In contradiction with the findings of the present study, Kapoor *et al*. found out that the resin cement (RelyX U200) had higher retentive strength (581,075 ± 21,55 MPa) than the zinc phosphate (Harvard Cement, Harvard Dental International GmbH, Germany) (529,48 ± 35,86 MPa) in their *in-vitro* study and non-eugenol TRC had the lowest retentive strength (140,49 ± 4,83), in accordance with this study.[7] Reddy *et al*. stated that where retention is strictly required, using a definitive cement after sandblasting with 50 µ $Al_2O_3$would be beneficial.[11] Therefore, the specimens in the present study were also sandblasted with 50 µm $Al_2O_3$ to prepare a homogeneous surface and contribute for retention strength as usually applied in clinical practice.

According to Hill *et al*., besides the type of the luting agent, the longevity of restoration depends on the abutment's height, taper and oral hygiene.[6] In addition to the luting agent retention, Pan *et al*.[9] stated that the retention of the crown was also affected by several other factors such as the geometric configuration, thermal stress, fabrication technique, and usage of more abutments. On the other hand, luting agents also prevent saliva leakage and bacterial accumulation to protect the peri-implant tissues.[5] In this study, luting agents were tested and compared only for retention strength but microleakage and bacterial accumulation of these products might be further studied.

The extra or incorrect milling of the abutment causes a decrease in the luting surface, therefore, a risk of de-cementation may occur. Thus, retrieving the crown due to restoration maintenance and hygienic controls of the peri-implant tissues may be required in clinical practice. Alvarez-Arenal *et al*. reported that using urethan based non-eugenol temporary cement would be a better choice if the clinician is not sure whether mechanical or biological complications may occur.[10] High retention strength is always not a good result for implant-supported restorations since the removal of restorations may be required at any time and must be done without any damage to implants. Since a critical retention value to keep the restorations in place stable is not indicated in the literature, clinicians should make a decision on their own considering the retention values of cement. In this study, by comparing the bond strength results of different brands of cement with varying chemistry, a guideline formation for clinicians to choose the right and adequate cement for the individual case was aimed. Since the SARC belonging to the same group (Bifix SE and Rely-X U200) in this study showed significantly different retention values, this finding may affect the clinicians' choice regarding their retention strength rates.

Liang *et al*. supported that removal of an excess resin cement frequently caused surface roughness on the implant-abutment junction line making scratches with sharp instruments.[5] Ease of excess cement removal is of great importance at this point and this must be kept in mind at the time of selection of luting agent type.[12] At this point, temporary cement may be a preferred option for their ease of cleaning.

It has been shown that another thing which promotes the retention is the undercut formed within the screw access opening.[13,14] Emms and Naik showed that complete filling of the screw access channel can reduce the removal force of a coronal restoration. In this study, this situation was eliminated due to the special design of the samples with no screw access channel.[13,14]

Since temporary cement does not have a strong chemical affinity to adhere to the substrate surface, the crowns are retained by the temporary cement mainly through a mechanical interlocking mechanism.[10] Leachable chemicals from some types of cement designed for teeth may affect metal surfaces.[15] Several reports indicate that some dental cement alters the protective titanium oxide layer, resulting in color changes to the titanium surface.[16,17] Color change has been associated with corrosion of the titanium alloy, which may show higher than expected bond strength values.[18] Corrosive changes to titanium alloy also increase the pathogenic microbial attachment.[18] The effect of the PCtested on the implant surface must be carefully considered despite their high bond strength. In the current study, no such effects of corrosion were observed, probably due to the short duration of the study. The highest bond strength value of CZPC may also be due to corrosion products that have not been pronounced for this cement group. However, this has not been investigated yet.

## Conclusion

Within the limitations of this study, the following conclusions may be drawn:

1. Cementation with CZPC provided higher bond strength
2. Maintaining a very high bond strength may create difficulties for removal and cause vital problems for implants

3. The choice of the luting agent depends on the clinical conditions. If there is a demand for easy retrievability, non-eugenol TRC or lower bonding valued permanent cement will be a better alternative for cementation.

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## Conflicts of interest

There are no conflicts of interest.

## References

1. Sailer I, Mühlemann S, Zwahlen M, Hämmerle CH, Schneider D. Cemented and screw-retained implant reconstructions: A systematic review of the survival and complication rates. Clin Oral Implants Res 2012;23:163-201.
2. Michalakis KX, Hirayama H, Garefis PD. Cement-retained versus screw-retained implant restorations: A critical review. Int J Oral Maxillofac Implants 2003;18:719-28.
3. Vigolo P, Givani A, Majzoub Z, Cor-dioli G. Cemented versus screw-retained implant-supported single-tooth crowns: A 4-year prospective clinical study. Int J Oral Maxillofac Implants 2004;19:260-65.
4. Prithviraj DR, Garg P, Pujari ML, Shruthi DP. Selection of dental cements for fixed implant supported restorations: Current perspectives. Int J Clin Dent 2010;3:191-9.
5. Liang T, Hu X, Zhu L, Pan X, Zhou Y, Liu J. Comparative *in vitro* study of cementing techniques for implant supported restorations. J Prosthet Dent 2016;116:59-66.
6. Hil E, Lott J. A clinically focused discussion of luting materials. Aust Dent J 2011;56:67-76.
7. Kapoor R, Singh K, Kaur S, Arora A. Retention of implant supported metal crowns cemented with different luting agents: A comparative invitro study. J Clin Diagn Res 2016;10:61-4.
8. Nagasawa Y, Hibino Y, Nakajima H. Retention of crowns cemented on implant abutments with temporaray cements. Dent Mater J 2014;33:835-44.
9. Pan YH, Ramp LC, Lin CK, Liu PR. Comparison of 7 luting protocols and their effect on the retention and marginal leakage of a cement-retained dental implant restoration. Int J Oral Maxillofac Implants 2006;21:587-92.
10. Alvarez-Arenal A, Gonzalez-Gonzalez I, deLlanos-Lanchares H, Brizuela-Velasco A, Ellacuria-Echebarria J. The selection criteria of temporary or permanent luting agents in implant-supported prostheses: *In vitro* study. J Adv Prosthodont 2016;8:144-9.
11. Reddy SV, Reddy MS, Reddy CR, Pithani P, R SK, Kulkarni G. The influence of implant abutment surface roughness and the type of cement on retention of implant supported crowns. J Clin Diagn Res 2015;9:ZC05-7.
12. Shapoff CA, Lahey BJ. Crestal bone loss and the consequences of retained excess cement around dental implants. Compend Contin Educ Dent 2012;33:94-6, 98-101.
13. Emms M, Tredwin CJ, Setchell DJ, Moles DR. The effects of abutment wall height, platform size, and screw access channel filling method on resistance to dislodgement of cement-retained, implant-supported restorations. J Prosthodont 2007;16:3-9.
14. Naik S, Tredwin CJ, Nesbit M, Setchell DJ, Moles DR. The effect of engaging the screw access channel of an implant abutment with a cement-retained restoration. J Prosthodont 2009;18:245-8.
15. Wadhwani C, Chung KH. Bond strength and interactions of machined titanium based alloy with dental cements. J Prosthet Dent 2015:14:660-5.
16. Worni A, Gholami H, Marchand L, Katsoulis J, Mericske-Stern R, Enkling N. Retrievability of implant-supported crowns when using three different cements: A controlled clinical trial. Int J Prosthodont 2015;28:22-9.
17. Horasawa N, Marek M. Effect of fluoride from glass ionomer on discoloration and corrosion of titanium. Acta Biomater 2010;6:662-6.
18. Rodrigues DC, Valderrama P, Wilson TG, Palmer K, Thomas A, Sridhar S. Titanium corrosion mechanisms in the oral environment. Materials 2013;6:5258-74.