Effect of Luting Agents on Retention of Dental Implant-Supported Prostheses

Yu-Hwa Pan, DDS, MS[1]
Tai-Min Lin, DDS, MS[1]
Perng-Ru Liu, DDS, MS, DMD[2]
Lance C. Ramp, DMD, PhD[3]*

To evaluate the retentive strength of 7 different luting agents in cement-retained implant abutment/analog assemblies. Fifty-six externally hexed dental implant abutment/analog assemblies and cast superstructures were divided randomly into 7 groups for cementation with each of the 7 luting agents. Five definitive cements tested were zinc phosphate cement, All-Bond 2, Maxcem, RelyX Luting cement, HY-Bond, and two provisional cements, ImProv and Premier. Cast superstructures were cemented onto the implant abutments and exposed to 1000 thermal cycles (0°C–55°C) and 100 000 cycles on a chewing simulator (75 N load). A universal testing machine was used to measure cement failure load of the assembled specimens. Cement failure load was evaluated with 1-way ANOVA and Duncan's multiple range analysis. Significant differences in cement failure loads were measured ($P < .0001$). Post hoc testing with Duncan's multiple range indicated 4 separate groupings. Maxcem and All-Bond 2 were comparable, having the greatest load failure. RelyX and zinc phosphate cement were analogous, and higher than HY-Bond. Improv and Premier constituted a pair, which demonstrated the lowest retentive values. Within the limitations of this in vitro study, Maxcem and All-Bond 2 are good candidates for cement-retained implant prostheses while concerning retention.

Key Words: implant, cement, luting agent

Introduction

Fixed dentures can be retained to dental implants by screw or cement. Although there is no consensus on whether one design is superior to the other, using cement to retain implant superstructures has become more popular due to higher fracture resistances of veneer ceramics, ease of fabrication, improved esthetics by elimination of screw access opening, and lower laboratory cost.[1–3]

Retention definitely influences the complications and longevity of implant prostheses. Cements can be classified as permanent or provisional luting agents. The ideal luting agent for implant applications would provide sufficient retention to prevent superstructures loosening during normal function, but allow the superstructures to be retrieved without damaging superstructures and abutments for complications or hygienic maintenance.[2,3] Selection of cement that is too retentive could lead to damage due to use of aggressive removal techniques. Using provisional cements as alternatives allows the clinicians to evaluate implant loading, occlusion and tissue response, and ensures the retrievability of cement-retained implant prostheses without damage.[4] The advantage in retrievability is accompanied by poor physical properties, such as low tensile strength and high solubility, leading to patient dissatisfaction.[2,5] Selection of cement that is not retentive enough could be a potential source of embarrassment for the patient. Knowledge of the relative retentiveness of different cements would improve selection of appropriate cements for specific purpose on cement-retained implant prostheses.[6,7]

The present study sought to measure the retentive strength of seven definitive and provisional cements, when used with cement-retained implant abutment/analog assemblies. Definitive cements, such as the resin-based cements Maxcem (Kerr Inc, Orange, Calif), and All-Bond 2, (Bisco, Inc, Schaumburg, Ill), the resin-modified glass ionomer RelyX Luting cement, (ESPE America Inc, Norristown, Penn), and HY-Bond polycarboxylate cement, (Shofu, Inc, Kyoto, Japan) were examined in the present study. Also provisional cements, ImProv (NobelBiocare, Inc, Goteborg, Sweden), an acrylic/urethane-based cement, and Premier (Premier Dental Products Company, Penn) a resin-based provisional cement, were examined. Zinc phosphate cement (Keystone, Inc, Cherry Hill, NJ) was used as a standard for comparison with respect to retention.

The null hypotheses for this study was that the retentive strengths of definitive cements would be higher than those of the provisional cements.

Materials and Methods

Fifty-six Steri-Oss titanium alloy 4.0-mm diameter Hex-Lock Straight Esthetic abutments with titanium screws and implant analogs (NobelBiocare Steri-Oss, Yorba Linda, Calif) were divided into 7 equal groups for testing cement failure load.

[1] Department of General Dentistry, Chang Gung Memorial Hospital, Chang Gung University, Taipei, Taiwan.
[2] Department of Prosthodontics, School of Dentistry, University of Alabama at Birmingham, Ala.
[3] Department of General Dental Sciences, School of Dentistry, University of Alabama at Birmingham, Ala.
**Corresponding author,* e-mail: lramp@uab.edu
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Figures 1–3. Figure 1. 0.001-inch thickness platinum foil was adapted onto the abutment surface as a die spacer. **Figure 2.** Split mold technique used to wax up implant superstructures. **Figure 3.** The testing jig with 3 side screws was attached to the universal testing machine to test the cement failure load.

To facilitate placement in a chewing simulator (O'Neal, Birmingham, Ala) and a universal testing machine (Instron Engineering Company, Canton, Mass), mounting jigs were fabricated to house the abutment/analog assemblies.

A 0.001-inch (25 μm) thick platinum foil die spacer was closely adapted and burnished to the abutment surface of a single abutment/analog assembly to provide a uniform space for luting agent (Figure 1).[8] A mold of the resulting assembly was created using silicon material (REDU-IT Duplicating Material, American Dental Supply, Inc, Penn). The mold was then used to make a Microstone cast (Whip-Mix, Louisville, Ky), after which an 8-mm diameter wax superstructure with a flat occlusal surface was built up on the stone replica. Using a split-mold technique, all 56 specimens were produced in wax to identical size (Figure 2). Specimens were sprued on the occlusal surface, invested with Jelenko phosphate-bonded investment, and cast with the silver-palladium alloy Electra (Ivoclar Williams, Amherst, NY) at 1400°F (760°C). Following retrieval of the specimens, casting were cleaned with a steam cleaner (Pro-Craft II Steamer Cleaner, Ivoclar North America, Amherst, NY). The casting quality was checked, and subsequently polished with rubber wheels. For the purpose of mounting the specimens into the mounting jig, a seating jig made with Duralay (Reliance Dental Mfg. Co, Worth, Ill) was fashioned to maintain precise alignment. Acrylic resin was used to secure the given assembly in the mounting jig, and the abutment screws were secured using a 35 N-cm torque force wrench (NobelBiocare, Yorba Linda, Calif), as recommended by the manufacturer. Screw access openings were filled with Fermit-N (Vivadent, Amherst, NY).

Seven different luting agents were evaluated. Following the manufacturers' instructions, each luting agent was selected in a randomly and mixed by a skilled dental assistant. Crowns were cemented to the implant abutments and then compressed with a 2-kg weight. A customized jig with an acrylic base was made to retain the weight used to seat the crown. While still loaded in the jig with the weight, each specimen was stored at 37°C and 100% humidity. One hour after cementation, the weight was removed, after which the specimen itself remained stored at 37°C and 100% humidity for an additional 23 hours.

Subsequently, each specimen was subjected to 100 000 cycles in the chewing simulator at 1.2 Hz and a 75 N load. This processing is equivalent to 3 years of chewing in vivo.[9] Each specimen was then further stressed by being subjected to 1000 thermal cycles in a water bath, alternating between 5°C and 55°C with a 1-minute dwell time (30 seconds per side).

The universal testing machine was used to determine cement failure load. To accomplish this, a purpose-built jig with a loop and 3 side screws was constructed to retain the cast superstructure. The universal testing machine was hooked to the loop of the customized jig. Uniaxial tensile force with a 0.05 inch/min (0.125 cm/min) cross-head speed was then applied to the abutment/crown assembly by a swivel hook attached to the upper member of the universal testing machine (Figure 3). Specimens were tested in a randomized order.

Cement failure load was assessed with 1-way ANOVA. Duncan's multiple range was used for post-hoc testing.

Results

The Table shows the means and standard deviations of the cement failure load of different cements. Significant differences in cement failure loads were determined by ANOVA. Duncan's multiple range was used as a post-hoc test. Maxcem and All-Bond 2 were similar and had significantly higher failure load values than other groups with Maxcem having the highest cement failure load and All-Bond 2 having the second highest cement failure load. There was no significant difference between zinc phosphate cement and RelyX Luting cement. There were also no significant differences between the provisional cements ImProv and Premier. ImProv had the lowest mean cement failure load among all seven groups although there were no significant differences between ImProv and Premier provisional cements.

Discussion

The Steri-Oss Esthetic abutment used in this study features a facial margin that is lower than the lingual margin as the means by which to achieve an enhanced esthetic appearance. The reason for choosing this abutment system was that its design provided greater resistance to the rotational torque applied when the universal testing machine was used to pull the superstructures until cement failure. As a result, the within-group cement failure load values in this study were relatively consistent.

In a previous study, retention of implant-supported superstructure was tested using 0.001-inch, 0.002-inch, and

TABLE

Mean cement failure load (pounds)*

Cement	Mean Failure Load (lbs)	Standard Deviation (SD)
Improv	12.3[a]	3.3
Premier	14.3[a]	4.7
Hy-Bond	24[b]	6.4
RelyX	54.3[c]	9.3
ZPC	55.1[c]	9.9
All Bond 2	75.7[d]	7.4
Maxcem	79[d]	10.3

*Superscript letters indicate statistical groupings.

0.003-inch platinum foils as die spacing for prefabricated titanium abutments, adapting one layer of platinum foil on the occlusal surface and axial surfaces of the abutments. Their technique succeeded in producing a uniform luting agent space between the entire casting/abutment interface. And using a platinum foil die spacer reduced seating discrepancies and increased retention under laboratory test conditions.[8] The present study employed 0.001-inch (25 μm) thick platinum foil as a die spacer, burnished onto the occlusal surface and all of the axial surfaces of the implant abutments. Creating this space for the luting agent between the superstructure and abutment did not lower retentive strength and had the potential to allow the luting agent to function as a shock absorber for occlusal forces. It apparently worked well because the cement failure load values for each group were evenly distributed.

Filling the access openings in the CeraOne system is more critical to retention than the choice of definitive or provisional cement. Filling the access openings to the gold screw in an abutment produced significantly higher cement failure load values than leaving the access openings unfilled. Cementation with Temp Bond noneugenol cement when the access opening is filled provided higher retention than zinc phosphate with an unfilled access opening.[10] Based on these findings, Fermit-N (Vivadent) was used to fill the access screw openings before cementation of the assemblies.

Glass ionomer cement and TempBond produce weaker retentive bonds than zinc phosphate cement when using the CeraOne abutment system.[10–12] A similar study of marginal seating discrepancy and retention of five luting agents used on the CeraOne single-tooth implant system reported that zinc phosphate cement bonds are 49% and 164% stronger, respectively, than composite resin and glass ionomer cement bonds.[13] As for marginal discrepancy, scanning electron micrographs revealed the margins of composite resin and zinc phosphate cement were nearly intact, while glass ionomer cement was noticeably dissolved.[14] As a result, most related studies have recommended zinc phosphate cement, despite the fact that it makes retrieval extremely difficult. With this in mind, zinc phosphate cement was used as a standard in the present study for comparison with respect to retention.

In one study, a glass ionomer cement (Ketac Cem, ESPE Premier, Norristown, Pa), 2 resin luting agents (Resiment, Septodent, Inc, New Castle, Del; Core Paste, Den-Mat Corp, Santa Maria, Calif), and 3 provisional luting agents Life (Kerr Mfg. Co, Romulus, Mich), containing calcium hydroxide, IRM, (Caulk Div Dentsply Intl Inc, NJ), containing reinforced zinc oxide eugenol, and Temp Bond, (Kerr Mfg Co, Mich) containing zinc oxide eugenol were compared.[4] The study proposed that the glass ionomer and 2 resin luting agents (Core Paste and Resiment) were more retentive than the 3 provisional cements (Life, IRM, and Temp Bond). Findings were consistent with the results of the present study, which likewise found that the provisional cements (ImProv and Premier) were far less retentive than Maxcem, All-Bond 2, RelyX Luting cement, and zinc phosphate cement. The primary difference between these 2 studies is that, specimens from the present study were subjected to simulated chewing cycles followed by thermal cycling after cementation. GaRey et al demonstrated that load cycling identified significant differences in retentive strengths among different cements, whereas the effect of thermal cycling was minimal. Their findings also demonstrated that load cycling and thermal cycling are useful tools for researchers seeking to imitate the oral environment in vivo.[15] In addition, while Temp Bond had the lowest cement failure load among three provisional cements evaluated,[4] the present study measured no significant differences between the failure load values of ImProv and Premier. Superstructures cemented with the provisional luting agents tested (Temp Bond, IRM, and Life) may be removed from implant abutments without causing any disturbance to the implant osseointegration or the prostheses.[4] Thus, the present study tested provisional cements because the retrievability of cement-retained implant prosthesis is an important consideration in dental implant therapy. If the patient experiences problems after the prosthesis delivery, removal of the superstructure from the implant without disruption of the implant or abutment is always the first challenge encountered. In the present study, resin cement (Maxem and All-Bond 2) and resin-modified glass ionomer cement (RelyX Luting cement) adhered to the abutment surface and was difficult to remove. Consequently, it may be concluded that acrylic/urethane based provisional cement (ImProv) and resin-based provisional cement (Premier) might be good choices to cement the implant-supported superstructure onto the abutment because the future maintenance (retrievability) is possible without damaging the abutment surface or Superstructure.

One study reported that glass ionomer and composite resin cements produce a weaker retentive bond than zinc phosphate cement.[13] However, this conclusion was not confirmed by other studies,[16–22] claiming that resin cement has the highest mean retentive strength in comparisons with zinc phosphate cement and glass ionomer cement. Additionally, zinc phosphate cement and glass ionomer cement may have solubility problems in oral environments compared with resin cements.[23] In the present study, Maxcem and All-Bond 2 exhibited much greater retentive strength than zinc phosphate cement, but there were no significant differences between RelyX Luting cement and zinc phosphate cement.

CONCLUSIONS

Within the limitations of this in vitro study, Maxcem and All-Bond 2 are good candidates for cement-retained implant prostheses while concerning retention.

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