The selection criteria of temporary or permanent luting agents in implant-supported prostheses: *in vitro* study

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PURPOSE. The use of temporary or permanent cements in fixed implant-supported prostheses is under discussion. The objective was to compare the retentiveness of one temporary and two permanent cements after cyclic compressive loading. **MATERIALS AND METHODS.** The working model was five solid abutments screwed to five implant analogs. Thirty Cr-Ni alloy copings were randomized and cemented to the abutments with one temporary (resin urethane-based) or two permanent (resin-modified glass ionomer, resin-composite) cements. The retention strength was measured twice: once after the copings were cemented and again after a compressive cyclic loading of 100 N at 0.72 Hz (100,000 cycles). **RESULTS.** Before loading, the retention strength of resin composite was 75% higher than the resin-modified glass ionomer and 2.5 times higher than resin urethane-based cement. After loading, the retentiveness of the three cements decreased in a non-uniform manner. The greatest percentage of retention loss was shown by the temporary cement and the lowest by the permanent resin composite. However, the two permanent cements consistently show high retention values. **CONCLUSION.** The higher the initial retention of each cement, the lower the percentage of retention loss after compressive cyclic loading. After loading, the resin urethane-based cement was the most favourable cement for retrieving the crowns and resin composite was the most favourable cement to keep them in place. ***[J Adv Prosthodont 2016;8:144-9]***

KEY WORDS: Cements; Cyclic compressive load; Fixed prosthesis; Implants

INTRODUCTION

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.[1-4] Both methods have advantages and disadvantages. Although the choice of either method seems to depend more on the preferences of the clinician rather than on the available scientific evidence, screw-retained is preferred in some clinical situations and cement-retained in other situations.[5] Although most studies showed that screw-retained prostheses were associated with more technical complications,[3,6] dentists might prefer screw-retained restorations for its predictable retrievability. Esthetics and good biomechanical properties are among the advantages of the implant-supported cement-retained prosthesis,[4,5] but they are not great enough benefits for dentists to choose this type of restoration. For the dentists' preference, the cement should have retrievability with sufficient retention strength to keep the restoration in place.

The degree of retrievability of the implant-supported cement-retained prosthesis is inversely proportional to the retention strength of the cement used. At the same time, regardless of is the cement type, provisional/temporary or permanent, and of the number and characteristics of the abutments, several mechanical and biological factors may

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affect the retentiveness of the cement in a given restoration.[7-12]

Urethane-based resin cement (temporary cement) and resin-modified glass ionomer and resin composite cements (permanent cements) are the examples of available luting agents that are used clinically to cement crowns to implant abutments.[12-14] The Multilink Implant (Multilink Implant, Ivoclar, Schaan, Liechtenstein) cement is dual-cured resin composite cement (bonding cement), composed of dimethacrylate resin, HEMA, and barium glass and ytterbium trifluoride fills. This cement has higher compressive, flexural and tensile strength, as well as greater bonding strength and less solubility or water absorption than resin-modified glass ionomer cements, such as FujiCem Automix (FujiCem Automix, GC Europe Leuven Belgium), and resin urethane-based cements, such as Premier Implant Cement (Premier Implant Cement, Premier, Plymouth Meeting, PA, USA). Nevertheless, its film thickness can be somewhat higher than that of FujiCem Automix cement and less than that of Premier Implant cement whose main components are urethane diacrylate, triethyl englycoldimetacrilate and HEMA. FujiCEM Automix is composed of fluoraluminosilicate glass, aqueous solution of polycarboxylic acid modified with hydrophilic methacrylate groups, HEMA, and other components to a lesser extent. It overcomes the weaknesses of conventional glass ionomer cement, resulting in enhanced mechanical properties and lower solubility in oral fluids.

Several studies comparing the retention strength of these cements in different experimental conditions are found in dental literature,[12-18] while few articles reported the retention strength after compressive cyclic loading or mastication.[19-22] 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) to use in the presence of the factors that may influence the retentiveness, such as parafunctional habits, accuracy of the marginal fits of the crowns and number, height, surface area and taper of the abutments. Since there are no recommendations in dental literature for the cement that combines retrievability and sufficient retention strength to keep the restoration in place, the following null hypothesis is stated: after compressive cyclic loading, both the temporary cement (urethane-based resin) and permanent cements (resin-modified glass ionomer and resin composite) allow the retrieval of crowns. Accordingly, the objective of this study was to evaluate and compare the retention loss after compressive cyclic loading of three cements (one temporary and two permanent) used to cement implant-supported crowns in relation to their retrievability and retention.

MATERIALS AND METHODS

The working model included five implant analogs Stark-D 4 x 10 (Sweden&Martina, Due Carrare, Italy). They were embedded in self-curing acrylic that filled the bottom of a rectangular container measuring 80 × 35 × 45 mm, with a metallic lower part and a methacrylate upper part. A solid titanium abutment (7 mm in height and tapered 6 degrees) was screwed to each implant analog with the manual torque controller at 30 Ncm. Each pair was then marked with an identification number, from 1 to 5, on the outside of the model (Fig. 1). Thirty metal copings were cast with nickel-chromium alloy (Wiron 99, Bego, Lincoln, RI, USA) using individual premachined castable copings. For casting, phosphate-based Type I cast investment (Sherafina 2000, Shera Werkstoff-Technologie Gmbh & Co. K6, Lemförde, Germany) and metal cylinders lined with asbestos-free ring liners (Deguvest Vlies, Degudent-Dentsply, Hanau-Wolfgang, Germany) were used to control the expansion of the investment. The copings were numbered 1 to 30 and randomized into the three cement groups (n = 10). Moreover, each coping of each cement group was randomly assigned to the abutments of the working model.

In orther to luting the copings, three quarters of the inside of each coping was filled with the corresponding cement and cemented to the assigned abutment by a single operator. Neither the operator nor the data analyst was aware which cement was being used and which group it belonged to (double blind). In this study, three types of cement were used: a temporary urethane-based resin cement (Premier Implant Cement, Premier, Plymouth Meeting, PA, USA. Lot No 4139CI) and two permanent cements, resin-modified glass ionomer cement (FujiCem Automix, GC Europe Leuven Belgium. Lot No 1006071) and resin-composite cement, (Multilink Implant, Ivoclar, Schaan, Liechtenstein. Lot No M10240). The copings were cemented in accordance with the manufacturers´ instructions and automix syringes were used to minimize the mixing error. No pretreatment of the inner surface of the copings was performed. The operator placed the copings on the abutment and applied finger pressure for 20 seconds and removed the excess cement with an excavator after 30 minutes. After another 30 minutes, the initial tensile test was carried out.

After the initial tensile test, excess cement was removed from the abutment using a Hollenback carver and cement on the copings was cleaned in an ultrasonic bath with distilled water for 10 minutes. Once the abutments and copings were cleaned, they were again cemented using the same technique and cements described above. The top of the working model container was then filled with a saturated physiological saline solution colored with crystal violet to the two thirds of the height of the copings. After the filling, compressive test was carried out. A cyclic compressive load of 100 N with a frequency of 0.72 Hz, to simulate two to three months of chewing (100,000 cycles), was applied to each coping from each cement group (Fig. 1). After the compressive test, the colored saline solution was removed with a syringe and the final tensile test was carried out (Fig. 2). A model EM1/5FR universal testing machine (Microtest, Madrid, Spain) with SCM3000 software (Microtest, Madrid, Spain) was used to apply the compressive and tensile forces to the copings (Fig. 3).

The ANOVA test with the post hoc Tukey test was used to determine the effect of cement type and compressive cyclic load on coping retention. All the statistical tests were conducted at $P < .05$ significance level.

Fig. 1. Working model and compressive cyclic load test.

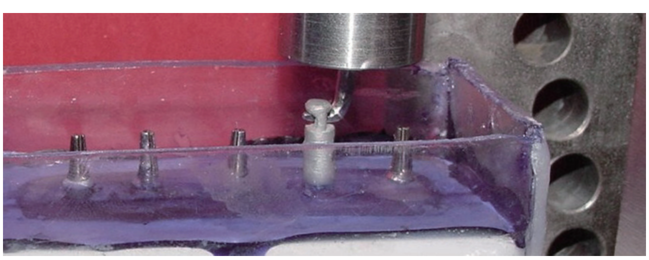

Fig. 2. Tensile test after compressive cyclic loading.

RESULTS

Before cyclic compressive loading, the two permanent cements (FujiCem Automix and Multilink Implant) showed the greater retention strengths compared with the resin urethane-based temporary cement (Premier Implant Cement). The retention strength of resin composite cement was 75% higher than that of the resin-modified glass ionomer cement and 2.5 times more than the resin urethane based cement. The differences were statistically significant according to Tukey's test (Table 1). After 100,000 cycles of compressive loading, the retention strength of the three cements decreases in a statistically significant manner compared to the initial retention for the resin urethane-based cement (P = .005), not significantly for the resin-modified glass ionomer cement (P = .155), and close to significance for the resin composite cement (P = .055). The greatest percentage

Fig. 3. Universal tensile and compressive test machine.

Table 1. Mean tensile retention strength of the tested cements and comparison of mean retention values. Values retention in Newtons; standard deviation in brackets

Cement (Brand)	Sample (n)	Retention before compressive loading	Retention after compressive loading	Retention index (%)
Resin-modified glass ionomer (FujiCem Automix)	10	253.35 (85.38)	174.50* (92.09)	31.12
Resin composite (Multilink Implant)	10	443.15* (69.41)	352.02* (76.05)	20.56
Resin urethane-based (Premier Implant Cement)	10	174.76 (45.59)	71.25 (73.86)	59.23

Tukey's test: * Significant differences with two other cements.

The retention index measures the rate of change of retention before and after compressive loading and is calculated using the formula:

Retention Index = (1 - retention after load/retention before load) × 100 retention loss, as indicated by the retention index, was shown in the temporary cement and the lowest in the resin composite permanent cement. At any rate, the two permanent cements, particularly the resin composite cement (352.02 N), showed high retention values with statistically differences among them and with the resin urethane-based cement.

DISCUSSION

This study evaluates the retention strength of one temporary and two permanent cements, used for cementing implant-supported fixed prostheses, after compressive cyclic loading to simulate 2 to 3 months of chewing. Before application of the compressive cyclic load, both the two permanent cements and the temporary one showed high retention strength to hold the crown in place, thus making them more difficult to retrieve. A lower retentiveness of resin urethane-based cement (Premier Implant Cement) compared to the permanent cements agrees with some previous studies[12,22-24] and differs from other studies that reported lower[21,25] or higher values.[10,14,26] On the other hand, the high retention values shown by the resin composite cement (Multilink Implant) agree with data reported in some studies for such types of cement, regardless of whether they include 10-MDP (10-methacryloyloxydecyl dihydrogen phosphate)[15,17,19,27] or not.[13,28,29] For its part, the glass ionomer modified resin cement (Fujicem Automix) showed retention strength values between those of resin composite and those of resin urethane-based cements. These values are similar to those reported by some authors,[15,27] although some other dental literatures reported quoted much lower[12,17] or much higher data.[13,21,29] Differences in cement formulation/composition, in experimental conditions, and in the abutment characteristics and prosthesis design, may explain the variability of the data of the different studies. Standardization of all these factors would be desirable for facilitating the comparison of the results. Clinically, the results of this study showed that any of the three cements could be used for cementing a crown onto an implant abutment. According to these data, it would not be necessary to carry out any pretreatment of the inner surface of the crown or abutment to enhance the retention of the three cements tested, e.g. by applying air abrasion, sandblasting or acid etching to improve the micromechanical retention of FujiCem Automix or Premier Implant cements or by applying an alloy primer to increase the bond strength of the Multilink Implant cement.

However, in clinical situations where complications are likely to occur in the very short term, the most suitable choice would be the temporary resin urethane-based cement because of its lower retentiveness. On the other hand, when the dentist does not foresee any technical-mechanical or biological complications, or when the abutment characteristics are unfavorable (taper greater than 12º, low height of 4 mm or less, and so on) it would be preferable to choose a permanent cement like resin composite or resin-modified glass-ionomer. Meanwhile, the obtained data confirmed that the compressive cyclic load, simulating human mastication, decreased the retentive capacity of the cement used in a non-uniform manner, at a rate inversely proportional to retention strength before loading. This tendency is consistent with other similar studies about crowns cemented with temporary or permanent cements.[19,21,22,30] Regardless of the adhesion mechanisms of the studied cements, differences in film thickness and solubility of cements may explain these results. Although this research was conducted in a humid environment and premachined castable copings were used, leaving the same distance between the abutment and the coping for the three cements, the thickness of the cement layer could not be measured. It is well-known that a low cement film thickness improves the seating of the restoration and reduces marginal discrepancies, plaque accumulation, and cement dissolution, whereas a greater film thickness can decrease the tensile, flexural, and fracture strength of the restorations. For Multilink Implant cement, its lower percentage of retention loss (20.56%) may be related to its virtual insolubility to oral fluids and somewhat higher film thickness than conventional cements reported in dental literature. The very unique setting process of the FujiCem Automix cement, which is a prolonged acid-base reaction that takes days or even weeks to reach its maximum strength, with expansion and hygroscopic expansion with fluid absorption, could explain its 31.12% of retention loss in spite of its lowest film thickness of the studied cements. A higher film thickness and higher water absorption compared to the other cements may explain the high percentage of retention loss of Premier Implant Cement (59.23%). This high percentage of retention loss and low retention strength (71.25 N) after compressive cyclic loading of the resin urethane-based cement makes its use questionable for cementing implant-supported prostheses. Although it is well-known that the oral chewing environment is not exactly comparable to an *in vitro* experiment environment, the 71.25 N (equivalent to 7.3 kg) retention strength of the resin urethane-based cement could be insufficient to avoid the dislocation of the crown as a consequence of functional chewing. The dentist should evaluate this information before choosing this type of cement to avoid frequent debonding. However, if he wants easy retrievability, this is the cement to choose.

Dental literature does not offer data regarding the minimum cement retentiveness to keep a restoration in place and, at the same time, allow it to be retrieved. However, in order to achieve these conditions, cement retentiveness should be greater than the extrusive force due to the contraction of mandibular depressor muscles during food chewing and less than the maximum force that can be applied by the dentist manually or with the help of instruments to retrieve a cemented crown on an implant-supported abutment. Koolstra and van Eijden[31] reported a maximum contraction force of the inferior lateral pterygoid muscle of 112.8 N, and the anterior digastric muscle of

46.4 N at the same time. Although the dentist could apply debonding forces equal to or greater than 7.3 kg, with or without instrumental assistance, these forces would not harm the bone/implant interphase because they do not exceed the bonding strength of osseointegration estimated 416 N/cm in integrated implants in rabbit tibias.[32] After compressive loading, the two permanent cements showed sufficient retention to keep the crowns in place, particularly for the composite resin cement (Multilink Implant). It would require a force of 35.9 kg to dislodge an implant-supported crown cemented with this cement. Though this clinical benefit is desirable in conventional fixed prostheses, it is less so in implant-supported prostheses. On the other hand, a fear of possible mechanical-technical or biological complications often leads practitioners to choose a screw implant-supported restoration or an easily retrieved cemented implant-supported restoration using a weak luting agent. As the data revealed that neither the resin composite cement (Multilink Implant) nor the resin-modified glass ionomer cement (Fujicem Automix) favoured the retrievability of the crowns, dentists should note that using the latter cement makes the chance of retrievability after chewing higher than the former one (Multilink Implant). However, it is almost always possible, in an implant-supported crown already cemented with a permanent cement, to make a hole in the occlusal surface to access the abutment screw and retrieve the restoration; the cement-screw restoration technique can be chosen otherwise. The cement-screw restoration includes casting the crown with an occlusal opening, which are cemented to the abutment on the working dental cast. The excess cement is cleaned, after which the restoration is screwed to the implant in the mouth. This technique eliminates the possibility of periimplantitis by minimizing cement excess in the gingival sulcus and allows the retrievability of restorations, no matter what complications may arise.

There are several limitations in this study that should be considered. This is an *in vitro* study does not exactly reproduce the oral environment during masticatory function. The temperature and the combined forces that occur in different directions during mastication were not taken into consideration; these forces were simplified to a single axial compressive load of 100 N. Within the wide variability of occlusal forces, the average force described for the anterior/middle sector of the mouth was chosen. The total number of cycles of compressive loading simulates a limited chewing time (2-3 months). Although these variables are similar to those described in other studies, they pose limitations when comparing this study with similar studies having different experimental conditions.

Moreover, abutments and copings were used repeatedly (each abutment 12 times and each coping twice). This reuse of abutments and copings can also be a limitation, since it has been reported that cement retentiveness may be altered after luting and removing cement.[15] Moreover, differences in film thickness of the cement layer occurred between the cements. As a rule, the luting agents should exhibit low film thickness to improve seating and mechanical properties of the restoration. In this study, as in other similar studies, this factor was not considered and therefore can be a limitation. Future research should consider these limitations. Furthermore, as *in vitro* studies are unable to reproduce all oral environment variables during chewing, which may influence the retention of a particular cement, it would be desirable to carry out a consensus among researchers aimed at standardizing all controllable variables such as temperature, aqueous medium similar to saliva (pH, flow rate, buffering capacity, etc.), number and frequency of cycles and occusal forces (intensity, direction, impact, etc.), and possible reuse of abutments and copings.

CONCLUSION

Within the limitations of this *in vitro* study and in accordance with the results obtained, the following conclusions may be drawn: the resin urethane-based temporary cement (Premier Implant Cement) is the cement of choice in an implant-retained prosthesis when a dentist suspects any mechanical-technical or biological complications. In contrast, the resin composite permanent cement (Multilink Implant) is the best option for keeping the restoration in place without frequent debonding.

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