Effect of Luting Cement on Tensile Bond Strength of Implant-Supported Crowns

İmplant Destekli Kronların Çekme Bağlantı Dayanıklılığına Yapıştırıcı Simanın Etkisi

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ABSTRACT Objective: The aim of this study was to evaluate tensile bond strength of titanium to base metal alloy and copy-milled copings luted with 2 different cements. **Material and Methods:** Twelve implants were embedded in acrylic resin. Solid abutments were attached to the implants. Twenty four copings were cast with a CoCr alloy (Group I) while 24 copy-milled copings were directly fabricated with Y-TZP ceramic using the Kavo Everest CAD/CAM system (Group II). Each of the 2 groups were divided into 2 subgroups (Group I, A and B, and Group II, A and B; n= 12). Group IA/IIA and Group IB/IIB specimens were luted with a polycarboxylate luting cement (Poly-F Plus Bondex) and an adhesive luting cement (Superbond C&B), respectively. After storage in distilled water at room temperature for 24 hours, all specimens were subjected to a tensile bond strength test in a universal testing machine (TSTM 02500). The results were then evaluated with Kruskal-Wallis and Mann-Whitney U tests (α= .05). **Results:** There was significant difference in the bond strength of all groups, except for Group IA and Group IIB (p> 0.05, p= 0.86). Superbond C&B adhesive luting agent showed significantly higher bond strength value when compared with polycarboxylate cement groups. **Conclusion:** Superbond C&B adhesive luting agent showed higher bond strength values for polycarboxylate cement for both base metal alloy and copy-milled copings.

Key Words: Dental prosthesis, implant-supported; adhesive cement; cementation; tensile strength

ÖZET Amaç: Bu çalışmanın amacı 2 farklı siman ile yapıştırılmış temel metal alaşımı ve copy-milled kopinglere titanyumun çekme bağlantı dayanıklılığını değerlendirmektir. **Gereç ve Yöntemler:** Oniki implant akrilik rezine gömüldü. Solit abutmentlar implantlara yerleştirildi. Yirmidört koping CoCr alaşımı (Grup I) ile dökülürken, yirmidört copy-milled koping doğrudan Kavo Everest CAD/CAM sistem (Grup II) kullanılarak Y-TZP seramik ile hazırlandı. Her iki grup 2 alt gruba ayrıldı (Grup I, A ve B, ve Grup II, A ve B; n= 12). Grup IA/IIA ve Grup IB/IIB örnekleri, sırasıyla, polikarboksilat yapıştırıcı siman (Poly-F Plus Bondex) ve adeziv yapıştırıcı siman (Superbond C&B) ile yapıştırıldı. 24 saat süre ile oda sıcaklığında distile su içinde bekletildikten sonra, tüm örneklere universal test cihazı (TSTM 02500) kullanılarak çekme bağlantı dayanıklılık testi uygulandı. Sonuçlar Kruskal-Wallis ve Mann-Whitney U testleri ile değerlendirildi (α= .05). **Bulgular:** Grup IA ve Grup IIB hariç, tüm grupların bağlantı dayanıklılıkları arasında önemli farklılıklar vardı (p> 0.05, p= 0.86). Superbond C&B adeziv yapıştırıcı siman grupları polikarboksilat siman ile karşılaştırıldığında istatistiksel olarak daha yüksek bağlantı dayanıklılığı gösterdi. **Sonuç:** Superbond C&B adeziv yapıştırıcı siman hem temel metal alaşımı hem de copy-milled kopingler için daha yüksek bağlantı dayanıklılığı gösterdi.

Anahtar Kelimeler: Dental protez, implant destekli; adeziv siman; simantasyon; çekme dayanıklılığı

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Fixed or removable partial dentures and implant supported prostheses are three options for patients, which is lose out on teeth, depending on the cost, location, condition of abutment teeth and bone. Implant supported prostheses for partially edentulous patiens may be screw-retained or cement-retained restorations. It was reported that cemented implant-supported prostheses, offer better handling characteristics, the reduction of microleakage, increased esthetics and function as well as the reduction of stress concentration.[1-5]

In cemented implant prostheses, the restoration is luted onto a transmucosal abutment, which is either pre-machined or custom-made from noble alloy, titanium, or reinforced ceramics. The shape and the size of the transmucosal abutments, the different cements available, and the materials of which prostheses and abutments are made may all affect the longevity of these restorations.[3,6-8]

The rising interest in esthetic dentistry by patients over the past decade has led to an increased demand for metal-free restorations in the anterior as well as posterior region.[9] Because of their esthetics and biocompatibility, many patients prefer all-ceramic crowns to metal-ceramic crowns.[10] Johansson and Ekfeldt[11] reported good long term results for ceramic veneered implant-supported bridges. Bragger et al[12] found significantly higher porcelain failure rates for implant-supported bridges than for restorations supported by natural teeth. The most recent core materials for all-ceramic restorations are the yttrium oxide partially stabilized zirconia (Y-TZP) that are industrially manufactured into blanks and milled to the desired dimensions using the Computer Aided Design/Computer Aided Manufacture (CAD/CAM) technology.[13]

The dentist has a wide choice of many different luting cement, each with advantages and disadvantages. For splinted multi- and single-unit implant-supported FDPs water-based as well as polymerizing cements could be used.[2] Plastic deformation of cement under loading and premature failure of the restoration can result from the lack of adequate mechanical properties within the cement or poor resistance and retention form of the abutment.[14,15] The choice of the appropriate cement for a specific clinical situation is still based on the clinician's experience rather than scientific data. Ideally, the cement should be strong enough to indefinitely retain the prosthesis in place, yet weak enough to allow the dentist to retrieve it if necessary.[6,16] Recently, the use of high strength cements has become more popular for implant supported prostheses.[17-20] The purpose of the study was to compare the effect of two luting cements on the tensile bond strength of titanium to cemented base metal and Y-TZP copy-milled copings. The null hypothesis of this study is adhesive luting cement had higher values for cement failure loads compared to the conventional cement for Y-TZP copy-milled copings and base metal copings.

MATERIAL AND METHODS

Twelve implants with a diameter of 4.8 and length of 10 mm (SwissPlus Implant System, Zimmer Dental, CA, USA) were used in this study. Implants were embedded into acrylic resin blocks. Solid titanium abutments with a distinctive nonrotational surface comprising one grooved and one flat side were attached to the implants using Fixture Mount Drill. Modified abutments were prepared with 6.28 mm in height and and 3° taper at a computer-assited lathe (NV 500A/40 Mori Seiki Yamato Koriyama City, Japan). The occlusal surface of each abutment were covered with a cotton pellet and Cavit (3M ESPE, St. Paul, MN).

For base metal copings, patterns were prepared with adapte technique directly onto each of modified abutments. A 0.5 mm termoplastic sheet was adapted over each abutment and waxed. A loop was waxed on the pattern' occlusal surface to permit the castings to engage a special device of universal testing machine. All patterns were sprued and vacuum invested in a phosphate-bonded investment (Bellastar, Bego, Bremen, Germany). The castings were made using a cobalt-chromium alloy (Bego, Bremen, Germany), then were cleaned. Then, all copings were examined by an experienced practitioner using a stereomicroscope (LeicaMZ16, Leica Microsystems, GmbH, Ernst-Leitz-Strasse) at 10% before being carefully seated onto their abutments to check passive fit. All manufacturing steps were carried out by the same certified dental technician and the recommended protocol for clinical practice (Figure 1).

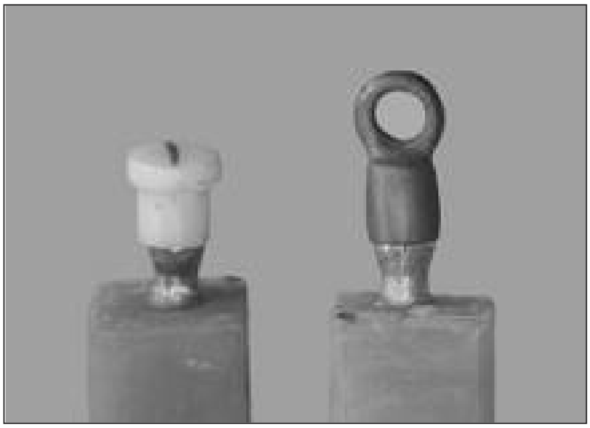

FIGURE 1: The view of Y-TZP copy-milled coping and base metal coping.

Copings have bases with an 7 mm diameter flat occlusal surface and 7.2 mm height were fabricated using the CAD/CAM system (Kavo Everest, Kavo, Germany). Each abutment was duplicated using reversible hydrocolloid and a stone die was made. The stone dies were laser scanned using the Kavo Everest Scan unit (Kavo Everest® Scan 4100, Kavo, Germany). All 3D contour dimensions of the die were scanned in the ratio 1:1 by a CCD camera and then converted into digital data. The surface of the scanned die was generated on the computer screen. The position of the finish line (preparation limit) was marked on the die using the computer software and a coping with a chamfer was constructed on the screen by the CAD module. The thickness of the coping was set at 0.50 mm and the space for the cement provided was 30 μm. There was no space left at the margins to ensure an accurate marginal fit. All data was saved by the CAM module to be used by the milling machine for the construction of the copings.[21]

Twentyfour cores were machined from Kavo Everest ZS-blanks (Kavo, Germany) using the Kavo Everest CAD/CAM system. Each blank was mounted using a specially designed insert (Everest Insert, Kavo, Germany) and a metal positioning ring which was filled with resin (Kavo Everest Universal Inplast, Kavo, Germany). The work pieces were positioned in slots in the clamping yoke of the Kavo Everest engine (Kavo Everest® Engine 4140, Kavo, Germany) and the inner surface was milled with coarse and then fine cutting tools. Once this was completed, the inner surface of the coping was rinsed thoroughly so that any excess powder from the milling process was removed. The copings were then dried carefully and molten Wax (Everest ZS Investing wax, Kavo, Germany) was applied to fill the cavity. The milling of the outer surface was next performed. Once the milling process was completed, the work pieces were removed from the clamping yoke and the copings were carefully separated by heating the wax. All the copings were placed on a firing tray and sintered in a furnace (Kavo Everest® Therm, Kavo, Germany) overnight at 1500 ◦C. Each coping was then placed on the respective die and the margins were adjusted with a diamond bur to remove bulk. After cleaning and drying, the copings were subjected to a conditioning heat treatment, in a porcelain furnace (Multimat MCII, Dentsply, Weybridge, UK), following the manufacturer's recommended parameters (Figure 1).[21]

Each of the 2 groups, base metal copings (Group I) and all-ceramic copings (Group II), were further divided into 2 luting cement groups of 12 each (Group I, A and B, and Group II, A and B). Group IA/IIA and Group IB/IIB specimens were luted with a polycarboxylate luting cement (Poly-F Plus Bondex, Dentsply Detrey GmbH, Konstanz, Germany) and an adhesive luting cement (Superbond C&B, Sun Medical Co Ltd, Moriyama City, Japan), respectively.

For the Poly-F Plus Bondex groups, the abutments were washed with water and dried. Two drops of liquid were mixed with 1 scoop of polycarboxylate powder with a spatula for 30 seconds, according to the manufacturer instructions. Then, all copings were definitively placed on the abutments and held in place using finger pressure until the cement was set.

The same 12 abutments were also used to test the Superbond C&B groups.[18] After test of Poly-F Bondex groups, abutments were cleaned in distilled water in an ultrasonic cleaner for 30 min, then wiped with cotton gauze. For the Superbond C&B groups, the mixture was combined with 2 scoops of powder and applied to the bonding surface. The copings were cemented to the abutments as previously described.

All the specimens were stored in distilled water at 37ºC for 24 hours, and tensile bond strength values were measured with a universal testing machine (TSTM 02500, Elista Ltd Şti, Istanbul, Turkey) at a crosshead speed of 0.5 mm/min. The maximum load at fracture (N) was recorded. The statistical analysis was performed using statistical software (SPSS for windows 2000/V 8.0 SPSS Inc, Chicago, Ill.). The means and standard deviations of the bond strengths for the 2 different luting cements were calculated for all groups. The bond strength values were analyzed with Kruskal-Wallis and Mann-Whitney U tests ($\alpha = .05$).

RESULTS

There was significant difference in copy-milled copings cemented with polycarboxylate cement and adhesive luting agent ($p < 0.05$, $p = 0.04$). Superbond C&B adhesive luting agent showed significantly higher bond strength value for Group IB (1057.77) and Group IIB (581.71) when compared with polycarboxylate cement for Group IA (616.51) and Group IIA (473.61) (Table 1).

There was significant difference in the bond strength of base metal and copy-milled copings cemented with polycarboxylate cement ($p = 0.03$), while there was no significant difference Group IA and Group IIB ($p > 0.05$, $p = 0.86$).

Cement failure occured at the cement-abutment interface, residual cement was present inside the base metal or copy-milled coping (100%).

DISCUSSION

Cement-retained, implant-supported prosthesis have gained popularity because they allow completion of clinical procedures using conventional fixed prosthodontic techniques. In the absence of occlusal screw access openings, cemented implant-supported restorations offer enhanced esthetics and an increased number of occlusal contacts. Cemented restorations compensate for minor fit discrepancies through use of a luting agent.[1] Loss of retention was than the most frequently encountered technical complications for implant-supported. Ideal values of retention for cemented implant restorations have not yet been established. At present it seems impossible to quantify the amount of retention necessary for retrievability, which at the same time guarantees long term endurence of the prosthesis.[6]

The retention of crowns on customized implants is influenced by many variables. When choosing the cement, the clinician should carefully evaluate the height and the taper of the abutments, and also be aware of the relative retentive values of the available luting agents. The longer, wider and more parallel the abutments are, if retrievability is desired, the less retentive the cement can be. In presence of short, tapered abutments, the more retentive cement especially resin cement may be prefered.[6,22]

It appears to be important to evaluate interocclusal space and occlusion, because in some instances when those factors are compromised, the risk of the prostheses loosening is high. The bond strength of the selected luting agent must be greated enough to resist lateral an vertical forces during function but a weaker cement may be clinically effective in allowing prosthesis retrieval in those situations.[1]

When selecting a luting agent, it is important that the cement be easy to manipulate and remove without damaging implant components or surrounding soft tissue. If residual cement remains, it should not cause peri-implant complications.[1]

The bond strength was affected by the restoration type and selected cements in our study. This study was an in vitro study and only 2 cements were tested-Poly-F Plus Bondex and Superbond C&B. Mansour et al[18] stated that the retention provided by polycarboxylate cement (23.55) was signifi-

TABLE 1: Summary of the results of found for the tensile bond strength values (Mean ± Standart Deviation).

Groups	N	Mean ± SD		
Group I	A	Base metal coping - Poly-F Bondex	12	616.51[a]
	B	Base metal copping- Superbond C&B	12	1057.77[b]
Group II	A	Copy-milled coping - Poly-F Bondex	12	473.61[c]
	B	Copy-milled coping - Superbond C&B	12	581.71[a]

Mean values having the same letters in same column not statistically different ($p < 0.05$).

cantly greater than zinc phosphate (10.9), and zinc oxide cements with/without eugenol (3.18 and 9.25) for noble alloy copings. It has been shown that, during setting, this type of cement can adhere to metal substrates by chelation of metallic ions.[18,23-25] The authors therefore suggest that the significantly higher retention obtained by polycarboxylate cement could be due to adhesion of the cement to the titanium abutment.[18,26] Mansour et al[18] Maeyama et al,[17] Pan et al[19] and Sadiq and Al Harbi[27] stated that resin based cements had higher values for cement failure loads compared to the other cements.

In our study, the adhesive luting agent was provided the tensile bond strength higher than polycarboxylate cement for copy-milled copings and base metal copings.

Copy-milled copings were fabricated from zirconium oxide blanks due to opaque nature and underlying metal color masks for present study. In literature, a study is present on the retention of zirconia copings cemented onto titanium abutments. Abbo et al[22] evaluated the effect of the height of a titanium abutment on the force required to dislodge a luted zirconia coping. They were used a provisional cement to luted copings.

In present study, the bond strength values of two cements were rather different than each other, but the cement failure was the same for all specimens, It was a adhesive failure occurred at the cement-abutment interface and residual cement was present inside the coping. The finding was similar to study of Mansour et al.[18] This result could be explaned with the machined abutment surface, which is unmodified by any surface treatment. The surface was relatively smooth and the taper, surface area, and surface texture were the same for all specimens. Besides, there was surface irregularities increasing the bond strength via mechanical interlocking and the surface area at inner surfaces of copings. Another possible reason is the micromechanical retention of the resin luting agents or the chemical retention of polycarboxylate cement.

Mansour et al[18] stated that the results do not suggest that one cement type is better than another for in vitro studys, but they do provide a ranking order of the cements in their ability to retain the restorations. It is at the clinician's discretion to use a certain type of cement, based on the situation at hand. Clinical trials are necessary to validate the results of this in vitro study. Although factors such as thermal cycling, aging, and loading were included in laboratory studies to simulate in vivo conditions, these factors were eliminated in this study.

Within the limitations of this study, Superbond C&B adhesive luting agent provided the more retention both copy-milled and base metal copings. So adhesive luting agent may be suggest in presence of short, tapered abutments and insufficient interocclusal space. Clinicians must be decide acceptable luting agent with regard to the amount of desired retention between copings and implant abutments.

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