Retentive Strength of Metal Copings on Prefabricated Abutments with Five Different Cements

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ABSTRACT

Background: Despite their wide use in implant dentistry, there is insufficient information concerning the retentive strength of cement-retained superstructures.

Purpose: This study compared the retentive strength of metal copings on prefabricated abutments with five different luting cements.

Materials and Methods: Eight prefabricated abutments were placed on titanium screw implants torqued to 35 Ncm. Metal copings were cast with Au-Pt-Pd alloy (DeguDent Universal, Degussa, Hanau, Germany) using burnt-out plastic copings. Cements used were zinc oxide–eugenol–free temporary (ZO), zinc phosphate (ZP), glass ionomer (GI), resin-reinforced glass ionomer (RG), and composite resin (CR) cements. Retentive strength was measured with a universal testing machine. The means of each group were compared by one-way analysis of variance and Tukey-Kramer multiple-comparison intervals at a significance level of $p < .05$.

Results: The mean ± SD retentive strength of the cements in Newtons was ZO 56 ± 12 (Tukey group C), ZP 158 ± 79 (Tukey group B), GI 132 ± 29 (Tukey group B), RG 477 ± 52 (Tukey group A), and CR 478 ± 50 (Tukey group A).

Conclusion: The retentive strength of metal copings on implant abutments is somewhat different from those of conventional cemented restorations on natural teeth. These differences may be influenced by differences in surface roughness and the height of the abutment.

KEY WORDS: cement-retained superstructure, dental implant, prefabricated abutment, retentive strength

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The original implant prosthesis, the so-called bone-anchored full bridge, is supported by several interforaminal implants and retained by screws.[1] Successful application in completely edentulous patients has allowed the use of this treatment in partially edentulous patients.[2] With this expansion in treatment capability, a new restorative design has evolved in the field of implant prosthodontics. Cement-retained prostheses have become a popular alternative and provide advantages over screw-retained prostheses. Michalakis and colleagues[3] comparatively reviewed these two retention systems for implant prostheses. By reviewing numerous reports, they came to a conclusion that cement retention has clear advantages in terms of ease of fabrication and cost,[4] the passivity of the framework,[5] and occlusion and aesthetics.[6] Screw-retained prostheses require

TABLE 1 Cements Tested in the Study

Product Name	Type	Batch No.	Manufacture
Temporary Pack	Zinc oxide–eugenol–free temporary	0086	GC, Tokyo, Japan
Elite Cement	Zinc phosphate	P: 251141 L: 211061	GC, Tokyo, Japan
Fuji I	Glass ionomer	P: 0408271 L: 04008191	GC, Tokyo, Japan
Fuji Luting	Resin reinforced glass ionomer	0410281	GC, Tokyo, Japan
Panavia F 2.0	Composite resin	A: 00054A B: 00012A	Kuraray Co., Kurashiki, Japan

for identification during cementation procedures. The fitting and cement space were measured using silicone disclosing medium (Fit Checker, GC Corporation, Tokyo, Japan) and a digital microscope (Digital HD microscope VH-7000, Keyence, Osaka, Japan) as follows. First, the Fit Checker was placed in the inner surface of the casting, and the casting was seated on the abutment with a load of 20 N. After polymerization of the paste, the silicone remaining between the casting and abutment was peeled off and embedded in a resin material. The embedded silicon was sliced at half of the long axis, and the silicon thickness was measured at four randomly selected points.

A provisional cement and four types of definitive cements were used (Table 1). Each cement was mixed according to the manufacturer's instructions and applied to the axial surface of the casting, and then the casting was seated immediately by finger pressure and subjected to a 100 N vertical static load for 10 min (Figure 2). During seating, only composite resin was additionally light-polymerized at the margin with a light-curing unit (Clear Light, Kuraray Co., Kurashiki, Japan). Excess cement was removed with a plastic scaler. At 1 hour after seating, all specimens were immersed in water at 37°C for 24 hours and then tested for retention using a universal testing machine (Shimadzu Corp., Kyoto, Japan) at a crosshead speed of 0.5 mm/min (Figure 3). The load required to pull the casting off the abutment was recorded, and the mean values were calculated. A new abutment was used for each cement; however, castings were reused through the five cements tested. Cement residues were cleaned from the inner castings according to Dixon and colleagues[12]; each

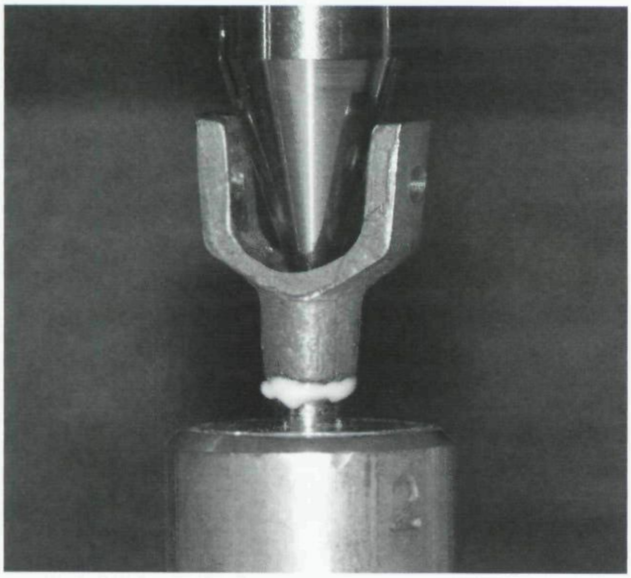

Figure 2 Cementation of a coping to the abutment with 100 N of load applied.

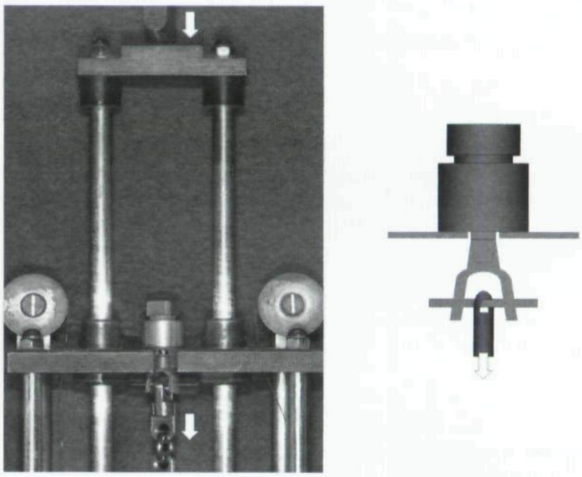

Figure 3 Overview and schematic diagram of a jig used for retentive testing in a universal testing machine.

casting was heated to 600°C for 1.5 hours and then allowed to bench cool at room temperature. The casting was then placed in an ultrasonic cleaner for 30 minutes with ethanol and was then inspected for complete cement removal. To maintain the uniformity of cast conditions, all castings were heated as mentioned above before the first cementation.

The mean values for each experimental group were compared by one-way analysis of variance and Tukey-Kramer multiple-comparison intervals. Statistical significance was set at $p < .05$.

RESULTS

The mean internal gap between abutments and castings for all specimens was 33.9 μm. As no differences were seen among any specimens, the cement spaces of all specimens tested were defined as the same thickness.

The mean retentive strength in Newtons and standard deviations of the tested cements are shown in Table 2 and illustrated in Figure 4. Zinc oxide–eugenol–free temporary (ZO) cement showed the weakest retention and was significantly lower than the other cements. Resin-reinforced glass ionomer (RG) and composite resin (CR) provided the highest retention and were significantly stronger than the other cements. Zinc phosphate (ZP) and glass ionomer (GI) showed statistically similar retention values.

DISCUSSION

The Nobel Biocare Easy Abutment system was developed with the concept of simplifying implant prosthetic work. Prostheses for abutments are fabricated using plastic or ceramic copings and relatively simple and predictable procedures. This system allows the production of consistent cement spaces and marginal fittings without the need for special casting adjustments. In the present experiment, the mean thickness of the cement space was around 33.9 μm, with no significant difference among specimens. Given suggestions that the cement space is a key factor in retention,[13] this finding indicates that this potential bias had no influence on the present results.

As expected, ZO showed the weakest retention among all of the cements tested, whereas CR showed the highest. Interestingly, RG showed the same retention value as CR, even though the adhesive strength of CR is reported to be significantly stronger.[14] Ernst and colleagues attributed the lower retentive strength of the resin cement to the lack of an adhesive system and stated that resin cements should be used in combination with such a system.[15] Sandblasting and proper priming of the abutment, either singly or together, may increase retention. However, retentive strengths in the present study were beyond the highest strengths obtained with prepared teeth using the same resin cements and a proper adhesive system.[16,17] It could, in fact, be considered that sufficient retention is already available; thus, further improvement is unnecessary. Similar experiments have been carried out using ITI Dental Implant System® (Straumann AG, Waldenburg, Switzerland) solid abutments and the same cements with[10] and without[11,18] thermocycling. The greater retentive strength in the present study may have been due to the difference in tapers, namely 8° for the ITI solid abutment and 6° for the Easy Abutment. ZP, which develops its retentive strength by mechanical interlocking and showed less retention with the smooth surface used

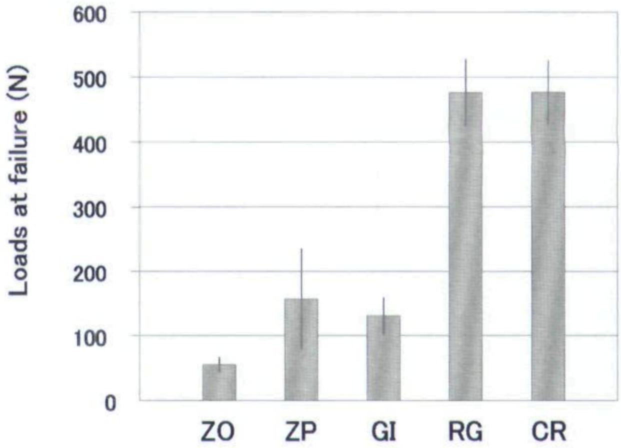

Figure 4 Tensile loads (N) at decementation. CR = composite resin; GI = glass ionomer; RG = resin-reinforced glass ionomer; ZO = zinc oxide–eugenol–free temporary; ZP = zinc phosphate.

TABLE 2 Mean Values and Standard Deviations of Loads Required to Displace Castings

Cement	Mean	SD	Tukey Grouping
ZO	56	12	C
ZP	158	79	B
GI	132	29	B
RG	477	52	A
CR	478	50	A

CR = composite resin; GI = glass ionomer; RG = resin-reinforced glass ionomer; ZO = zinc oxide–eugenol–free temporary; ZP = zinc phosphate.

here than CR and RG. This is supported by the observation that cement failure always occurred at the cement-abutment interface. The relatively large standard deviations seen with ZP cement were related to its cement properties. ZP cement is well known to be hypersensitive to temperature, humidity, and mixing methods.[19] Surprisingly, GI, which has a shear bond strength to titanium surfaces of about 4 MPa,[20] did not perform as anticipated. Possible explanations include early water contact and the lack of aging before testing.[21]

With regard to the retrievability of cement-retained implant prostheses, the retrieval force required should not be so great as to adversely affect osseointegration. Hallgren and colleagues performed pull-out tests of cylindrical implants inserted into rabbit tibiae.[22] Shear strength between bone and implants of 4 mm diameter and 6 mm length was 4.16 MPa, whereas the shear strength required to displace the implant directly out of the socket along its long axis was about 290 N. Applying these results to the present findings clearly indicates that RG and CR are not suitable for use with retrievable prostheses but should be categorized instead as definitive cements for implant prostheses. In contrast, ZO appears to be the safest cement tested with regard to implant safety, but this cement is too weak to control retrievability, with unexpected cement failure allowing displacement of the prosthesis when the maintenance schedule cannot be kept. According to Singer and Serfaty, 9.8% of 92 cement-retained fixed partial dentures showed cement failure over a 6-month to 3-year period.[23] Clinically, cemented prostheses are exposed to repeated masticatory forces, temperature change, and high humidity. These factors may cause a weakening of retention and thereby necessitate the frequent recementation of implant-supported prostheses. On the other hand, given the moderate retentive strengths of ZP and GI, the possibility of unforeseen cement failure with these is low but still present. In emergency situations, prostheses with this level of retention can be removed without adverse effects on osseointegration.

CONCLUSION

Within the limitations of this in vitro study, it was shown that the retentive strength of the castings on the Easy Abutment is influenced by the type of cement used. Cements could be grouped into three ascending levels of retention: group 1, ZO; group 2, ZP and GI; and group 3, RG and CR. This ranking differs from those with conventional cemented restorations on natural teeth, possibly owing to differences in surface roughness and the height of the abutment. Cements for cement-retained prostheses should be selected based on careful treatment planning.

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REFERENCES

1. Adell R, Lekholm U, Rocker B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of edentulous jaw. Int J Oral Surg 1981; 10:387–416.
2. Naert I, Quirynen M, van Steenberghe D, Darius P. A six-year prosthodontic study of 509 consecutively inserted implants for the treatment of partial edentulism. J Prosthet Dent 1992; 67:236–245.
3. Michalakis KX, Hirayama H, Garefis PD. Cement-retained implant restorations: a critical review. Int J Oral Maxillofac Implants 2003; 18:719–728.
4. Chee W, Felton DA, Johnson PF, Sullivan DY. Cemented versus screw-retained implant prostheses: which is better? Int J Oral Maxillofac Implants 1999; 14:137–141.
5. Taylor TD, Agar JR, Vogiatzi T. Implant prosthodontics: current perspective and future directions. Int J Oral Maxillofac Implants 2000; 15:66–75.
6. Hebel KS, Gajjar RC. Cement-retained versus screw-retained implant restoration: achieving optimal occlusion and esthetics in implant dentistry. J Prosthet Dent 1997; 77:28–35.
7. Guichet DL, Caputo AA, Choi H, Sorensen JA. Passivity of fit and marginal opening in screw- or cement-retained implant fixed partial denture designs. Int J Oral Maxillofac Implants 2000; 15:239–246.
8. Chee WW, Torbati A, Albouy JP. Retrievable cemented implant restorations. J Prosthodont 1998; 7:120–125.
9. Covey DA, Kent DK, St Germain HA Jr, Koka S. Effect of abutment size and luting cement type on the uniaxial retention force of implant supported crowns. J Prosthet Dent 2000; 83:344–348.
10. Squier RS, Agar JR, Duncan JP, Taylor TD. Retentiveness of dental cements used with metallic implant components. Int J Oral Maxillofac Implants 2001; 16:793–798.
11. Mansour A, Ercoli C, Graser G, Tallents R, Moss M. Comparative evaluation of casting retention using the ITI solid abutment with six cements. Clin Oral Implants Res 2002; 13:343–348.
12. Dixon DL, Breeding LC, Lilly KR. Use of luting agents with an implant system: part II. J Prosthet Dent 1992; 68:885–890.
13. Macorra JC, Pradies G. Conventional and adhesive luting cements. Clin Oral Investig 2002; 6:198–204.

14. Piwowarczyk A, Lauer HC, Sorensen JA. In vitro shear bond strength of cementing agents to fixed prosthodontic restorative materials. J Prosthet Dent 2004; 92:265–273.
15. Ernst CP, Wenzl N, Stender E, Willershausen B. Retentive strengths of cast gold crowns using glass ionomer, compomer, or resin cement. J Prosthet Dent 1998; 79:472–476.
16. Proussaefs P. Crowns cemented on crown preparations lacking geometric resistance form. Part II: effect of cement. J Prosthodont 2004; 13:36–41.
17. Ergin S, Gemalmaz D. Retentive properties of five different luting cements on base and noble metal copings. J Prosthet Dent 2002; 88:491–497.
18. Akca K, Iplikcioglu H, Cehreli MC. Comparison of uniaxial resistance forces of cements used with implant-supported crowns. Int J Oral Maxillofac Implants 2002; 17:536–542.
19. Shepherd WB, Leinfelder KF, Hershey HG. The effect of mixing method, slab temperature, and humidity on the properties of zinc phosphate and zinc silicophosphate cement. Angle Orthod 1978; 48:219–226.
20. Hibino Y, Kuramochi K, Hoshino T, Moriyama A, Watanabe Y, Nakajima H. Relationship between the strength of glass ionomers and their adhesive strength to metals. Dent Mater 2002; 18:552–557.
21. Mojon P, Hawbolt EB, MacEntee MI, Ma PH. Early bond strength of luting cements to a precious alloy. J Dent Res 1992; 71:1633–1639.
22. Hallgren C, Sawase T, Ortengren U, Wennerberg A. Histomorphometric and mechanical evaluation of the bone-tissue response to implants prepared with different orientation of surface topography. Clin Implant Dent Relat Res 2001; 3:194–203.
23. Singer A, Serfaty V. Cement-retained implant-supported fixed partial dentures: a 6-month to 3-year follow-up. Int J Oral Maxillofac Implants 1996; 11:645–649.