The Effects of Abutment Wall Height, Platform Size, and Screw Access Channel Filling Method on Resistance to Dislodgement of Cement-Retained, Implant-Supported Restorations

Mark Emms, LDS, MSc;[1] Christopher J. Tredwin, BDS, BSc, MSc, MFDS RCS, ILTM;[2] Derrick J. Setchell, BDS, MS, FDS RCS, ILTM;[3] and David R. Moles, PhD, BDS, MSc, MSc, DDPH RCS[4]

Purpose: **Factors affecting the retention of fixed prostheses to natural abutments are well understood. In contrast, little is known concerning factors influencing the retention of fixed prostheses cemented to implant abutments. The purpose of this study was to investigate the effect that varying implant abutment wall height, platform size, and screw access channel filling method has on the retention of castings cemented to implant abutments using TempBond.**

Materials and Methods: **Four 15° preangled abutments (Nobel Biocare Replace Select Esthetic) of each platform size—narrow (NP), regular (RP), and wide (WP)—were used. In each group of abutments the screw access axial wall was either unadjusted, one-third removed, two-thirds removed, or completely removed. The screw access channels were either fully or partially filled with Memosil, a vinyl polysiloxane impression material. For each abutment a casting was constructed that incorporated an attachment to allow removal. Castings were cemented to abutments with TempBond. The tensile force required to separate the cemented castings from the abutments was measured using an Instron Universal load-testing machine.**

Results: **The mean peak removal force for comparable abutments was significantly different ($p < 0.05$): (1) where the screw access channel was completely filled with Memosil compared with those partially filled with Memosil; (2) with platform sizes—WP > RP > NP; (3) with alteration of axial wall height—1/3 removed > unadjusted = 2/3 removed > total wall removal.**

Conclusions: **The retention of castings cemented to implant abutments with TempBond is influenced by the wall height, platform size, and the filling modality of the screw access channel.**

J Prosthodont 2007;16:3-9. Copyright © 2007 by The American College of Prosthodontists.

INDEX WORDS: screw retention, cementation, implant-supported prosthesis, dental temporary cement

[1]Graduate, Department of Conservative Dentistry, Eastman Dental Institute, University College London, London, UK.

[2]Clinical Lecturer/Honorary Specialist Registrar in Restorative Dentistry, Eastman Dental Institute, University College London, London, UK.

[3]Head of Conservative Dentistry, Eastman Dental Institute, University College London, London, UK.

[4]Senior Clinical Lecturer in Health Sciences Research, Eastman Dental Institute, University College London, London, UK.

Accepted September 15, 2005.

Correspondence to: Christopher J. Tredwin, BDS, BSc, MSc, MFDS RCS, ILTM, Eastman Dental Institute, University College London, 256 Grays Inn Road, London, WC1X 8LD. E-mail: c.tredwin@eastman.ucl.ac.uk

1059-941X/06

doi: 10.1111/j.1532-849X.2006.00150.x

SCREW-RETAINED, implant-supported prostheses were developed in response to the need for retrievability of restorations should removal be required. As techniques continue to evolve, the survival rates of implant-retained restorations are improving.[1] Consequently, the use of cement-retained, implant-supported restorations has increased, due in part to the ability to optimize occlusal interdigitation, enhance esthetics in areas that would otherwise be the locations of screw access holes, and provide a passive fit, which may actually improve loading characteristics.[2]

Many present-day implant systems have screw-retained abutments onto which restorations can

be cemented. The majority of abutment preparation designs and cementation techniques now mimic conventional fixed prosthodontic procedures for natural teeth. Factors that influence the retention of conventional cement-retained restorations have been well documented.[3-6] Factors that have currently been shown to be of importance in the retention of restorations on implant abutments are taper,[7] size,[8] length,[7] and cement type.[7-10] One clear difference between an implant abutment and a natural tooth preparation is the presence of a screw access channel.

Methods of managing the screw access channel prior to cementation of the restoration include partial or complete filling with silicone impression material. Such methods are used to prevent cement from reaching the head of the abutment screw, thus complicating later clinical access should it become necessary. The method chosen is at present largely dependent on operators' preference and convenience and has little scientific basis.

The null hypotheses of this study are that varying wall height, platform size, and screw access channel filling modality will have no significant influence on the retention of castings cemented to standard implant abutments.

Figure 1. Mounting of implant replica and abutment in acrylic resin with casting constructed on top.

Materials and Methods

Fifteen degree angled Esthetic Abutments (Brånemark System®, Nobel Biocare, Zurich, Switzerland) were chosen for use in this study as they are preformed standardized abutments with a screw access channel and are commonly used clinically. Four narrow, regular, and wide platform abutments were attached to their implant replicas and identically vertically mounted in acrylic resin (RP self-cure clear acrylic resin, Dentsply DeTrey GmbH, Konstanz, Germany) to permit a tensile force to be applied in the long axis of the axial form of the abutment. The mounting resulted in the implant replica being buried to simulate the implant in bone, with the head of the implant exposed for restoration (Fig 1).

The abutment assemblies were then mounted in a milling machine (Metalor MP300, Metalor Technologies Ltd., Birmingham, UK), and identical modifications were made to the screw access aspect of the wall. The Esthetic Abutments, regardless of platform, are 9 mm in height. The screw access channel wall of the abutments of each platform size was treated as follows: unmodified, 3 mm (1/3 of wall height) removed, 6 mm (2/3 of wall height) removed, and 9 mm (total wall) removed (Fig 2).

The access holes of the abutments were carefully blocked out, and a putty matrix (Coltene Lab Putty, Coltene AG, Altstaeten, Switzerland) of the abutment shape was constructed. Two layers of die spacer (Belle de St Claire, Kerr Laboratories, Orange, CA) were painted to within 2 mm of the margin, and type III gold castings (EC830, Degussa AG, Geshaftsbericht Dental, Dusseldorf, Germany) with an attachment were constructed for all 12 abutments (Fig 1). The exterior of the castings was polished while the interiors were left untouched.

During the experiment the screw access channels of each of the abutment combinations were either completely filled with a vinyl polysiloxane impression material (Memosil [Memosil 2 vinyl polysiloxane, Heraeus Kulzer GmbH & Co. KG, Dormagen, Germany]) (Fig 3) or partially filled so that the screw was covered with 1 mm of Memosil (Fig 4), the depth of which was assessed with a graduated periodontal probe (Hu-Friedy, Chicago, IL) during the setting reaction. Care was taken to maintain the fully filled access channels within the contour of the abutment using the original putty matrix for guidance.

Weighed amounts of TempBond (Kerr Italia S.p.A, Scafati, Italy) were used for the cementation of the castings on the implant abutments and mixed for 30 seconds

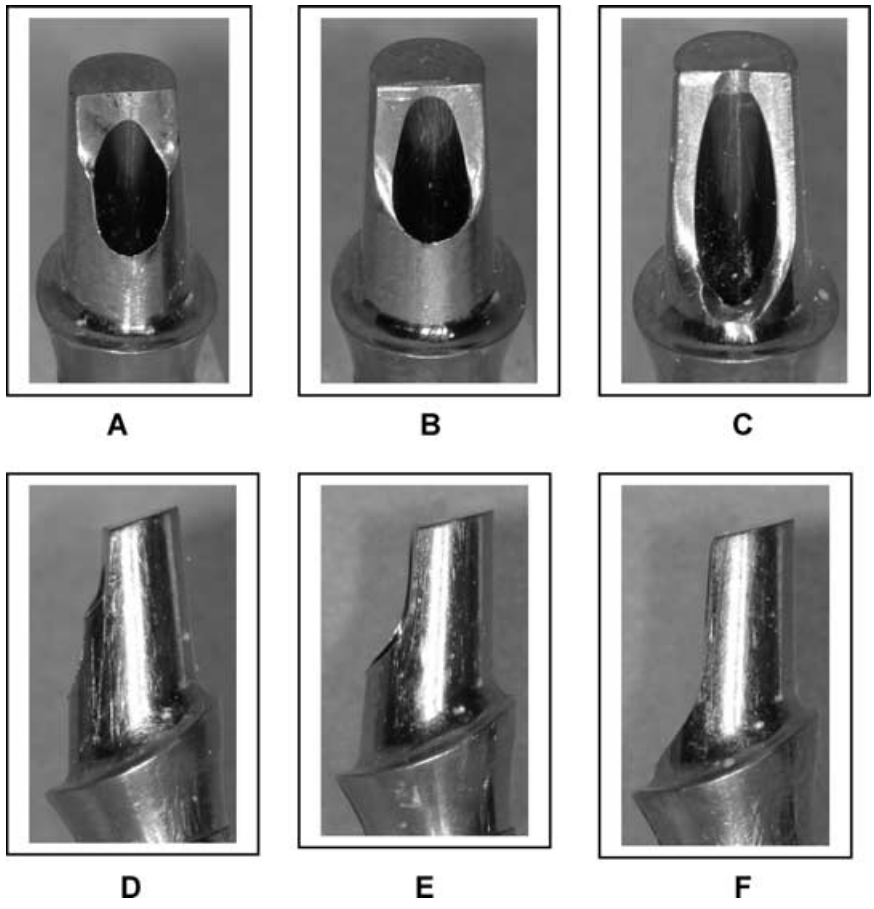

Figure 2. (*A-F*) Wall adjustments—1/3, 2/3, and total wall removal using a regular platform abutment as an example.

in proportions according to the manufacturer instructions. The mixed cement was placed into the castings using a crown-fill technique, seated onto the abutment with finger pressure, and placed under a 5-kg seating force in a static-loading machine for 5 minutes. Excess cement was removed using a plastic instrument. The assemblies were then stored in 100% humidity at 37°C for 24 hours.

Figure 3. Abutment fully filled with Memosil.

Figure 4. Abutment partially filled with Memosil.

Table 1. Results of the Three-Way ANOVA Test

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Significance*
Corrected model	330*	23	1	84.6	<0.001
Intercept	970	1	970	56923.3	<0.001
Adjustment	110	3	4	219.8	<0.001
Access hole filling method	7	1	7	402.1	<0.001
Width	14	2	7	399.2	<0.001
Error	4	216	0.4		
Total	1006	240			
Corrected total	37	239			

*R squared = 900 (adjusted R squared = 889).

A universal load-testing machine (Instron, Norwood, MA) was used to measure the peak force required to remove the castings from the abutments. With reference to previous studies using the same machine, the crosshead speed was set at 5 mm/min.[8,10,11] The force required for complete separation of the castings from the abutments was recorded. The procedure was completed 20 times for each filling modality. Abutments were completely cleansed of all residual lute by soaking in temporary cement remover (Premier Dental Products Co., Plymouth Meeting, PA) for 20 minutes in an ultrasonic bath and subsequent steam cleaning. Examination under magnification (25×) was used to confirm complete removal of all the temporary cement.

Three-way analysis of variance (ANOVA) was used to test for any differences between platform width, wall adjustment, and access channel filling method (α = 0.05). A conservative post hoc test correction was applied (Bonferroni multiple test comparison) to see what difference lay between the means of subgroups.

Results

Results of the three-way ANOVA are summarized in Table 1 and reveal significant differences ($p < 0.05$) as a function of the adjustment, access hole filling method, and width.

Estimated marginal means for adjustment, access channel filling method, and platform widths are shown in Table 2.

Multiple comparisons using the Bonferroni test revealed significant differences ($p < 0.001$) between all adjustments, with the exception of unadjusted and 2/3 wall removal ($p = 1.000$), all platform sizes, and fully filling or partially filling the access channel with Memosil.

Figures 5 and 6 summarize the mean results obtained with 95% confidence intervals for platform widths/adjustments for fully filled (FF) and partially filled (PF) Memosil specimens, respectively.

Table 2. Estimated Marginal Means with Standard Error and 95% Confidence Intervals for Adjustment, Access Channel Filling Method, and Platform Widths

			95% Confidence Interval	
	Mean (N)	*Standard Error*	*Lower Bound*	*Upper Bound*
Adjustment				
Unadjusted	63	1.000	62	64
1/3 Wall removed	74	1.000	73	75
2/3 Wall removed	63	1.000	62	64
Total wall removed	55	1.000	54	56
Access channel filling method				
Fully filled Memosil	58	1.000	57	59
Partially filled Memosil	69	1.000	68	70
Platform Width				
Narrow	54	1.000	53	55
Regular	64	1.000	63	65
Wide	73	1.000	72	74

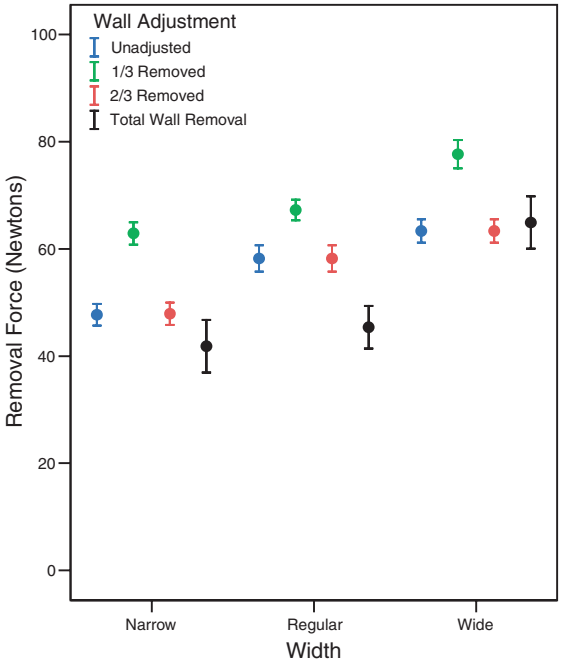

Figure 5. Mean results obtained with 95% confidence intervals for platform widths/adjustments for fully filled Memosil specimens.

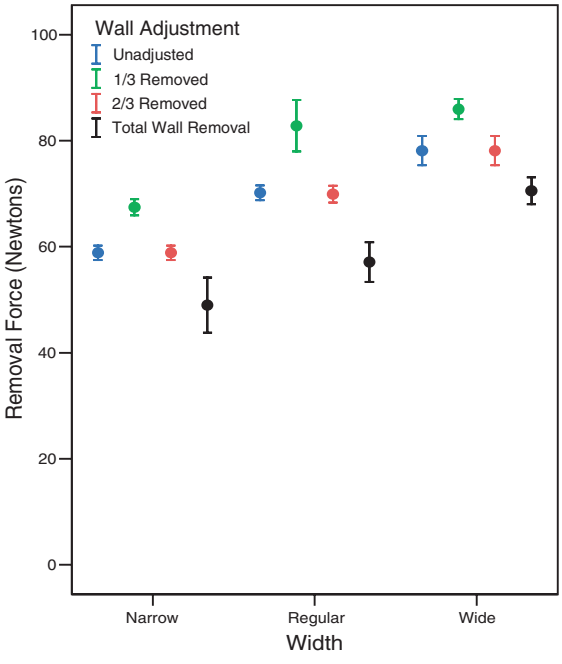

Figure 6. Mean results obtained with 95% confidence intervals for platform widths/adjustments for partially filled Memosil specimens.

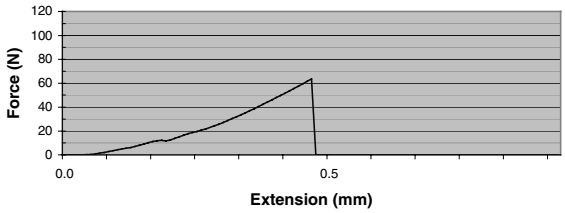

Figure 7. Force displacement graph for a typical fully filled Memosil specimen.

The patterns of the force displacement graphs were very similar, with the exception of the filling modality graphs. Figures 7 and 8 show typical force displacement graphs found for a FF and PF specimen with Memosil.

After the removal of the cemented abutments, the pattern of the cement distribution was noted. For the FF group all the cement was found on the fitting surface of the castings, while there was no cement left on the abutment surface. For the PF group all the cement adhered to the fitting surface of the casting but with a block of cement always left in the screw access channel.

Discussion

The null hypothesis of this study stating that varying wall height, platform size, and screw access channel filling modality will have no significant influence on the retention of castings cemented to standard implant abutments was rejected. Varying wall height, platform size, and screw access channel filling method had significant influences on retention; however, the limitations of this study should be noted from the outset, since it only investigated retention and not resistance. Clinically, removal of castings might not employ forces along a single path of withdrawal.

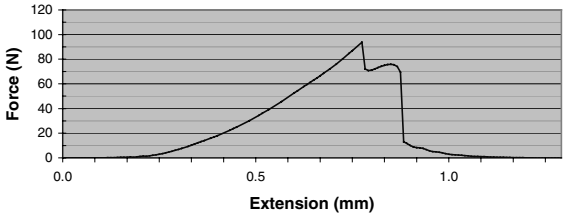

Figure 8. Force displacement graph for a typical partially filled Memosil specimen.

The comparative retentive forces to remove the cemented abutment were always as follows: wide platform > regular platform > narrow platform. This confirms current understandings of retention:[3-6] with decrease in size of platform, and thus surface area and diameter, there is a resultant decrease in retention. Clinically this means the smaller the abutment size used, the less the retention may be, with further caution being paid to ensure the other retentive features of the abutment are maximized.

The method employed to fill screw access channels on implant abutments had a clear effect on the retention of a coronal restoration cemented with TempBond. One of the major concerns with cemented restorations is the challenge of retrieval when an abutment screw loosens. A cast restoration that fits well may be difficult to remove after provisional cementation to a prepared tooth.[7] Likewise, a casting for an implant abutment may be difficult, if not impossible, to retrieve without sectioning it.[7] Clinically if there is a risk of screw loosening and the retentive form of the abutment is good, the results of this study suggest that fully filling the screw access channel with Memosil when cementing with TempBond would be appropriate to minimize contribution of the filling method to retention.

Conversely, if the retentive form of the abutment is compromised, through for example, loss of length,[7] then the method used to fill the screw access channel should be such that its contribution to removal force should be maximized with the screw access channel being partially filled with Memosil.

For the FF group, cement was found mostly on the fitting surface of the castings with no cement left on the abutment surface. This implies that TempBond adhered to the (possibly rougher) gold fit surface much more strongly than to the titanium/Memosil surface. The cement breakage seemed to occur in an instant on analysis of the force displacement graphs, as the force recorded dropped sharply after the break, and the castings fell apart immediately.

The cement breakage in the PF group appeared to be in a more gradual manner. Cement adhered to the gold surface with a block of cement always left in the screw access channel. This is almost certainly a consequence of part of the channel forming an undercut relative to the axial surfaces of the abutment, and is a potential source of retention that does not appear to have received attention to date. It may explain why the PF group had a higher removal force than the FF, as force was needed to cause a cohesive fracture within the TempBond. It is likely that a similar effect could be expected with other cements, including permanent luting agents, but further work is required to confirm this.

Wall removal also affected retention of a casting cemented with TempBond. Removal of 3 mm (one-third) of the screw access channel wall significantly increased retention. On examination of the abutment, removal of this portion of the wall actually was able to increase the parallelism of the abutment and thus, the retention form. Removal of 6 mm (two-thirds) of the screw access channel wall did not make a significant difference to the retention of the cemented abutment. It can be postulated here that the loss of surface area was directly offset by the increase in parallelism offered by the adjusted portion. Total removal of the screw access channel wall significantly decreased retention. Here it can be proposed that despite the increase in parallelism offered by the adjustment, this was too little to compensate for the loss of surface area.

This study has shown that minor modifications to an abutment can have an influence on retention. The shape and design of implant abutments has been very much influenced by those of natural tooth preparation. There are simple changes that can be made to implant abutments that can be used to increase the retention that cannot/would not be done to teeth. This is clearly an area where further research is needed.

Conclusions

Within the limitations of this study, we can draw the following conclusions:

1. Increasing the platform diameter of implant abutments leads to an increase in retention of the casting cemented to it.
2. The method employed to fill the screw access channel of implant abutments can have an effect on the retention of coronal restorations cemented with TempBond.
3. Fully filling the screw access channel with an elastomeric impression material reduced

the removal force of a coronal restoration cemented with TempBond.
4. Partially filling the screw access channel with elastomeric material increased the removal force of a coronal restoration cemented with TempBond.
5. Wall removal can have a significantly detrimental effect on retention form of an abutment.
6. Selective wall removal can be an adjunct to retentive form of an implant abutment.

References

1. Adell R, Eriksson B, Lekholm U: Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347-359
2. Hebel KS, Gajjar RC: Cement-retained versus screw-retained implant restorations: achieving optimal occlusion and esthetics in implant dentistry. J Prosthet Dent 1997;77:28-35
3. Jorgensen KD: The relationship between retention and convergence angle in cemented veneer crowns. Acta Odontol Scand 1955;13:35-40
4. Kaufman EG, Coelho DH, Colin L: Factors influencing the retention of cemented gold castings. J Prosthet Dent 1961;11:487-502
5. Gilboe DB, Teteruck WR: Fundamentals of extracoronal tooth preparation. Part 1. Retention and resistance form. J Prosthet Dent 1974;32:651-656
6. Guyer SE: Multiple preparations for fixed prosthodontics. J Prosthet Dent 1970;23:529-553
7. Bernal G, Okamura M, Munoz CA: The effects of abutment taper, length and cement type on resistance to dislodgement of cement-retained, implant supported restorations. J Prosthodont 2003;12:111-115
8. Covey DA, Kent DK, St Germain HA Jr, et al: Effects of abutment size and luting cement type on the uniaxial retention force of implant-supported crowns. J Prosthet Dent 2000;83:344-348
9. Ramp MH, Dixon DL, Ramp LC, et al: Tensile bond strengths of provisional luting agents used with an implant system. J Prosthet Dent 1999;81:510-514
10. Clayton GH, Driscoll CF, Hondrum SO: The effect of luting agents on the retention and marginal adaptation of the CeraOne implant system. Int J Oral Maxillofac Implants 1997;12:660-665
11. Breeding LC, Dixon DL, Bogacki MT, et al: Use of luting agents with an implant system: part 1. J Prosthet Dent 1992;68:737-741