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The Effect of Engaging the Screw Access Channel of an Implant Abutment with a Cement-Retained Restoration

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Abstract

Purpose: Factors affecting the retention of fixed prostheses to natural abutments are well understood. In contrast, little is known concerning the factors influencing the retention of fixed prostheses cemented to implant abutments. The purpose of this study was to investigate the effect that extending a casting into the screw access channel of an implant abutment has on the retention when cemented using Temp Bond.
Materials and Methods: Replace Select Straight abutments received set modifications (buccal wall removal at 15°, 22°, and 30°) using a milling machine; controls were unmodified. Two castings were fabricated for each of the modified abutments, one with and one without an extension into the screw access channel. Following cementation with Temp Bond under standardized conditions, the castings were removed from the abutments using an Instron machine, and the peak removal force was recorded.
Results: Extending the casting into the screw access channel significantly ($p < 0.001$) increased the peak load of removal. Significant differences ($p < 0.05$) were found between no modification and 30° modification, 15° and 30° modification, and 22° and 30° modification in the groups when the casting extended into the abutment. In the group where the casting did not extend into the abutment, all groups were significantly different ($p < 0.001$) with the exception of 22° and 30° modification.
Conclusions: The increased load required to remove a casting that extends into the screw access channel of an implant abutment may compensate for loss in retention, which occurs through unfavorable modification of the abutment.

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] Recent studies have established that the retention of castings cemented to implant abutments with Temp Bond is influenced by the wall height,[7] platform size,[7] and the filling modality of the screw access channel.[7,8] Extension of the casting into the screw access channel as a method to improve retention has been suggested;[9] however, this has to be investigated.

The purpose of this study was to investigate the effect that extending a casting into the screw access channel of an implant abutment has on the retention when cemented using Temp Bond. The null hypothesis was that engagement of a casting into the screw access channel of an implant abutment with varying modifications will have no significant influence on the retention of castings cemented to standard implant abutments.

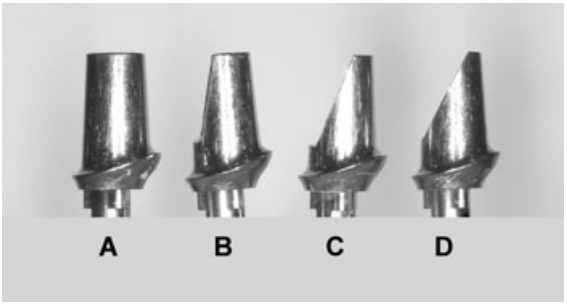

Figure 1 Abutments; unmodified control (A) modified to 15º (B), 22° (C) and 30º (D).

Materials and methods

Replace Select Straight Abutments (Brånemark System®, Nobel Biocare AB, Gothenburg, 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 abutments were attached to their implant replicas and identically vertically mounted in acrylic resin (RR self-cure clear acrylic resin, Dentsply DeTrey GmbH, Dreireich, Germany) to permit a tensile force to be applied to 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.

The abutment assemblies were then mounted in a milling machine (Metalor MP300, Metalor Technologies Ltd., Birmingham, UK) and the buccal wall of three of them modified by 15°, 22°, and 30º (Fig 1). In all cases, 2 mm of buccal wall height was retained. The fourth abutment was left unmodified as a control.

Two sets of castings were constructed for each abutment. In the first set of castings the access holes of the abutments were carefully blocked out, and a putty matrix (Coltene Lab Putty, Coltene AG, Altstätten, Switzerland) of the abutment shape 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, Geshaftsbereich Dental, Frankfurt, Germany) with an attachment were constructed (Fig 2). In the second group, the screw head was protected with PolyTetraFluoroEthylene (PTFE) tape up to the top of the remaining buccal wall (2 mm in height). Two layers of die spacer (Belle de St Claire) were painted to within 2 mm of the margin, and internally, four layers of die spacer were painted onto the walls of the screw access channel. Following application of wax separator (Isolit, Degussa Dental GmbH & Co, Hanau, Germany), molten wax was introduced into the screw access channel, and the casting constructed as above (Fig 3). The exterior of all the castings was polished, while the interiors were left untouched.

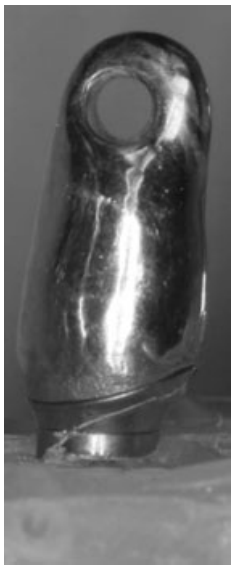

Figure 2 Example of gold coping constructed on an implant abutment.

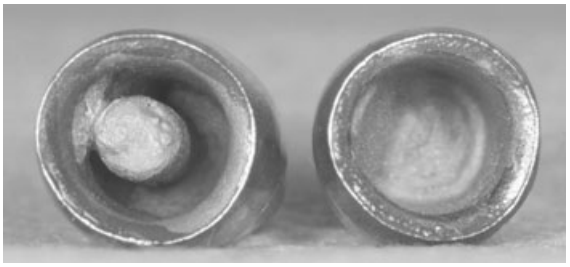

Figure 3 Abutment with and without an extension into the screw access channel.

During the experiment, the screw access channels of each of the abutment combinations were protected with PTFE (as above).

Weighed amounts of Temp Bond (Kerr Italia S.p.A, Salerno, Italy) were used for the cementation of the castings on the implant abutments and mixed for 30 seconds in proportions according to the manufacturer's 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.

A universal load-testing machine (Instron, Canton, 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.[10-12] The force required for complete separation of the castings from the abutments was recorded. The procedure was completed fifteen times for each filling modality. Abutments were completely cleansed of all residual lute by soaking in temporary cement remover (Premier Dental Products Co., Philadelphia, 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. Each abutment/casting combination was allocated a number, and randomization was achieved in the experiment by use of a computer-generated random number table.

Two-way analysis of variance (ANOVA) was used to test for any global differences ($\alpha = 0.05$). A conservative post hoc test

Table 1 Results of two-way ANOVA

Source	Type III sum of squares	df	Mean square	F	Significance
Corrected model	53,054	7	7579	38.4	<0.001
Intercept	993,847	1	993,847	5036	<0.001
Access hole engagement	22,541	1	22,541	114	<0.001
Abutment taper	25,035	3	8,345	42.3	<0.001
Access hole engagement and abutment taper interaction	5,487	3	1825	9.3	<0.001
Error	22,101	112	197		
Total	1,069,002	120			
Corrected total	75,155	119			

*R squared, 0.706 (Adjusted R squared = 0.688).

correction was applied (Bonferroni multiple test comparison) to see what difference lay between the means of subgroups.

Results

Results of the two-way ANOVA are summarized in Table 1 and reveal statistically significant differences ($p < 0.001$) as a function of the access hole engagement, abutment taper, and the interaction between the access hole engagement and abutment taper.

Estimated marginal means for access hole engagement and abutment taper are shown in Table 2.

Multiple comparisons using the Bonferroni adjustment are shown in Table 3 and reveal significant differences ($p < 0.05$) between: no modification and 30° modification, 15° and 30° modification, and 22° and 30° modification in the groups when the casting extended into the abutment. In the group where the casting did not extend into the abutment, all groups were significantly different ($p < 0.001$) with the exception of 22° and 30° modification.

Table 2 Estimated marginal means with 95% confidence intervals for engagement of the access channel and modification of the abutment

Extension and modification	Mean (N)	95% Confidence interval	
		Lower bound	Upper bound
Extension of casting into abutment			
Unadjusted	108.6	101.5	115.8
15° Modification	120	112.9	127.3
22° Modification	104.4	97.2	111.6
30° Modification	85.8	78.6	93
Non-extension of casting into abutment			
Unadjusted	101.1	93.9	108.3
15° Modification	90.5	83.3	97.6
22° Modification	58.8	51.6	66
30° Modification	58.8	51.6	66.1

Table 3 Multiple comparisons (Bonferroni) between the abutment modifications in each of the two groups

Level of abutment reduction		Mean difference	Standard error	Significance
Extension of casting into Abutment				
No modification	15° Modification	−11.4	5.92	0.351
	22° Modification	4.28	5.92	1.000
	30° Modification	22.9	5.92	<0.001
15° Modification	22° Modification	12.7	5.92	0.162
	30° Modification	34.3	5.92	<0.001
22º Modification	30° Modification	18.6	5.92	0.016
Nonextension of casting into abutment				
No modification	15° Modification	10.7	4.20	<0.001
	22° Modification	42.3	4.20	<0.001
	30° Modification	42.3	4.20	<0.001
15° Modification	22° Modification	31.7	4.20	<0.001
	30° Modification	31.7	4.20	<0.001
22° Modification	30° Modification	−0.03	4.20	1.000

Figure 4 summarizes the mean results obtained for removal load for each of the modified abutments in the extended and nonextended casting groups.

Discussion

The null hypothesis of this study stating that engagement of a casting into the screw access channel of an implant abutment with varying modifications will have no significant influence on the retention of castings cemented to standard implant abutments was rejected. Both engaging the screw access channel of the abutment with the casting and varying the abutment taper 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.

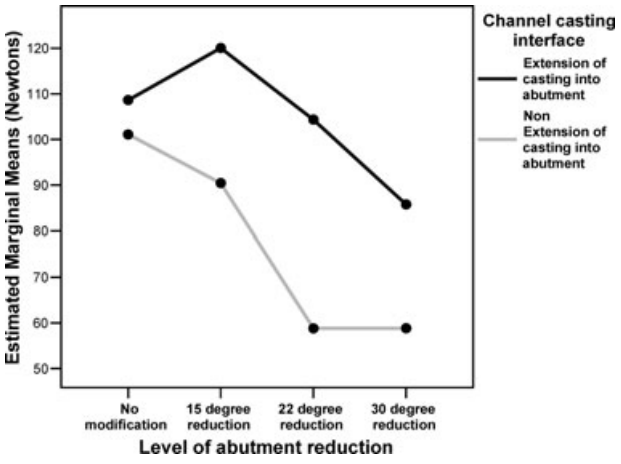

Figure 4 Estimated marginal means of removal load for each of the modified abutments in the extended and nonextended casting groups.

In all cases, the comparative retentive forces to remove the cemented abutment when the casting extended into the screw access channel were greater than those where the casting did not engage the abutment. Clinically this means that if a single-tooth abutment has compromised retention, then engagement of the casting into the screw access channel will significantly increase the force required for its removal.

Within the group with the casting that did not engage the abutment, the larger the modification to the taper on the buccal wall of the abutment, the lower the force required to remove the abutment. This is in line with other published studies in this area.[7]

The only area where this did not hold true in the group that did not engage the abutment was between the 22° and 30° modification. It can be postulated here that so much retention had been lost by the time the 22° modification had been made, that any further modification would not exhibit a significant effect.

The results were very different within the group of castings that engaged the abutment. The engagement of the casting into the screw access channel was sufficient to counteract up to 22° modification in taper to the buccal wall. Clinically this means that if modification is required to an abutment tapering up to 22°, any loss in retention caused by this can be offset by engaging the screw access channel with the casting; however, this method does have its limitations, as the force required for removal was significantly lower between the unmodified and 30° group.

This study has shown that minor modifications to the taper of an abutment can have an influence on retention. Engagement of the casting into the screw access channel of the abutment can significantly improve retention and is a technique that can be recommended clinically in single-unit cases where, due to clinical circumstances, the retention has been compromised. The shape and design of implant abutments has been very much influenced by those of natural tooth preparation. This study has shown that there are simple changes that can be made to the castings on cement-retained implant abutments with screw access channels that can be used to increase the retention that cannot/would not be possible to use with natural teeth.

Conclusions

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

(1) Increasing taper on an implant abutment directly affects and causes decreased retention of a cemented cast restoration.
(2) Engagement of a casting cemented with Temp Bond into the screw access channel of an implant abutment significantly increases retention.
(3) Engagement of a casting cemented with Temp Bond into the screw access channel of an implant abutment is able to offset the loss of retention of the cemented casting with up to 22° of taper.

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