

Effect of Metal Extension of Crown in the Screw Access Channel of a Posterior Implant Abutment on the Retention of Cement Retained Prosthesis

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Purpose: Reducing the height of the implant abutment due to limited interarch space decreases the surface area for retention of cemented restorations. The purpose of this in vitro study was to see whether engaging the screw access channel with metal extension compensates for the loss of retention of posterior crowns cemented on shorter abutments. **Material and Methods:** Four identical prefabricated abutments were mounted on implant replicas embedded in acrylic resin blocks. Three of these abutments were reduced in height by 1 mm, 2 mm, and 3 mm respectively and one was left unmodified. Two sets of base metal crowns were fabricated for each abutment, one without and one with the metal extension inside the screw access channel. The crowns were cemented using Tempbond NE. The tensile forces required to separate the cemented crowns from abutments were measured using an Instron testing machine. Statistical analysis of the data was performed using a 2-way analysis of variance and Fisher's protected least significant difference at 0.05 level of significance. **Results:** An increase of 24% to 261% in retentive forces was observed for the group having metal extension in the screw access channel. Statistically significant differences ($P < .001$) were found among 2 types of crowns and four heights of abutments. Generally, the retentive forces were reduced in magnitude as the abutment height was reduced. **Conclusion:** The retention of a casting cemented to posterior implant abutments is influenced by the height of the abutment and the metal extension engaging the screw access channel. The crowns made with a metal extension showed superior retention values.

Key Words: dental implant abutment, extension of casting, retention, cement retained restoration

INTRODUCTION

Predictable retrievability of screw retained prostheses without any damage to supporting fixtures in both edentulous and partially edentulous situations has been well recognized. However, with an increase in the treatment of partially edentulous patients, especially for single unit restorations, the factor of retrievability has become somewhat less significant. More emphasis is now being placed on better esthetics, passive fit, and optimum occlusal relation of restoration, which may actually improve loading characteristics.¹

As cement-retained implant restorations employ conventional clinical procedures and concepts, achieving sufficient

retention for crowns cemented on shorter abutments can be challenging. Earlier studies by Chu et al² and Emms et al³ have shown that the filling modality of the screw access channel have an influence on the retention of cemented prostheses. Morgano and Haddad⁴ suggested engaging the screw access channel of abutment with casting as a method to improve retention, and Naik et al⁵ investigated this suggestion on the anterior implant abutments. They reported that the act of engaging the screw access channel with metal extension was able to offset the loss of retention of the cemented casting with up to 22° of buccal wall removal.^{2,6} A recent study by Tan et al⁶ also concluded that the retention of cemented crowns on implant abutments is influenced by the number and position of axial walls. However, no published study has addressed the effect of engaging the screw access channel on the retention of posterior cemented implant restoration where both buccal and lingual walls of abutment are shortened equally.

The purpose of this study was to investigate the effect of extending the metal casting into the screw access channel of posterior implant abutments of different heights on the

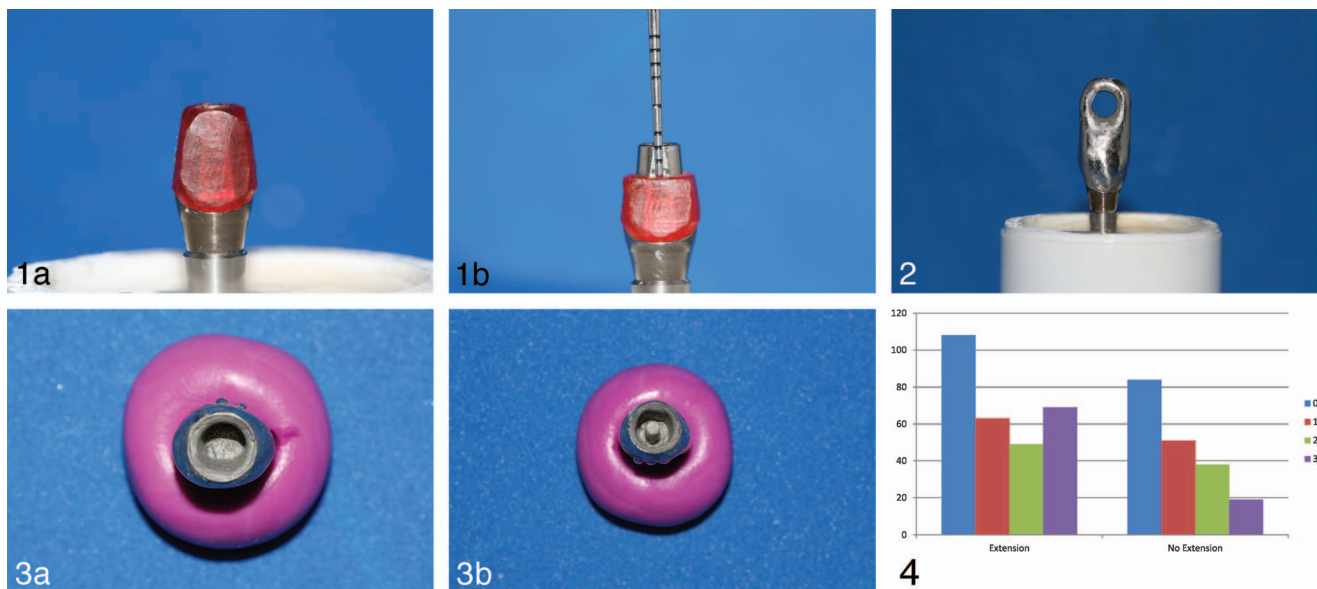
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FIGURES 1–4. **FIGURE 1.** Resin pattern used as a guide to reduce the height of the implant abutments. **FIGURE 2.** Cast test crown with the loop for applying the tensile displacing force. **FIGURE 3.** Fitting surface of the cast test crowns with and without metal extension. **FIGURE 4.** Effect of extension and abutment height reduction on retention (N).

retention of cemented crowns. The null hypothesis tested was that engagement of a casting into the screw access channel of a posterior implant abutment has no significant influence on the retention of castings cemented with provisional cement.

MATERIAL AND METHODS

Four identical prefabricated TiDesign 4.5/5.0 abutments with their implant replicas (Astra Tech Mölndal, Sweden) were used for this study. Implant replicas were embedded in acrylic resin (Ortho resin, Dentsply, York, PA) vertically with the help of Ney surveyor to allow for the application of tensile force along the long axis of the implant. The samples thus simulated the implant buried in the bone with the most cervical portion exposed for the attachment of abutment. Prefabricated abutments were hand-tightened initially to their mounted implant replicas and then torqued to the manufacturer’s recommendation of 25 Ncm.

As supplied, the TiDesign abutment is 6 mm in height from the buccal margin and 5 mm on the lingual, mesial, and distal aspects. One of the 4 abutments was left as unmodified (control). The heights of the remaining 3 abutments were reduced by either 1 mm, 2 mm, or 3 mm respectively with milling burs in a high-speed lathe. Resin patterns (GC America Inc, Alsip, Ill) were fabricated to the respective heights served as template to modify the abutments (Figure 1).

Two sets of test crowns were fabricated in nonprecious metal alloy (Wirobond C, BEGO USA Inc, Lincoln, RI) for each height of the abutment, 1 crown having a metal extension extending to the end of the screw access channel and the other with no extension. To fabricate the wax pattern for a crown without extension, the screw access channel was blocked to the top of the abutment with a light body PVS material. Two layers of die spacer were applied to the entire axial walls of the

abutment and a pattern resin coping was fabricated. Inlay wax was then added to this coping to complete the waxing for the test crown. A small loop was waxed on the top center of the wax up, so that the chain for a tensile test could engage it vertically. Figure 2 shows the finished crown with the metal loop. To fabricate the wax pattern for a crown with metal extension, a pattern resin coping was fabricated and left open at the top for access to the screw access channel. A smooth burnout post 1 mm in diameter was then dropped in the center of the screw access channel (no contact with the side walls) with the aid of Ney surveyor and attached to the coping by adding pattern resin. Wax patterns were invested in phosphate-bonded investment, burned out, and cast using routine laboratory protocol. Intaglio surface of the specimens was adjusted to ensure its complete seating on the abutment and the exterior of the castings was polished. Figure 3 shows the intaglio surface of test crowns with and without metal extension.

Auto mix Tempbond NE (Kerr-Corp, Orange, Calif) cement was placed inside the casting and the test crown was positioned onto the abutment initially with finger pressure and then placed under 5 kg of static load for 5 minutes. Excess cement was removed with Teflon scalars and the specimens were stored in 100% humidity at 37° C for 24 hours prior to testing.

The tensile force required to debond each specimen was recorded in Newton (N) by using an Intron Universal testing machine Model 8501 (Intron Corp, Canton, Mass) at a crosshead speed of 0.5 mm/min. The procedure was repeated 10 times for each casting. After each test, the castings and abutments were completely cleaned of residual cement by soaking in temporary cement remover (Henry Schein Inc, Melville, NY) for 30 minutes in an ultrasonic bath and subsequent steam cleaning. The specimens were examined under magnification to ensure complete removal of cement. No mechanical removal of cement was used to ensure casting surface integrity.

Reduction in Abutment Height		Mean	Standard Deviation	Standard Error
Extension	0 mm	108.562	13.423	4.245
	1 mm	63.526	5.167	1.634
	2 mm	49.481	10.858	3.434
	3 mm	69.106	5.760	1.822
No extension	0 mm	84.094	11.206	3.544
	1 mm	51.191	10.165	3.214
	2 mm	38.082	8.412	2.660
	3 mm	19.191	5.645	1.785

Means and standard deviation of the bond strengths were calculated and analysis of the data was performed using a 2-way analysis of variance (ANOVA). Comparison of the means was performed by using Fisher's protected least significant difference (PLSD) intervals calculated at the 0.05 significance level.

RESULTS

The means and standard deviations of retentive forces measured for all groups are listed in Table 1. Statistically significant differences were observed among 2 types of crowns ($P < .0001$) and 4 heights of abutments ($P < .0001$). Fisher's PLSD intervals (Table 2) for comparisons of means at the 0.05 significance level between 2 types of crowns and among 4 abutment heights were also significant (differences between 2 means greater than the appropriate Fisher's PLSD intervals are considered statistically significant). Generally greater retentive forces were observed for the group having metal extension engage the screw access channels (Figure 4). The data also show that as the height of the abutment decreased for both groups, retention value decreased as well, except for a metal-extension crown cemented on smallest abutment. The retentive force measured for this crown was greater than that measured for similar crowns cemented on longer abutments.

Effect of reducing abutment height (within extension and no extension groups)

Table 3 presents the differences in retentive forces recorded for each reduction of abutment height within the metal or no metal extension groups. The largest reduction of retentive

forces (64.9 N) was observed for no metal extension group (0 vs 3) and the lowest difference (−5.6) was seen in the metal extension group (1 vs 3). This is the only group where Fisher's PLSD was not statistically significant. A significant observation made in the metal extension group was that an increase of retentive force was observed upon reducing the abutment height by 3 mm.

Effects of extension (yes) versus no extension (no) for each reduction

Generally, having a metal extension engage the screw access channel of implant abutment resulted in an increase of retention of the crowns (Table 4). The largest relative increase of 50 N (261%) was observed for the crowns made for smallest abutment heights tested (Yes 3 vs No 3) and the lowest difference of 12.4 N (24%) was recorded for abutment reduced in height by 1 mm.

DISCUSSION

The results of this study rejected the null hypothesis as generally greater retentive forces were observed for the group having metal extension in the screw access channel, and the retentive forces were reduced in magnitude for both groups as the abutment height was reduced.

Effect of height

The observation in this study that reducing the height of abutment causes reduction in retentive force for cemented crowns is in agreement with Bernal et al⁷ who reported that an

	Mean Difference	Critical Difference	P-Value	
A. Effect: Metal extension vs no extension				
	24.529	4.138	<.0001	
B. Effect: Reduction of abutment height (0: unmodified abutment, 1, 2, 3: shortened abutments by 1 mm, 2 mm, 3 mm, respectively)				
0, 1	38.969	5.852	<.0001	S
0, 2	52.547	5.852	<.0001	S
0, 3	52.180	5.852	<.0001	S
1, 2	13.577	5.852	<.0001	S
1, 3	12.210	5.852	<.0001	S
2, 3	−0.367	5.852	.9008	

TABLE 3

The effect of reducing the abutment height on retention (N)

Crowns with Metal Extension*		Crowns without Metal Extension*	
0 vs 1	108.5 – 63.5 = 45	0 vs 1	84.0 – 51.1 = 32.9
0 vs 2	108.5 – 49.4 = 59.1	0 vs 2	84.0 – 38.0 = 46.0
0 vs 3	108.5 – 69.1 = 39.4	0 vs 3	84.0 – 19.1 = 64.9
1 vs 2	63.5 – 49.4 = 14.1	1 vs 2	51.1 – 38.0 = 13.1
1 vs 3	63.5 – 69.1 = -5.6	1 vs 3	51.1 – 19.1 = 32.0
2 vs 3	49.4 – 69.1 = -19.7	2 vs 3	38.0 – 19.1 = 18.9

*0 indicates unmodified abutment; 1, 2, 3, height reduced by 1 mm, 2 mm, and 3 mm respectively.

8-mm axial wall height of an implant abutment provides significantly higher removal forces than a 4-mm axial wall height. This observation is also in agreement with the general principles of fixed prosthodontics as investigated by Kaufmann and Coelho.⁸ In the present study, the largest reduction of retentive force was noticed for the implant abutment, which is reduced by 3 mm in height compared to an unmodified abutment in no-extension group. Clinically, this means that reducing the abutment in height because of reduced interarch space will require incorporation of some additional retentive feature to ensure sufficient retention of cemented crowns. Engaging the access channel with metal extension for this crown provided additional 50 N of resistance against displacement.

Effect of extension

Generally, greater dislodging forces were required to displace the cemented casting with extension than castings without extension. This is in agreement with the Naik et al study,⁵ where they reported that engagement of a casting into the screw access channel was able to offset the loss of retention with up to 22° of buccal wall removal for the anterior implant abutment. The largest comparative increase of 261% reported in present study (50N) was observed for the crowns made for the smallest abutment height (Table 4; Yes 3 vs No 3) tested. The retentive forces offered by smallest abutment with extension (69.1 N) was comparable to the retention offered by tallest abutment without extension (84 N). This suggests that in a clinical situation requiring reduction in abutment height, the engagement of the metal casting into the screw access channel could substantially compensate for the expected loss of retention.

Metal extension crown cemented on the shortest abutment (abutment reduced by 3 mm) showed relatively higher retention values than the metal extension crown cemented on the abutment, which were reduced by 1 mm and 2 mm. This unexpected result may be due to the fact that the shorter crown having short extension was relatively easy to cement with less trapped air and reduced hydraulic pressure during the cementation procedure. This observation suggests that for tall abutments, extending a metal extension only a few millimeters inside the access channel instead of the entire length of the abutment may provide increased retention because of improved cement flow inside the access channel. A crown with short extension will be relatively easy to retrieve as well. This was not evaluated in this study. The effect of metal extension on resistance against laterally directed forces is another aspect that needs to be evaluated.

Observations regarding the type of failures (no magnification)

For the “No Ext” group, the tensile bond failure was primarily adhesive (>98%). The cement was mostly found adhering on the intaglio surface of the casting with little cement left on the abutment surface. This suggests that Tempbond NE adhered to rougher casting surface more strongly than to the polished titanium abutment. Roughening the abutment surface prior to cementation should increase the retention of these crowns further; however, this was not studied in this experiment. It was also noted that the bond failure was abrupt or instantaneous for the no extension group with a sudden drop in retention and separation of the casting from the abutment. This observation agreed with the Emms et al study,³ which reported that the cement breakage occurred in an instant on analysis of the force displacement graphs for the fully-filled screw access channel.

The bond failure for the extension group (>98%) mostly was a cohesive failure within the cement itself as the cement was observed adhering to the intaglio surface of the casting as well as in the screw access channel of an implant abutment. After the initial bond failure had occurred, the separation of the casting and implant abutment was more gradual for this group. This could be due to the extension itself and the remaining cement inside the screw access channel providing some binding/frictional resistance during the pull test, especially for the longer abutments.

CONCLUSIONS

Within the limitation of this study, the following conclusions can be drawn:

1. Extending a casting inside the screw-access channel of posterior implant abutment significantly increased retention of cemented crowns, especially for the shortest abutment. The maximum relative increase in retention recorded due to

TABLE 4

The effect of engaging the access channel with metal extension

(Yes: extension; No: without extension)		
Yes 0 vs no 0	108.5 – 84.0 = 24.5N	29%
Yes 1 vs no 1	63.5 – 51.1 = 12.4 N	24%
Yes 2 vs no 2	49.4 – 38.0 = 11.4 N	30%
Yes 3 vs no 3	69.1 – 19.1 = 50.0 N	261%

metal extension was 50N (261%) and the minimum increase was 24%.

2. The retention offered by a casting cemented to implant abutments with Tempbond NE was reduced as the height of the abutment was reduced; however, this loss of retention was greatly compensated by engaging the access channel with metal extension of the casting.

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