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Effects of Different Surface Treatments on Retention of Implant Supported Cement Retained Bridge with Short Abutment- An In Vitro Study

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ABSTRACT

Aim: To evaluate the effect of surface treatments of implant abutment and metal framework on the retention of implant-supported cement-retained bridge with short abutments.

Methodology: Straight implant abutments of sizes (4.3 mm × 4 mm) and analogues were selected and mounted on the acrylic block. Four such assemblies were made. 40 number of 3-unit metal framework were casted and divided into four groups. Group 1- (control group) No modification. Group 2- The abutments were subjected to surface modifications by bur, cementing surface of the framework was sandblasted. Group 3- The abutments were subjected to surface modifications by bur and framework was sandblasted and also subjected to alloy primer (M.L. Primer Shofu Inc.) Group 4- Both the abutment and framework are subjected to sandblasting and alloy primer. The framework was cemented with a Resin cement (Panavia F). Retention tests were conducted with a universal testing machine (5 mm/min), and tensile bond strengths were recorded.

Statistics: Data were subjected to one-way analysis of variance, Post Hoc Tukey's significant difference test, ($\alpha = 0.05$).

Results: The mean retentive force for Group 1 was 200.70 +- 22.930 N, for Group 2 was 460.70 +- 96.40 N, for Group 3 was 749.80 +- 134.474 N and for Group 4 was 658.00 +- 20.025 N. Group 3 showed highest mean peak force required for dislodging the metal framework from the abutments after cementation than all the other groups at 749.80 N.

Conclusion: Modification of the implant abutment by bur and sandblasting while modification of 3-unit metal framework by sandblasting and alloy primer showed the highest retention and demonstrated the significant difference in the tensile bond strength than all other groups.

Key words: abutment; alloy primer; implant supported fixed restoration; retention; sandblasting

1. INTRODUCTION

Dental implants have shown high capability to restore esthetic, proper function of lost teeth and long durability and success. [(1)] Fixed implant-supported restorations have become the standard treatment for partially or totally edentulous patients, improving their mastication and appearance. Implant supported bridge may be screw- or cement- retained to the implant. [(2)]

Success of cement-retained prosthesis depends largely on the adequate retention and resistance of the overlying prosthesis. [(3)] There are many factors that can influence the retention when luting a restoration to an implant abutment [(4)] such as the geometry of the abutment preparation, surface area, abutment height, surface roughness, and cementing medium. [5]

Out of the few factors, surface modification of abutments and crown is most important factor to increase the retentive strength of cemented casting. [6] Different implant abutment surface modifications namely, air borne particle abrasion, [7] bur modifications, [8] addition of retentive grooves [9] and using alloy primers and modification of cementing surface of framework by sandblasting, tin plating, silicoating, and metal primer have been advocated to enhance the retention of cement retained implant supported prosthesis.

Various studies in the past have analyzed the methods to increase retention by treating the abutment surfaces. Most of these studies have been done on single implant abutment. However there are very few studies reported in the literature studying the effect of shortened abutments on the retention of Implant supported cement retained bridge. Thus the need for the study was felt. The study aims to evaluate the effect of different surface treatments of the abutment and framework on the retention of Implant supported cement- retained bridge (ISCRB) under tensile load. The null hypothesis was that there would be no significant difference on the retention of cemented ISCRB on abutments with reduced height after different types of surface modifications.

2. MATERIALS AND METHODS

2.1 Specimen preparation

A total of eight straight narrow diameter implant abutments (Noble Biocare), 4.3mm in diameter and 4 mm in height and eight Nobel Biocare analogues were selected.

Two analogues were aligned (2mm above the margins) vertically in the center of a plastic ring using dental surveyor with a distance of 10 mm between the two implant-analogues (measured from the center of screw channel). Auto polymerizing resin (RR cold cure DPI, India) was poured and the assembly was maintained until the acrylic resin set. Two abutments one on each analogue were then screwed on to the implant analogues with titanium abutment screws and torqued to 25Ncm as per the manufacturer’s instructions. The effects of the setting of the screws that reduces the preload was limited by was done by retightening of the components 10 minutes after the initial torque to their respective torque values. The mounting resulted in the implant replica simulating the implant in bone, with the head of the implant exposed for restoration. Four such assemblies were made.

A wax pattern of the three unit implant supported bridge comprising of 2 copings on the abutments with an intervening pontic was fabricated using blue inlay wax (Bego Wilhelm – Herst Gmbh & co, Germany). The thickness of the copings were maintained at 0.5mm. A 5 mm diameter ring was waxed on the center of the occlusal surface of each pattern to facilitate the connection of the crown to the universal testing machine. The pattern was casted using Non-Precious dental alloy Cobalt- Chromium (NDN, Germany) according to standard casting technique.

The internal surface of each casting was visually inspected and the fit of each metal framework was examined utilizing Fit- Checker media. The stability of each framework was assessed by applying finger pressure vertically to the crown while seating on the abutment. The margin of each coping was checked at x4 magnification. On inspection, the samples that were not satisfactory were excluded. Finally, 40 such frameworks were selected.

Samples were randomly grouped into 4 groups of 10 samples each. Surface modification of each group is enlisted in table 1.

Sandblasting was done using 50 microns aluminium oxide at 50 psi at a 10 mm distance. The surface treatment by bur modification of implant abutment was carried out by roughening the abutment arbitrarily by a 0.5mm diameter diamond bur and additionally creating 5 dimples on each axial wall of the abutment. The surface treatment using alloy primer (Shofu M.L Primer, Inc) of implant abutment and framework was done by applying the primer on the surface of abutment and framework by brush.

2.2 Various surface treatments

Table 1: Different Surface treatments of Samples

Group	Surface treatment of Abutment	Surface treatment of 3-unit metal framework
1. n (10) (control)	No Treatment	No Treatment
2. n (10)	Bur	Sandblasting
3. n (10)	Bur + Sandblasting	Sandblasting+ Alloy Primer
4. n (10)	Sandblasting + Alloy Primer	Sandblasting + Alloy Primer

The specimens were then cemented with resin cement (Panavia F) under a 4.5 kg load for 1 minute followed by 0.9 kg load for 2 minutes and then allowed to bench set for reaching its final set and the excess cement was removed.

2.3 Retentive testing

The size of the acrylic blocks was reduced according to the dimensions of the clamp for holding the specimens on the Universal Testing Machine (AS- IS Shimazu, Japan). The specimens were attached to universal testing machine by clamping them directly onto the loop attachment for retention testing. Vertical tensile force at a crosshead speed of 5 mm per minute was applied until the dislodgement of the framework from the abutment took place. The peak load required to dislodge the crown was recorded.

The data was collected and analyzed statistically using one way analysis of variance (ANOVA) and post hoc Tukey's significant difference test for further comparison using premier (version 6) statistical software.

3. RESULTS

The mean and standard deviation of the tensile bond strength of all the groups with different surface treatments are listed in Table 2.

For all the surface treatments, One-way ANOVA test showed that there was a significant difference in the mean values of tensile bond strength between all the groups. Group 3 showed the highest mean value of Tensile Bond Strength of 749.80 N.

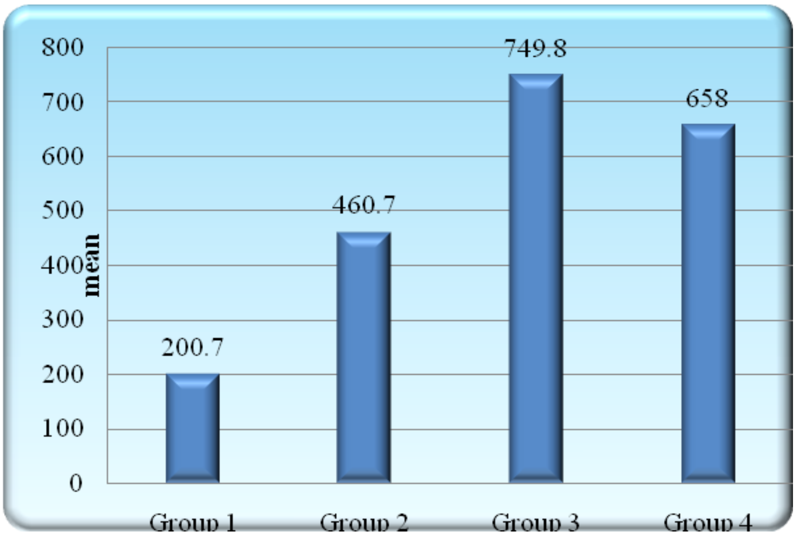
Post Hoc Tukey test showed that there was a significant difference between the group with no treatment and all other groups with the surface treatments with bur and groove, sandblasting and alloy primer. Though, Group 3 with bur and groove and sandblasting on implant abutment and Group 4 with sandblasting and alloy primer with same treatment of framework with sandblasting and alloy primer showed no significant difference in Tensile Bond Strength.(Table 3)

Table 2: One-Way ANOVA for Tensile Strength (N)

	N	Mean	Std. Deviation	Minimum	Maximum	*p* value
1	10	200.70	22.930	160	231	0.001 (S)
2	10	460.70	96.407	334	629	
3	10	749.80	134.474	610	1046	
4	10	658.00	20.467	621	685	
Total	40	517.30	228.025	160	1046	

Table 3: Intra Groups Comparison (Post Hoc Tukey Test)

Groups	Groups	Mean Difference	*p* value	95% Confidence Interval	
				Lower Bound	Upper Bound
1	2	-260.000*	.000	-361.35	-158.65
	3	-549.100*	.000	-650.45	-447.75
	4	-457.300*	.000	-558.65	-355.95
2	3	-289.100*	.000	-390.45	-187.75
	4	-197.300*	.000	-298.65	-95.95
3	4	91.800	.088	-9.55	193.15



Mean Tensile Strength in Newton for Test Groups

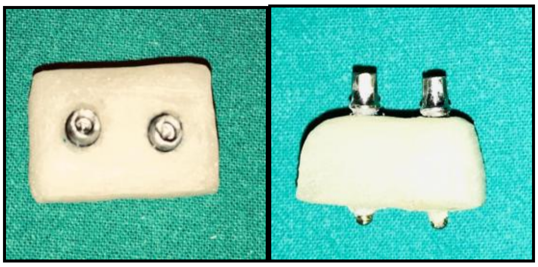


Figure : Mounted Implant Abutments with Embedded Implant Analogues

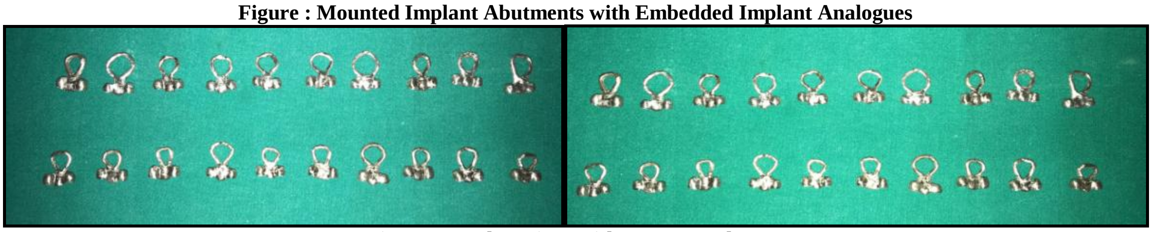


Figure: Metal Copings with Loop Attachment

Figure: Specimen Clamped in The Universal Testing Machine

Figure: Inner Surface of the Bridge After Testing

4. DISCUSSION

The success of cement-retained prosthesis is largely dependent on the retention and resistance forms. Factors such as size, surface area, surface roughness of abutment and the texture of the internal surface of the crown have shown to affect the retention of implant-supported crowns. (10)

Certain challenging clinical situations may require placement of short abutments. In such situations additional steps may be required to enhance the retention of prosthesis. As abutment height of 4-5mm is a primary requirement for retention in implant retained restorations, in the current study, 4mm height abutments were used. (5) It has been stated that various types of intraoral forces may cause high stresses between the abutment and cement layer, which causes dislodgement of final prosthesis. (11) Thus additional retention form if required for implant supported prosthesis with short abutments.

Various forms of surface treatments of abutments as well as the prosthesis have been shown to enhance the retention. There are various treatments such as sandblasting, bur modification, oxidation, CO_2 laser, metal primer application, tin plating, silicoating etc. have been shown to increase the retention.

Irregularities created by sandblasting on the metal surfaces results in increasing the surface area and mechanically remove debris. As a result, alumina particles get coated on the metal surface due to velocity and pressure with which they strike the surface that cannot be separated even by ultrasonic cleaning or acid etching. Thus, resulting in the chemical bonds of the alloy primer and silane agents to the sandblasted surface that increases the bond strength of resin cements. In our study sandblasting was done using 50-micrometer aluminium oxide at 50 psi at a 10 mm distance. [(5)] A study by Denizoğlu et al concluded that all the groups in the study, sandblasted surfaces showed the highest bond strength values. [(12)]

Roughening of the abutment surface was carried out by 0.5mm diameter diamond bur and additionally 5 dimples on each axial wall of the abutment were created. As reported in one study, tooth preparations grounded with coarse diamonds and cemented with Panavia 21 cement shown maximum retention out of all groups in the study. [(13)]

Due to the mechanical lock caused buy the bur; there is an increase in the retention of fixed dental prostheses in situations with short abutments. [(8)]

Surface treatment with of metal alloys with primer has shown to enhance the retentive properties, though depend on the type of metal/alloy and primer composition used. This chemical method is easy to use, as it requires no complex equipment. [(14)] The metal primer used in this study was Alloy Primer (Shofu M.L Primer, Inc) is 10-MDDT and 6 MPHA based metal primer. It has been proved that monomers present in the primer chemically react with the alloy surface leading to increase the bond of resin cement to the metal surface. [(15)]

Resin luting cement (Panavia F) was used in this study for luting the samples with abutments. In previous study it was proved that resin cement has the highest retentive strength followed by zinc phosphate, resin-modified glass ionomer cement, non-eugenol acrylic based temporary implant cement and non-eugenol temporary resin cement. [(16)]

Three experimental types of surface modifications of the abutments were done in the present study: sandblasting and bur and groove of abutment and 3-unit metal framework, sandblasting and bur and groove on abutment and sandblasting and alloy primer on framework and sandblasting and metal alloy primer on both the abutment and framework.

Tensile bond strength test is one of the methods used to evaluate the adhesive strength of resin bonding cement to the metal used in the fabrication of the prosthesis. In this study Universal Testing Machine (UTM) was used to determine TBS.

Sample size was calculated at 80% study power and alpha error of 0.05 assuming standard deviation of 8 N in tensile strength as observed in the study of Gandbarzadeh J et al. For minimum detectable difference of 12 N in tensile strength minimum 10 observation/ samples were required in each group for our study.

The result of our study showed statistically significant differences in the retentive values across all the 4 groups and hence, the null hypothesis was rejected. Group 3, the implant abutment with bur and groove with sandblasting and 3-unit metal framework with sandblasting and alloy primer modified surface had significantly higher mean peak forces of dislodgement (749.80 N) than all other groups.

Our study result was similar to the study done by Shrivastav M in 2018, [(17)] concluded that the addition of Groove and Bur to implant abutments significantly increase the retention of cement-retained frameworks. Another study by Kunt et al in 2010 [(5)] stated that sandblasting plus alloy primer application is a very effective method of increasing the bond strength. Ganbarzadeh et al in 2012 [(10)] showed similar results which concluded that surface modification of implant abutment by diamond bur may be an effective method to increase retention of crown when TempBond is used.

All the three experimental groups have significantly greater values as compared to the control group. Group 3 with bur and groove and sandblasting on implant abutment and alloy primer and sandblasting of the framework and Group 4 with sandblasting and alloy primer of implant abutment as well as framework showed no significant difference in Tensile

Bond Strength. Hence this can be stated that the cumulative effect of the various surface treatments done in this study increases the bond strength between the prosthesis and the implant abutment. So along with bur and groove modifications, alloy primer may be recommended as a good practical chair side option to improve retention of a bridge cemented on short implant abutments when resin cement is being used.

Limitation of this Study

Creating *in vitro* dynamic conditions similar to those in the mouth is difficult, and hence, the present study was done in a laboratory. In this study, only one type of abutment and cement were used. It has been demonstrated that bond strength can be significantly different based on cement type and surface roughness need to be further investigated.

5. CONCLUSION

All the tested surface treatments of the abutment and bridge showed statistically significant difference in the mean tensile bond strength. The bur and groove modification of sandblasted abutment and sandblasted bridge with application of alloy primer showed highest mean bond strength. Thus, modification of the abutment by bur, groove and sandblasting while modification of bridge by sandblasting and alloy primer is advised for enhancing the retention and clinical longevity of the implant supported cement retained bridge with short abutment.

6. Ethical statement

Has not been published in whole or in part elsewhere;

The manuscript is not currently being considered for publication in another journal;

All authors have been personally and actively involved in substantive work leading to the manuscript and will hold themselves jointly and individually responsible for its content.

7. Declaration of Competing Interest

The authors deny any conflict of interest related to this study.

8. ACKNOWLEDGMENT

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