Original Article

# Effect of surface treatments on the retention of implant-supported cement-retained bridge with short abutments: An *in vitro* comparative evaluation

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## Abstract

**Statement of Problem:** In clinical situations, short implant abutments create lack of retention with overlying cemented prosthesis.

**Aims:** The aim of this study is to evaluate the impact of different surface treatments on the retention of implant-supported cement-retained bridge with short implant abutments.

**Materials and Methods:** Six straight Adin implant abutments of similar sizes (3 mm diameter × 3 mm height) were selected. All were divided into three groups ($n = 2$): with circumferential grooves and sandblasting (G + SB), with a circumferential groove and bur modification (G + B) and third one taken as control. The framework simulating three-unit bridge was casted in each group. A total of 30 such frameworks (10 for each group) were fabricated. Each casting was cemented with a zinc phosphate cement (Dentsply). The cemented frameworks were then being stored in 100% humidity at 37°C for 24 h. Retention tests were conducted with a universal testing machine (5 mm/min), and retentive forces were recorded. Data were subjected to one-way analysis of variance, Tukey's honestly significant difference test, ($\alpha = 0.05$).

**Results:** For the first group, retentive value increased by 619.30 N, the second group increased the retention by approximately 749.80 N ($P < 0.001$). The null hypothesis was rejected, the abutments with G + B showed significantly higher retention, than the G + SB and control group ($F = 15.95$, df = 29, $P < 0.001$).

**Conclusion:** The addition of G + B to implant abutments significantly increased the retention of cement-retained frameworks. For long-term prognosis of the prosthesis; G + B modification can be a better option as compared to G + SB.

**Keywords:** Groove + bur modification (G + B), groove + sandblasting modification (G + SB), implant supported cement-retained bridge, retention, short abutments

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## INTRODUCTION

In clinical situations, reduced inter-arch space[1] create lack of retention problem in the cemented prosthesis. The use of implant-supported cement-retained restorations has increased, due in part to the ability to optimize occlusal inter-digitation, enhance esthetics and provide

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a passive fit. In such clinical situations, the use of cement-retained prosthesis become a mandatory option over screw-retained.[2,3] To enhance the retention; airborne-particle abrasion[4,5] bur modifications,[5,6] addition of retentive grooves,[7,8] and minimal angle of convergence[9] are to be used. Studies on implant-supported cement-retained bridge (ISCRB) in short abutment[10] condition is still not known. That is why this study was designed.

## MATERIALS AND METHODS

A total of six straight narrow diameter implant abutments (Adin Rs Slim Titanium Abutment, Adin Dental Implant System Ltd Israeli), 3 mm in diameter and 3 mm in height were selected [Figure 1]. Along with this, six Adin implant analogs (Adin Rs Internal Hex Implant Analog, Adin Dental Implant System Ltd., Israeli) were also selected [Figure 2], two analogs were aligned vertically in the center of a plastic ring using dental surveyor with a distance of 10 mm (measured from the center of screw channel).

Chemically cured acrylic resin (RR Cold-Cure DPI, India) was poured between and surrounded the analogs, the assembly was maintained until the acrylic resin set. The abutments were then screwed on to the implant analogs with Universal Torque Ratchet and Hex Drive and torqued to 25 Ncm. Three such similar assemblies were formed ($n$ = 2). A framework simulating three-unit bridge was casted over the assemblies using non-Precious Dental Alloy Nickel–Chromium (Ndn, Dfs-Diamon, Germany). For that purpose, tin platinum foil of 0.001 inches (0.025 mm) thickness was closely adapted and burnish onto the abutment surface as a die spacer. The assembly was then duplicated using silicon material and micro stone.

Wax patterns for copings had been formed using blue inlay wax with a thickness of approximately 1 and 8 mm diameter occlusal surface on the stone replica. All samples are waxed to this identical size using the split mold technique with silicon material. A 5 mm diameter ring was being waxed on the center of the occlusal surface of each pattern to facilitate the connection of the crown to the universal testing machine.

The wax patterns were then sprued with 2 mm diameter (12 gauges) wax sprues, and invested in phosphate bonded investment. The investment had been mixed according to the manufacturer's instructions and then poured using a vibrator to spaced metal rings. The rings was then being kept overnight in a dry environment and then casted with a Co-Cr base metal alloy.

The fit of metal copings was being examined utilizing Fit-Checker disclosing media and the internal surface of each casting was inspected with a microscope and minute nodules were removed with a half round bur in the straight handpiece. Stability was assessed by applying finger pressure vertically to the crown while seating on the abutment and considered acceptable if the crown does not have any rotational movement on the abutment.

The investment, burnout, and casting techniques were standardized. Patterns were sprued and invested individually in a phosphate-bonded investment with the casting technique described by white. Devesting had been completed in the usual manner with the minimum use of aluminum oxide air abrasives on critical interfaces. Further internal adjustments had been made by painting a thin layer of die lubricant on the abutments and removing any wet, shiny areas on the lightly air-abraded internal surfaces of the castings.

A total of 30 such frameworks, ten for each group were fabricated. Metal loops [Figure 3] were mounted over the frameworks for pull-off movements.

Each assembly was randomly selected and assigned to modification as follows [Table 1]:

- Group I (G + SB): The abutments were subjected to surface modification; by milling one circumferential groove [Figure 4] in the middle of each abutment. The circumferential groove was 0.5 mm wide and 0.3 mm deep with an inter-wall angle of approximately 60° [Figure 5]. The abutments were then [Figure 6] roughened by sandblasting (50 μm aluminum oxide)
- Group II (G + B): The abutments were subjected to surface modification by adding one circumferential groove that was milled in the similar manner followed by

Figure 1: Implant abutment

Figure 2: Implant analogs

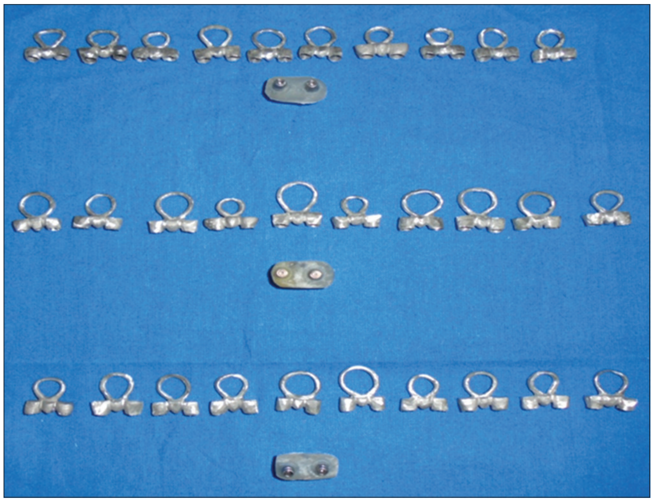

**Figure 3:** Metal frameworks with loop attachment with mounted implant abutments

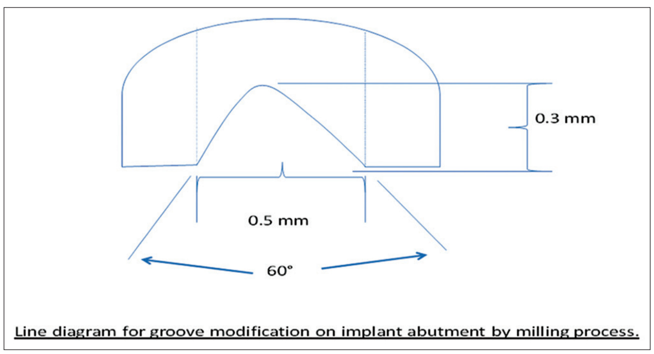


**Figure 5:** Diagrammatic representation of circumferential groove

**Table 1: Modifications of groups**

| Group names | Modifications |
|---|---|
| Group I | Groove + sandblasting (G + SB) |
| Group II | Groove + bur (G + B) |
| Group III | Control |

bur modification by creating punches of size whole bur diameter 5 per axial surfaces of abutments [Figure 7]
- Group III: [ Figure 8] control; having no any surface modifications.

The frameworks were seated and checked with the fit-checker to check for fitting and any visible problems. The Frameworks were then cemented with zinc phosphate[11] (Adhesor Fine, Shofa Dental, Kerr Company) on each assembly. This resulted in a simulation of ISCRB with short abutments.

The cemented frameworks were taken under a 4.5 kg load for 1 min followed by a 0.9 kg load for 2 min and then allowed to bench set. Before testing the specimens, the size of the acrylic blocks was reduced according to the dimensions of the clamp for holding the specimens.

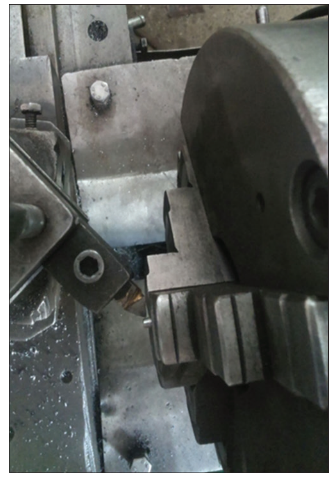

**Figure 4:** Lathe machine

**Figure 6:** Groove+ sandblast

A universal load testing machine [Figure 9] was used to apply vertical tensile forces at a crosshead speed of 5 mm/min, to dislodge the framework from the abutments. The peak load to dislodge was documented (N) and used to indicate the retentive values. All frameworks were tested for retentive strength in a similar manner.

The data were analyzed statistically using one-way analysis of variance (ANOVA) and Tukey honestly significant difference (HSD) test for further comparison.

## RESULTS

The analysis revealed a statistically significant difference in retention among the three groups based on one-way ANOVA test in Table 2 and according to Tukey's HSD test in Table 3, the amount of force required to remove the metal bridge from implant abutments after cementation was higher for bur modification when comparing Group II with Group III as compared to other groups.

**Figure 7:** Bur+ groove

**Figure 8:** Control

**Figure 9:** Specimen clamped to the universal testing machine

The comparative retentive forces to remove the cemented bridge from the abutments were always as follows Group II > Group I > Group III except with ninth sample testing.

**Table 2: One-way analysis of variance for tensile strength (*n*)**

| Source | Sum of squares | *df* | Mean square | *F* ratio | *P* |
|---|---|---|---|---|---|
| Between groups | 419,210.07 | 2 | 209,605.03 | 15.91 | <0.001 |
| Within groups | 355,691.80 | 27 | 13,173.77 | | |
| Total | 774,901.87 | 29 | | | |

**Table 3: Mean tensile strength (*n*) of test assemblies**

| Abutments surface roughness | *n* | Mean | SD | Tukey HSD test |
|---|---|---|---|---|
| (a) Sand blast | 10 | 619.30 | 110.20 | a: b - *P*=0.044 |
| (b) Bur treated | 10 | 749.80 | 134.47 | a: c - *P*=0.012 |
| (c) No surface treatment (control) | 10 | 460.70 | 96.41 | b: c - *P*<0.001 |

HSD: Honestly significant difference, SD: Standard deviation

## DISCUSSION

Currently, dental implants are restored with two types of crowns, i.e. cement-retained and screw-retained. The screw-retained prosthesis was developed in response to the need for retrievability of restorations. Later, the use of implant-supported cement-retained restorations has increased, due in part to the ability to optimize occlusal inter-digitation, enhance esthetics and provide a passive fit.

In certain clinical situations, reduction of the abutment height due to limited inter-occlusal space which can compromise retention of the cemented prosthesis, methods to enhance the retention of cement-retained prosthesis are advocated. A few factors can be controlled by the clinician to increase retention is surface roughness which is the most important factor that a clinician has control over it. Moreover, cemented prosthesis is the need when considering the anterior quadrant region, majority of them were fixed partial denture (FPD) type of cases, and hence by considering the situation like three-unit bridge overlying implants, we tried to judge the splinting effects along with surface modification on retention of the prosthesis because previous studies are done on single crowns only and splinted prosthesis are studied for stress distribution effects on bone. No study till done on FPD to analyze retention of overlying implant prosthesis.

Hence, this study was conducted to evaluate the effect of retention of ISCRB on short abutments with different surface treatments G + B and G + SB.

The result of this study showed G + B modification showed significant influence on retention of ISCRB over short abutments as compared to no modification.

Cement-retained prosthesis have gained popularity due to several advantages such as loading along a linear axis, better passive fit, small occlusal table, lower fracture of porcelain due to lack of screw accessibility hole, and better comfort to cemented restoration in posterior regions.[12] Minimum abutment height may lack to provide adequate retention for an implant supported cement-retained restorations as quoted in the study of Saleh Saber *et al*.[13]

However, there could be situations where a three-unit bridge has to be fabricated on implant abutments having reduced crown height space. This may compromise the retention of the prosthesis. Many procedures have been suggested to modify the surfaces of short abutments to improve retention. Among them sandblasting, bur modification, the addition of circumferential grooves, and alloy primers[5] are practically achievable at chairside. Roughening the surface of abutment by a bur increases the retention of cemented crowns in comparison with sandblast and control assemblies as showed in a study of Ganbarzadeh *et al*.[12] On the metal surfaces sandblasting creates irregularities, the surface area increases, and removes debris mechanically, thus increasing the bond strength of cements.[ 2,8,12,14] Circumferential grooves added to implant abutments was also found to increase the retention of cemented restorations. Circumferential groove creates a local lock, and this may increase the length of the fracture line (plane) and have a greater effect on cements with a high modulus of elasticity such as zinc phosphate cements.[8]

Zinc phosphate cement provides casting retention by micromechanical interlocking into the casting and the abutment surface irregularities. For zinc phosphate cement, 1 groove was as effective as several, as quoted in the study of Lewinstein *et al*.,[8] thus in the present study only one circumferential groove was milled on the center of each abutment that underwent modifications.

Group II had a significantly higher mean peak forces of dislodgment than all other groups, which correlated to the study of Ganbarzadeh *et al*.[12] Group II showed the highest tensile strength values followed by Group I and control group.

Studies done by Clayton *et al*.[15] and Sheets *et al*.[16] have shown that dislodging loads in natural tooth and implant abutment intraorally range between 207 and 509 N. From this study, it is evident that the control group showed retentive bond strength values within the range, whereas the Group I and II showed higher values than the dislodging forces encountered intraorally. The inter-group comparison revealed group II and I that showed the statistically significant difference from that of Group III. Although, both have significantly greater value as compared to intraoral dislodging forces, for long-term prognosis of the prosthesis; G + B modification may be better as compared to G + SB.

The repeated dislodgement of restoration on short abutments can always be a problem when implant-supported restorations are luted with temporary cement.[15] Thus, in such cases, the choice of cement is a permanent cement.[16,17] However, many clinicians are of the opinion that retrievability of crowns is more important than retention in implant crowns, in such clinical situations, simulating the present study, using temporary/semi-permanent cement would compromise retention to a higher level.

Inside the mouth, implant-supported restorations are under the influence of various forces such as shear, tensile, and compressive and the combination of these forces can create different dynamic forces resulting in the dislodgement of restoration. Creating *in vitro* dynamic conditions similar to those in the mouth is difficult.

It has been revealed that bond strength could be significantly different based on cement type[11,15] and surface roughness.[5,6,18] Sandblasting the surface of abutment can increase resistance to dynamic lateral loading[19], and the amount of this increase is different in various cements.

The results of this study indicated that the retention of metal crowns on titanium abutments noticeably increases with factors such as roughening the surface of abutment with a diamond bur. This matter is very practical in clinics because it is very important to access a method which enables clinicians to cement crowns on titanium abutments with a long-term durability in spite of temporary cement.

Here, in the present study, our main focus is on mechanical modifications rather chemical changes or different cements types because in many different studies expensive methods were used for it. The main goal is to provide almost same services to patients without any extra expense to him/her. Second, by doing this study on the bridge, we indirectly splint the implants to compensate for increased crown to implant ration.[20]

So considering the retrievability[21-24] and functionality of prosthesis Group II modification sounds good. The effect of surface modifications on short abutments when cemented with temporary cement needs further study.

## Strength of this study

Modifications are made to allow retrieval when necessary and at the same time it should have sufficient retention during function and should not dislodge off the abutment frequently.

Modifications can be done clinical side only, no need for extra laboratory time consumption and also economical for patient benefits.

## Limitation of this study

1. Creating *in vitro* dynamic conditions similar to those in the mouth is difficult, and hence, the present study was done in a static condition
2. 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.

## CONCLUSION

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

- Retention of the ISCRB with short implant abutments is improved by surface treatments of the abutments, namely, G + SB and G + B
- Surface modification done by G + B showed to have the greatest influence on increasing the retention of ISCRB
- For long-term prognosis of the prosthesis; G + B modification may be better as compared to G + SB.

G + B modification may be recommended as a good practical chairside option to improve retention of a bridge cemented on shorted implant abutments when zinc phosphate cement is used.


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## Conflicts of interest

There are no conflicts of interest.


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