Dental Research Journal

Original Article

# Bond strength of locator housing attached to denture base resin secured with different retaining materials

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## ABSTRACT

**Background:** The type of housing retaining material may affect the bond strength of the housing to denture base resin. The aim of this *in vitro* study was to evaluate the bond strength of locator housing attached to polymethyl methacrylate (PMMA) denture base resin secured with different retaining materials.

**Materials and Methods:** In this *in vitro* study Forty-four PMMA blocks (10 mm × 15 mm × 15 mm) were prepared with a central cylindrical canal inside to allow the insertion of locator housings. The prepared specimens were then randomly divided into four groups ($n$ = 11). Each group received one of the following retaining materials for housing insertion: Auto-polymerized acrylic resin (APAR), auto-polymerized composite resin (Quick up), application of alloy primer on titanium housing plus Quick up (AL-Quick), and heat-polymerized acrylic resin (HPAR). The specimens were thermocycled 5000 times between 5°C and 55°C, followed by 1000 cycles of vertical insertion separation on the locator abutment. A push-out force was applied on the flat back surface of the housing after which the failure and shear bond strength values were calculated. The data were analyzed using one way-ANOVA and Games-Howell test ($\alpha$ = 0.05).

**Results:** HPAR group had significantly higher shear bond strength values compared to the other groups ($P < 0.05$). No significant differences were found among the other remaining material groups ($P > 0.05$).

**Conclusion:** Inserting of locator housing using HPAR resulted in higher bond strength between housing and denture base resin. The application of alloy primer did not improve the bond strength of locator housing which was retained with "Quick up".

**Key Words:** Attachment denture, bond strength, overdenture

**Received:** September 2018
**Accepted:** January 2019

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## INTRODUCTION

Implant overdentures are considered a favorable treatment for edentulous patients, especially those with conventional dentures problems. Patients who receive implant supported dentures are more satisfied with their treatment outcome as a result of improved retention, stability, and masticatory function.[1,2]

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Implant-retained overdentures are connected to the implants through either solitary type or bar type attachments. The locator is a solitary attachment which is widely used due to several advantages including low vertical profile, dual retention, self-aligning, and pivoting action.[3] The locator matrix consists



**How to cite this article:** Nakhaei M, Dashti H, Baghbani A, Ahmadi Z. Bond strength of locator housing attached to denture base resin secured with different retaining materials. Dent Res J 2020;17:34-9.

of titanium housing (denture cap) and color plastic components (retentive male), with different retention values.

A common clinical occurrence associated with the locator attachment is the de-bonding of its titanium housing from the denture base resin over time. Reinserting of the housing into the denture base is costly and time-consuming. Moreover, the masticatory function and esthetics of the patient is compromised until proper clinical care is provided. Therefore, achieving a strong and durable bond between denture base resin and titanium housing is essential.

Processing of the locator attachment into the overdenture can be performed either by the chairside (direct technique) or during a laboratory process (indirect technique). Many practitioners prefer to pick up the housing by using the chairside technique to minimize errors resulting from denture processing.[4] Conventionally, auto-polymerized or light polymerized acrylic resin is used for direct chairside pickup of housing attachment. In recent years, pink-colored self-curing composite-based materials have also been introduced to the market as alternatives for chairside pickup of attachments housing. One of these commercially available materials is Quick Up (Voco GmbH, Cuxhaven, Germany).[5] The bonding ability of these materials to titanium housing is based on the macro-mechanical retention through engaging the undercuts on the axial walls of the housing attachment.

It is assumed that the chemical bonding between the titanium housing and the retentive materials is also important. Domingo *et al*. demonstrated that when the titanium housing was airborne-particle abraded with silica-coated alumina particles and silanated, produced a better bond between the housing and acrylic resin.[6] Studies have demonstrated that alloy primers containing phosphoric or carboxylic acid functional monomers enhance the bond strength of heat-polymerized acrylic resin and composite resin to titanium alloy.[7-11] Compared to other methods that have been introduced for improving the bond strength at metal-resin interface, the application of alloy primers is simpler and more economical because it does not require any special equipment.

It is important for clinicians to use reliable materials and techniques when inserting implant attachments into a denture base. This study aimed to compare the bond strength of locator housing attached to a heat polymerized denture base resin secured with different materials: auto-polymerized acrylic resin, a commercially available self-curing composite resin for direct transfer of attachment housings with/without alloy primer application, and heat-polymerized polymethyl methacrylate (PMMA) resin. The null hypotheses were that the bond strength between the overdenture housing and the denture base resin would not be influenced by the type of retaining material, and application of an alloy primer would not improve the bond strength.

## MATERIALS AND METHODS

To conduct this *in vitro* study, 44 denture blocks measuring 10 mm × 15 mm × 15 mm were fabricated from heat-polymerized (PMMA) denture base material. The PMMA blocks were prepared by investing metal patterns in a conventional denture flask. Putty impression material (Speedex, Coltene, Switzerland) was placed around the metal patterns to facilitate the removal of processed PMMA from the flask. The heat-polymerized denture base resin (Triplex, IvoclarVivadent, Schaan, Liechtenstein) was mixed and packed in the denture flask and processed in a water bath at a temperature of 100°C, for 30 min.

A central cylindrical canal with a diameter of 5 mm was drilled through each block that corresponded to the flat back surface of the locator housing. To achieve maximum retention of retaining materials, it is recommended that a clearance of about 1.5–2 mm is provided between the attachment housing and denture base. Therefore, the canal size was further widened to 8.5 (±0.5) mm.

The prepared specimens were then randomly divided into four groups ($n = 11$). Each group received one of the following retaining materials for housing insertion:

1. Auto-polymerized acrylic resin (APAR): The surface of the PMMA canal prepared for housing insertion was wetted with liquid methyl methacrylate monomer using a disposable brush for 30 s. A metal rod, 5 mm in diameter, was attached to the flat back surface of the housing with sticky wax to keep the housing in the middle of the central canal during insertion process [Figure 1]. The auto-polymerized acrylic resin (Triplex, IvoclarVivadent, Schaan, Liechtenstein) was placed around the housing using a plastic instrument. The PMMA block was then inverted and pressed on a glass slab until the housing leveled with the

block surface. The denture block was held in the same position using finger pressure for 10 min. Excess auto-polymerized PMMA resin was gently removed with a micro brush. After polymerization, the metal rod was removed so that the flat back surface of the housing remained exposed

2. Auto-polymerized composite resin (Quick up): The surface of the PMMA canal prepared for housing insertion was wet using Quick up adhesive for 60 s and later air-dried for 30 s according to the manufacturer's instruction. A metal rod, 5 mm in diameter, was attached to the flat back surface of the housing with sticky wax to keep the housing in the middle of the central canal during the insertion process [Figure 1]. The auto-mixed auto-polymerized composite resin retaining material (Quick Up; Voco GmbH) was injected with a mixing syringe around the housing. The PMMA block was then inverted and pressed on a glass slab until the housing leveled with the block surface. The denture block was held in position with the fingers for at least 3.5 min until polymerization occurred, according to the manufacturer's recommendation. After polymerization, the metal rod was removed so that the flat back surface of the housing remained exposed
3. Alloy primer plus auto-polymerized composite resin (AL-Quick up): The alloy primer (Metal Primer Z GC, Corporation Ltd., Tokyo, Japan) was applied on the axial surface of the locator housing using a disposable micro brush and was allowed to dry for 30 s at room temperature. All housing insertion procedures, using Quick Up composite resin retaining material, were done in the same manner as described for Group 2
4. Heat-polymerized acrylic resin (HPAR): The locator housing was inserted into the denture block using melting wax (Cavex, Haarlem, the Netherlands) in the same manner as described for the other groups. The specimens were then invested in a denture flask containing silicone-gypsum mold to facilitate easy removal of specimens. After eliminating the wax, the heat-polymerized acrylic resin (Triplex, IvoclarVivadent, Schaan, Liechtenstein) was packed into the flask and processed according to the manufacturer's instruction.

All specimens were then subjected to 5000 thermal cycles at a temperature range of 5°Ċ–55°Ċ, with a 30 s dwelling time and 5 s transfer time. To perform load cycling, a fixture analog (Biodenta Swiss AG, Bernek, Switzerland) was secured in an acrylic block. The locator abutment (Biodenta Swiss AG, Berneck, Switzerland) was then connected to the analog, and the assembly was connected to the lower holder of the universal testing machine (SANTAM, Tehran, Iran). The acrylic block containing the locator housing was then attached to the opposing arm of the universal testing machine, and each housing was subjected to 1000 vertical insertion-separation cycles on the locator abutment with a cross-head speed of 40 mm/min and 1 s dwelling time to simulate approximately 1-year over denture use.[12] The specimens were then subjected to shear load using a universal testing machine (SANTAM, Tehran, Iran) with a 1 mm/min crosshead speed and a 50 kg load cell until failure occurred. A flat-end apparatus was used to apply a push-out force on the flat back surface of the housing [Figure 2]. The force at fracture point was recorded, and the values of the shear bond strength were calculated using the following formula:

$$S = F/A$$

Where S is the shear stress (in MPa), F is the force at the fracture point (in N), and A is the area of the axial surface of the housing surrounded by retaining materials (in $mm^2$). The data were statistically analyzed using one-way ANOVA and Games-Howell *post hoc* test ($\alpha = 0.05$).

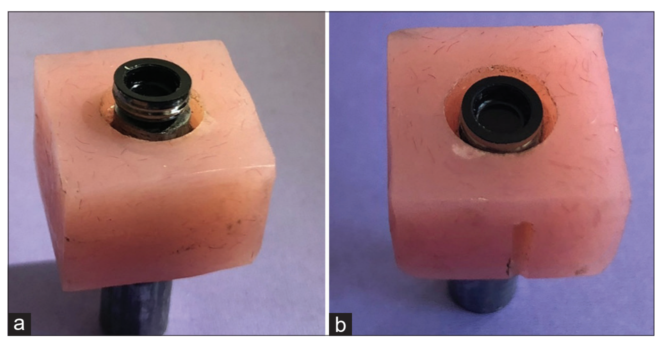


**Figure 1:** (a and b) The locator housing was attached to the metal rod with sticky wax to keep the housing in the middle of the central canal before retaining material injection.

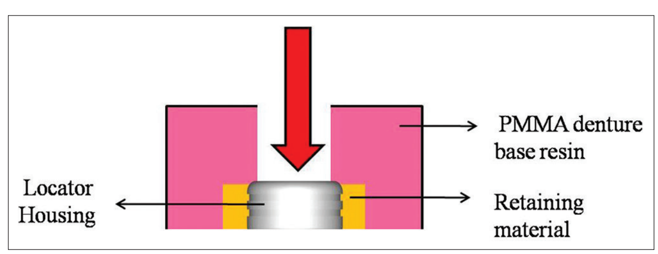


**Figure 2:** Schematic showing test specimen with retaining material and housing.

## RESULTS

The values of mean shear bond strength (MPa) and standard deviations of all groups are presented in Table 1. The normal data distribution was confirmed by the Shapiro–Wilk test ($P > 0.05$). The one-way ANOVA test revealed that a significant difference exists between the studied groups ($P < 0.001$) [Table 2]. According to the Games-Howell *post hoc* test, the heat-polymerized acrylic group had significantly higher shear bond strength compared to the other groups ($P < 0.05$) [Table 3]. However, no significant differences were found among the remaining groups ($P > 0.05$) [Table 3]. Analyzing the results of the specimens showed that the mode of failure in all specimens from APAR, Quick up, and AL-Quick up groups was adhesive failure at the housing/retaining material interface [Figure 3a], but only in the heat-polymerized group did two of the specimens exhibit adhesive failure at the retaining material/denture base resin interface [Figure 3b].

## DISCUSSION

According to the results of this study, inserting of locator housing using heat-polymerized acrylic resin produced the highest bond strength between the attachment housing and denture base resin. Thus, the first null hypothesis, that the bond strength of overdenture housing to denture base resin would not be influenced by the type of retaining materials is rejected.

**Table 1: Mean shear bond strength values, minimum, maximum, and standard deviation (MPa) of experimental groups**

| Groups | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| APAR | 13.2 | 3.2 | 8.4 | 19 |
| Quick up | 10.4 | 1.4 | 7.9 | 12.6 |
| AL + quick up | 11.5 | 4.5 | 4.4 | 18.4 |
| HPAR | 18.4 | 2.8 | 15.1 | 23.7 |

SD: Standard deviation; HPAR: Heat-polymerized acrylic resin

**Table 2: Results of one-way ANOVA test**

| Source | df | Mean square | *F* | *P* |
|---|---|---|---|---|
| Between groups | 3 | 137.632 | 13.567 | <0.001 |
| Within groups | 40 | 10.145 | | |
| Total | 43 | | | |

**Table 3: Games-Howell *post hoc* test**

| Group (I) | Group (J) | Mean difference (I-J) | *P* |
|---|---|---|---|
| HPAR | APAR | 5.4 | 0.003* |
| HPAR | Quick up | 8.0 | <0.001* |
| HPAR | AL + quick up | 6.84 | 0.002* |
| APAR | Quick up | 2.6 | 0.098 |
| APAR | AL + quick up | 1.4 | 0.794 |
| Quick up | AL + quick up | −1.1 | 0.841 |

*Significant difference ($P<0.05$). HPAR: Heat-polymerized acrylic resin

The bonding of acrylic resin retaining materials to attachment housing is based only on the macromechanical retention through engaging the existing undercuts on the axial walls of the housing. In this study, a push-out force was applied to the locator housing which resulted to a shear force being exerted on the existing acrylic resin around the housing. Consequently, the acrylic resin was embedded in the undercut bends. Therefore, the higher the flexural strength of the retaining material, the greater the mechanical bond strength would be between the retaining materials and the housing. According to the results of this study, housings secured with HPAR showed higher bond strength values than those secured with APAR. This finding could be attributed to the higher flexural strength of HPAR compared to APAR that has been demonstrated in previous studies.[13,14]

The choice of alloy for fabricating attachment housing is based on the following criteria: It should be nontoxic, corrosion resistant and should have a low density as well as high strength. Accordingly, titanium alloys are conventionally used for constructing attachment housing. Studies have demonstrated that

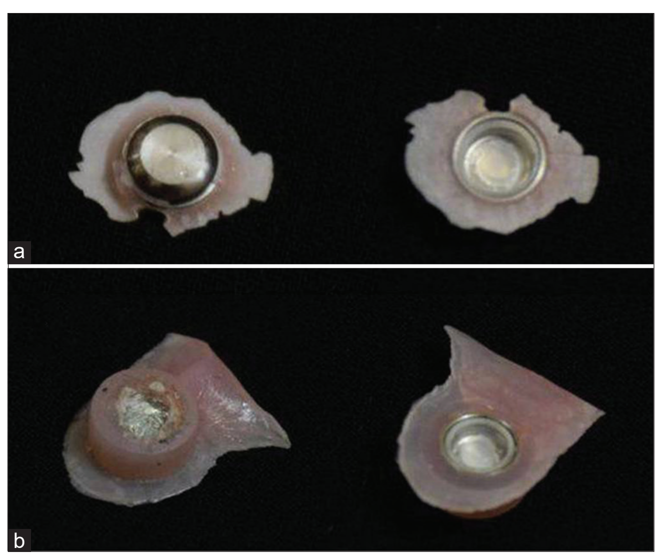


**Figure 3:** Fracture sites at specimens: (a) Adhesive failure at the housing/retaining material interface, (b) adhesive failure at the retaining material/denture base resin interface.

the application of alloy primers improves the bond strength of the composite resin to titanium alloy.[9,10] However, in the present study, the application of alloy primer did not increase the bond strength of specimens secured with Quick up composite resin. Thus, the second null hypothesis is also rejected. As previously mentioned, locator housings have undercuts on their axial wall that provides mechanical retention for the retaining material; therefore, it is possible that in AL‑Quick up group, the chemical bonding is affected by the mechanical bonding and the obtained bond strength values are merely related to mechanical retention.

The examination of specimens with the naked eye showed that in APAR, Quick up, and AL‑Quick up groups, all samples exhibited adhesive fracture at the housing/retaining material interface and no fracture was observed at the retaining materials/denture base resin. This finding is in agreement with the findings of previous studies where an acceptable bond was reported for Quick up composite resin, and this confirms that the bonding of this material to PMMA denture base resin fulfills the clinical requirements.[5,15]

Two samples in HPAR group showed adhesive failure at the retaining material‑denture base interface that could be related to any defect in the interface during the processing procedure. However, this problem would be eliminated through overdenture fabrication since attachment housing is directly picked up within the denture base during processing procedure.

Thermal cycling and load cycling are two essential factors in simulating the oral environment. In the current study, the samples were thermos‑cycled for 5000 cycles between 5ºC and 55ºC, which is widely accepted as a standard procedure for artificial aging. In implants overdenture treatment, the implant may not be placed parallel to one another or the path of insertion of the prosthesis; therefore, this may clinically lead to the attachment housing being subjected to off‑axial dislodgment force. In the present study, load cycling was performed only as vertical seating and separation of specimen on abutment limits the portability of the results to the clinical situation. Nonetheless, due to standardization of the setup that allows reliable differentiation between the various materials and techniques tested, the obtained results can be helpful in predicting their behavior under a clinical setting. Locator attachment has some color retentive males with different degrees of retention. In this study, pink retentive male with light retention was used since it is the most widely used by clinicians. However, different results might have been achieved if clear attachment with regular retention or blue attachment with extra light retention were used instead.

In further studies, housing surface treatment with other methods, changing the denture base material, and using the other retaining materials is recommended. In addition, the application of load cycling as off‑axial may affect the bond strength of the specimens and the interaction of retaining material and denture base material.

## CONCLUSION

Considering the limitation of the present study, the following conclusions were drawn:

1. Inserting the locator housing using heat‑polymerized acrylic resin resulted in higher bond strength between metal cap and denture base resin
2. Application of alloy primer did not result in higher bond strength of locator housing to denture base resin when the Quick up self‑polymerized was used for attachment pick up.

### Acknowledgment

The authors would like to thank the vice chancellor for Research of Mashhad University of Medical Sciences for their support.

### Financial support and sponsorship

This study was supported by a grant (960,378) from the vice chancellor for Research of Mashhad University of Medical Sciences. The results presented here are based on a postgraduate thesis (No. 654) submitted to Mashhad School of Dentistry and Dental Research Center. The implant components were provided by KMT Co., Tehran, Iran.

### Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non‑financial in this article.

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