ORIGINAL ARTICLE

Evaluation of Acetal Resin and Cobalt–Chromium Clasp Deformation and Fatigue Resistance in Removable Partial Denture Clasps - An *In Vitro* Study

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ABSTRACT

Purpose: This study was aimed to evaluate the fatigue resistance (amount of clasp deformation) of acetal resin clasps and cobalt–chromium (Co–Cr) clasps after attachment/detachment cycles on abutment teeth with two different undercuts. **Materials and Methods:** Twenty models were constructed by placing either an upper first premolar or upper first molar inside an acrylic rectangular block. Models were divided according to the abutment teeth into two groups (Group I for first premolar group and Group II for first molar group), 10 each. Each group was divided into two subgroups according to the framework material, SGA for acetal resin clasp and SGC for Co–Cr clasp. Each testing models and its framework were mounted inside universal testing machine (Lloyd Instruments Ltd., England). Cycling was carried out for each specimen until 2920 cycles. The data of the amount of clasp deformation after cycling were collected and tabulated. The data were subjected to statistical analysis using student's *t* and paired *t*-tests. **Results:** After 2920 cycles, the mean values and standard deviations of the clasp deformation for SGIC, SGIA, SGIIC, and SGIIA were 0.0532 ± 0.006, 0.007 ± 0.003, 0.04323 ± 0.0048, and 0.0275 ± 0.004 mm, respectively. **Conclusions:** Co–Cr clasps had significant clasp deformation more than acetal resin clasps. Increase the thickness of cross-section of the acetal resin clasp more than 1 mm was recommended in case of engaging undercut more than 0.25 mm.

Key words: Acetal resin, cobalt–chromium, clasp deformation, fatigue, clasp material

INTRODUCTION

Several types of polymers and metal alloys have been used in removable partial dentures (RPDs) construction. Frequently, RPD clasps were made from the same alloy as the metal framework. The most common alloys used for clasps are cobalt–chromium (Co–Cr) alloy and gold and titanium alloys, although these may be unesthetic.[1]

Fatigue resistance and esthetics of RPDs are considered as important factors affecting their clinical success. Hence, the achieving of optimal esthetics while maintaining higher resistance to retention loss is a big dilemma.[2,3]

Many investigations have determined the properties of the materials used to fabricate RPD clasps. Many investigations have determined the properties of the materials (Titanium alloys, gold alloys, nickel-chromium alloys and Co-Cr alloys) that can be used to fabricate RPD clasps. Co–Cr alloys have replaced noble metal alloys as they possess advantages such as better flexibility, lighter weight, and cost-effectiveness. At the same time, they have few drawbacks such as failure of retentive arms under stress, frequency of repairs, and esthetics.[4]

Metals and metal alloys undergo permanent deformation and fatigue when exposed to repeated stress. The fatigue of a

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denture clasp is based on the repeated deflection of the clasp during insertion and removal of the RPD over the undercuts of the teeth.[5] Furthermore, others reported that the clasps lost its retention due to multiple deflection.[6,7]

It was revealed that acetal resin clasps are resistant to deformation and may offer a clinical advantage over the conventional metal clasps. The retentive clasp arm of the clasp fabricated using acetyl resin aids in engaging deeper undercuts on the abutments than the Co–Cr due to the flexibility and the lack of stiffness. It can be used for RPDs where esthetics or periodontal health is a primary concern.[8]

While Lopes *et al*.[9] found that the acetal resin clasp displayed higher deformation values than the Co–Cr in any direction of the applied load, also Arda and Arikan[10] found that the retentive force of Co–Cr clasps after deformation remained significantly higher than the retentive force of acetal resin clasps of both thicknesses.

Wu *et al*.[11] revealed that acetyl resin showed significantly greater deformation compared with metal alloy direct retainers after 3 years of simulated use.

However, Savitha *et al*.[12] mentioned that no permanent deformation was detected in acetal resin clasp after loading cycles when deflected to 0.25 mm and 0.50 mm, whereas, Co–Cr clasp under 0.25-mm deflection showed no deformation while 0.5 mm deflection showed significant deformation.

Others reported that the thermoplastic resin direct retainer is more flexible than the conventional Co–Cr direct retainer.[13-18]

There is controversy in the literatures[19-21] and also little data available regarding the long-term performance of such direct retainers. Therefore, this study was aimed to evaluate the fatigue resistance (amount of clasp deformation) of acetal resin clasps and Co–Cr clasps after attachment/detachment cycles on abutment teeth with two different undercuts.

MATERIALS AND METHODS

Ten maxillary first premolars and ten maxillary first molar were used for construction twenty testing models using laboratory custom-made copper model (30 mm in length, 20 mm in width, and 25 mm in height) [Figure 1a] as follows:

The testing models were constructed from rectangular acrylic (Stellon, DeguDent Gmbh, England) [Figure 1b] blocks with a natural tooth embedded in each model vertically to the cementoenamel junction.

According to the model's teeth, the testing models were divided into two groups: Group I contained ten testing models, each testing model having first premolar (0.25 mm undercut), and Group II contained ten testing models, each testing model having first molar (0.50 mm undercut).

Each testing model was duplicated into investment model (Calibra-M, Protechno, Spain), each group was divided into two subgroups (SG) according to the framework material, and each SG contained five testing models, SGA for acetal resin clasp material and SGC for Cr-Co clasp material.

On the investment model, half round cross-section Aker clasp wax patterns with 1.0 mm thickness (Polywax, Bilkim, Izmir, Turkey) were used to construct the wax patterns of all frameworks of this study.

The flasking and the injection process of acetal resin (bredent, Germany) for the wax pattern of the frameworks of SGIA and SGIIA were carried out using the acetal furnace (Thermopress 400, Bredent, Senden, Germany); however, the wax pattern of frameworks of SGIC and SGIIC was cast into Co–Cr (Kera C, Eisenbacher Dentalwaren ED GmbH, Germany) as conventional manner [Figures 2 and 3].

Each clasp and its model were mounted on a universal testing machine (Lloyd Instruments Ltd., England) for cycling. Cycling of each specimen was carried out cycled at room temperature until 2920 cycles (corresponding to 24 months of simulated clinical use of a RPD)[6,7] to simulate the fatigue resistance test.

For studying fatigue resistance, the distance between the tips of the retentive and reciprocal arms of each clasp was measured before and after the 2920 cycles using a digital

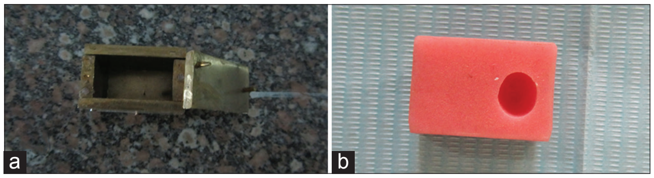

Figure 1: (a) Custom-made copper mold, (b) rectangular acrylic block.

Figure 2: Cobalt–chromium Aker clasp and the framework with the testing model

caliper. The data of the fatigue resistance were collected and tabulated. The data were subjected to statistical analysis using ANOVA test, student's *t*-test, and paired *t*-test.

RESULTS

Table 1 and Figure 4 show the mean values and standard deviations (SDs) of the clasp deformation for different SGs after cycling; however, Table 2 shows the pairwise comparisons between the different SGs after cycling.

The mean values and SDs of the clasp deformation for SGIC, SGIA, SGIIC, and SGIIA were 0.0532 ± 0.006, 0.007 ± 0.003, 0.04323 ± 0.0048, and 0.0275 ± 0.004 mm, respectively.

ANOVA test showed a statistical significant difference between the different SGs ($P \leq 0.05$).

Figure 3: Acetal resin Aker clasp and the framework with the testing model

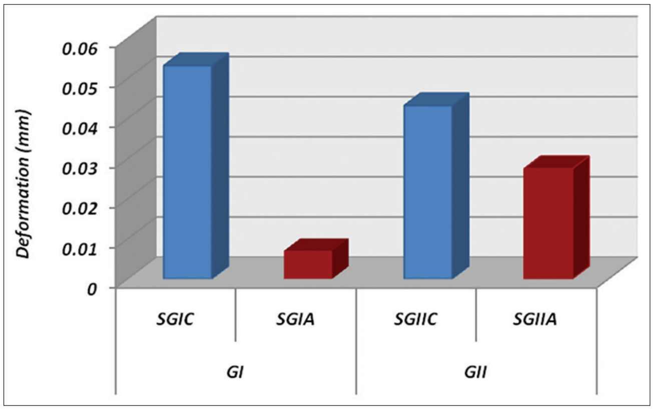

Figure 4: Column chart comparing the mean values and standard deviations of the clasp deformation for different subgroups at the end of testing cycles

There were statistically significant differences between SGIA and SGIIA, as indicated by paired *t*-test. Furthermore, there were statistically significant differences between SGIA and SGIC and SGIIA and SGIIC ($P \leq 0.05$) as indicated by student's *t*-test. However, there was no statistical significant difference between both SGIC and SGIIC ($P \geq 0.05$) as indicated by paired *t*-test.

DISCUSSION

An *in vitro* study was carried out to compare the fatigue resitance (in the form the amount of clasp deformation) of acetal resin clasps and Co–Cr clasps with two amounts of undercut after cycling. This experiment was conducted for 2920 cycles to simulate approximately an 2 years' period, if an RPD would be removed 4 times each day for 2 years.[6,7]

Both the Co–Cr clasps and acetal resin clasps had clasp deformation after simulated clinical use. The Co–Cr clasps had a significant increase in clasp deformation more than the acetal resin clasps in both premolar and molar groups at the end of cycling ($P \leq 0.05$), this may be due to the difference in the modulus of elasticity between acetal resin and Co–Cr materials.

Table 1: Means and SDs of the clasp deformation of different SGs at the end of testing cycles

SGs	At the end of testing cycles
	Mean ± SD
SGIC	0.0532±0.006
SGIA	0.007±0.003
SGIIC	0.04323±0.0048
SGIIA	0.0275±0.004

SGs: Subgroups, SDs: Standard deviations

Table 2: The pairwise comparisons between the different SGs at the end of testing cycles

Variables		Mean±SDs	*t*-test	
			t	*P*
GI	SGIA	0.007±0.003	15.9	<0.0001*
	SGIC	0.0532±0.006		
GII	SGIIA	0.0275±0.004	13.9	<0.0001*
	SGIIC	0.04323±0.0048		
SGA	SGIA	0.007±0.003	7.5	0.0001*
	SGIIA	0.0275±0.004		
SGC	SGIC	0.0532±0.006	2.2	0.0615 ns
	SGIIC	0.04323±0.0048		

*Significant ($P \leq 0.05$), NS: Non-significant ($P > 0.05$).
SGs: Subgroups, SDs: Standard deviations

These findings were disagreeing with a study made by Arda and Arikan[10] who mentioned that in spite of the presence of evidence of deformation in the Co–Cr clasps, no deformation noted for the acetal resin clasps over a simulated 36-month period. In the same time, these results were at variance with Lopes *et al*.[9] who reported that the acetal resin clasps showed higher deformation value than Co–Cr clasps and with a study performed by Wu *et al*.[11] who showed greater deformation with acetal resin direct retainers after 3 years of simulated use.

The results of the present study revealed that there was an increase in the clasp deformation for the Co–Cr clasps that engaged 0.25 mm undercut more than that engaged 0.50 mm undercut but without significant differences at the end of testing cycles ($P > 0.05$). This may be due to an increase in the length of the retentive arm of the molar group that affects the flexibility of the retentive arm. These findings are in disagreement with Savitha *et al*.[12] who mentioned that the deformation of Co–Cr clasp specimen under deflection of 0.50 mm was observed while Co–Cr clasp under 0.25 mm deflection and an acetal resin specimen under 0.25 and 0.50 mm deflection did not show any significant deformation.

Furthermore, the results of the present study were at variance with Meenakshi *et al*.[15] who showed an increase in the distance between the tips of the Co–Cr clasps more than that occurred with acetal resin clasps but without significant deformation after 12 months test period.

In the Co–Cr SGs, there was no significant difference in clasp deformation between Co–Cr clasps that engaged 0.25 mm undercut and Co–Cr clasps that engaged 0.50 mm undercut at the end of cycling ($P > 0.05$). While in the acetal resin SGs, there was significant increase in clasp deformation of the acetal resin clasps that engaged 0.50 mm undercut more than that of the acetal resin clasps that engaged 0.25 mm undercut at the end of cycling ($P \leq 0.05$), this may be due to using similar (1 mm) diameter of retentive arm with the different amount of undercuts, and also, the proportional limit and modulus of elasticity of Co–Cr clasps allow it withstand the deflection test and engaged large undercut which did not occurred in acetal resin SG.

The previous results of this study confirmed the results of other deflection fatigue study that obtained by Abd-Elrahman *et al*.[19] who reported that the rigidity of 1 mm diameter acetal resin clasp does not permit it to engage large undercut and obtain clinically acceptable retention. Furthermore, the results of the present study were in accordance with Fitton *et al*.[16] who stated that "the POM clasps must have greater cross-section area than metal clasps to provide adequate retention," and in accordance with these results, Tannous *et al*.[13] reported that the greatest retentive force for acetal clasps was found in the 1.5 mm thick clasps designed to engage the 0.50 mm undercut. Furthermore, others[20] stated that "the POM clasp must be greater in cross-sectional diameter (approximately 1.4 mm) and approximately 5 mm shorter than Co–Cr clasps in order to have the stiffness similar to a cast Co–Cr clasp 1 mm in cross-sectional diameter and 15 mm long." On the other hand, these results were disagreeing with others[10,17] who reported that the proportional limit of acetal resin enables it to engage large undercut. Furthermore, others[14,21] reported that acetal resin has superior flexibility compared to the Co–Cr alloys.

This study suggests to study the effect of long-term cycling on the thermoplastic resin clasp at different amount of undercut for further study.

CONCLUSION

- Co–Cr clasps had significant clasp deformation more than acetal resin clasps.
- No significant difference in clasp deformation between Co–Cr clasps that engaged 0.25 mm undercut and Co–Cr clasps that engaged 0.50 mm undercut.
- There was significant increase in clasp deformation of the acetal resin clasps that engaged 0.50 mm undercut more than the acetal resin clasps that engaged 0.25 mm undercut.
- Increase the thickness of cross-section of the acetal resin clasp more than 1 mm was recommended in case of engaging deeper undercut (more than 0.25 mm).

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