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EVALUATION OF ACETAL RESIN AND COBALT–CHROMIUM CLASP DEFORMATION AND FATIGUE RESISTANCE IN REMOVABLE PARTIAL DENTURE CLASPS. AN IN-VITRO STUDY

Mohamed Ahmed M. Helal*, Ibrahem Ali Abd El Rahman**, Hassan Mohamed Sakar***, Amr Salah El-Din Abd Elshafy Gomaa**** and Mohamed Abbas*****

ABSTRACT

Purpose: this study was aimed to evaluate the fatigue resistance (amount of clasp deformation) of acetal resin clasps and Cobalt-Chrome (Co-Cr) clasps after attachment/detachment cycles on abutment teeth with two different undercuts.

Materials and Method: Twenty models were constructed by placing either an upper 1st premolar or upper 1st molar inside an acrylic rectangular block. Models were divided according to the abutment teeth into two groups (GI for 1st premolars group and GII for 1st molars group), 10 each. Each group was divided into two subgroups according 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 till 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.

* Professor of Removable Prosthodontics, Faculty of Dental Medicine, Al-Azhar University. Boys Branch, Cairo, Egypt.
** Dentist at the MOH, El-Mansoura, Egypt.
** Assistant Professor of Removable Prosthodontics, Faculty of Dental Medicine, Al-Azhar University. Boys Branch, Cairo, Egypt.
**** Lecturerof Removable Prosthodontics, Faculty of Dentistry, Al-Fayoum University, Fayoum, Egypt.
*****Assistant Professor of Dental Material, Faculty of Dental Medicine, Al-Azhar University. Boys Branch, Cairo, Egypt.

INTRODUCTION

Several types of polymers and metal alloys have been used in removable partial dentures (RPDs) construction. Frequently, RPD clasps 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. So 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. Titanium alloys, gold alloys, nickel-chromium alloys and Co-Cr alloys. Co-Cr alloys have replaced noble metal alloys as they possess advantages like better flexibility, lighter weight and cost effectiveness. At the same time they have few drawbacks like 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 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) Also 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 aesthetics 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(19-22) 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 METHOD

Ten maxillary 1st premolars and ten maxillary 1st 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) (Fig. 1a) as following:

The testing models were constructed from rectangular acrylic (Stellon, DeguDent Gmbh, England) (Fig. 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 (GI) contained ten testing models, each testing model having 1st premolar (0.25 mm undercut), and group II (GII) contained ten testing models, each testing

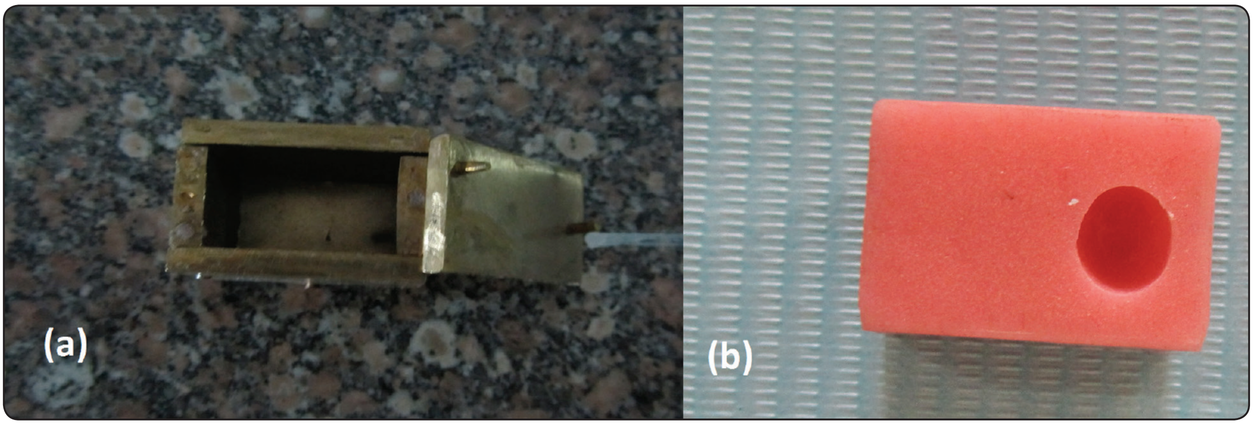

Fig. (1) (a) Custom made copper mold, (b) rectangular acrylic block.

model having 1st molar (0.50 mm undercut).

Each testing model was duplicated into investment model (Calibra-M, Protechno, Spain), each group was divided into two subgroup (SG) according the framework material, 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, Seden, Germany), however the wax pattern of frameworks of SGIC and SGIIC were cast into Co-Cr (Kera C, Eisenbacher Dentalwaren ED GmbH, Germany) as conventional manner (Fig. 2).

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 till 2920 cycles (corresponding to 24 months of simulated clinical use of a RPD) [6,7] to simulate the fatigue resistance test.

Fig. (2) Co-Cr Aker clasp and the framework with the testing model.

Fig. (3) Acetal resin Aker clasp and the framework with the testing model.

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 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 Fig. 4 show the mean values and standard deviations of the clasp deformation for different subgroups after cycling, however table 2 Shows the pairwise comparisons between the different subgroups after cycling.

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.

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

There were statistical significant differences between SGIA and SGIIA, as indicated by paired t test. Also there were statistical 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.

Table (1) Means and standard deviations of the clasp deformation of different subgroups at the end of testing cycles.

Subgroups	**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

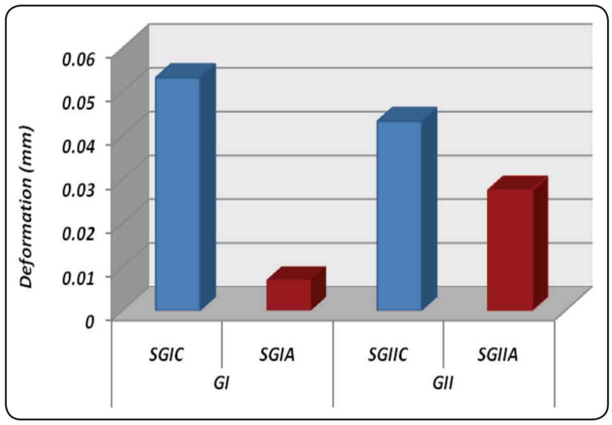

Fig. (4) Column chart comparing the mean values and standard deviations of the clasp deformation for different subgroups at the end of testing cycles.

Table (2) The pairwise comparisons between the different subgroups 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 ($p > 0.05$)**

DISCUSSION

An in-vitro study was carried out to compare the fatigue resitanace (in the form the amount of clasp deforamtion) 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 two years period, if an RPD would be removed four times each day for two years.[6,7]

Both the Co-Cr clasps and acetal resin clasps had clasp deformation after simulated clinical use. The Co-Cr clasps had significant increased 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 elasticitiy between acetal resin and Co-Cr materials.

These findings were disagreeing with a study made by Arda and Arikan[10] who mentioned that in spite of presence of evidence of deformation in the Co-Cr clasps but no deformation noted for the acetal resin clasps over a simulated 36-month period. In the same time this 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 were increase in the clasp deformation for the Co-Cr clasps that engaged 0.25 mm undercut more than that engaed 0.50 mm undercut but without significant differences at the end of testing cycles ($P<0.05$). This may be due to increase the length of the retentive arm of the molar group that affect 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.

Also the results of the present study were at variance with Meenakshi et.al [15] who showed 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 subgroups there was no significant difference in clasp deformation between Co-Cr clasps that engaed 0.25 mm undercut and Co-Cr clasps that engaed 0.50 mm undercutat at the end of cycling ($P<0.05$). While in the acetal resin subgroups there was significant incerased 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 (1mm) diameter of retentive arm with the different amount of undercuts, 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 occure in acetal resin subgroup.

The pervious results of this study confirmrd the results of other deflection fatigue study that obtanied by Abd-Elrahman et al.[19] who reported that the rigidity of 1 mm diameter acetal resin clasp doesn't permit to it to engage large undercut and obtain clinically acceptable retention. Also the results of the present study were in accord with Fitton et al.[16] who stated that "the POM clasps must have greater cross-section area than metal clasps to provide adequate retention," 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. Also 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, 21] who reported that the proportional limit of acetal resin enabling it to engage large undercut. Also others [14, 22] 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 engaed 0.25 mm undercut and Co-Cr clasps that engaed 0.50 mm undercutat.
- There was significant incerased 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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