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COMPARISON BETWEEN THE RETENTIVE FORCE AND CLASP DEFORMATION OF ACETAL AND CONVENTIONAL COBALT CHROMIUM FRAMEWORKS IN REMOVABLE PARTIAL DENTURE: IN VITRO STUDY

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ABSTRACT

Objective: This study was conducted to evaluate the clasp retentive force and deformation of RPD frameworks made from cobalt chromium and acetal **Subjects and Methods:** Ten premolars natural teeth were collected and divided into two groups according to the framework material. Each tooth was embedded vertically till the cement enamel junction in one side of acrylic block. RPA clasps were constructed on each model utilizing 0.25mm undercut. Modeles were divided into two equal group. Group I contained five testing model for Cr-Co while Group II contained five testing models for acetal resin. Retention was measured by applying withdrawal force to frameworks by a universal testing machine at 5 mm/min. Deformation of clasps was evaluated by measuring the distance between 2 reference points on the tips of the retentive and reciprocal arms before and after repeated insertion/removal cycles by a chewing simulator. **Results:** Clasp deformation and retentive force showed significant difference between the two groups, cobalt chromium was greater than acetal clasp**. Conclusion:** Within the limitations of this study, it could be concluded that cobalt-chromium clasps had significant clasp deformation and retentive force more than acetal resin clasps.

KEY WORDS: Acetal, cobalt chromium, retentive force, deformation.

INTRODUCTION

Removable dentures are still an important prosthetic consideration in many oral rehabilitation situations, especially when edentulous spaces posterior to the remaining teeth need to be restored[1].

For the rehabilitation of partially edentulous patients, traditional removable dental prosthesis (RDP) with chrome cobalt frameworks and clasps have been an inexpensive and predictable therapeutic choice. Because of the disadvantages of metallic frameworks, such as the undesirable appearance of metal clasps, the increased weight of the prosthesis, the potential for metallic taste, and allergic reactions to metals, a variety of thermoplastic materials have been introduced into clinical practice [2-4].

Although cobalt-chromium is widely considered the best material for a denture framework, the main problem with traditional metallic removable partial dentures is that the rigid clasps damage the natural dentition by engaging the undercuts, as well as being unsightly and releasing toxic metallic ions that can cause a variety of tissue reactions. Response of hypersensitivity [5].

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The use of thermoplastic resins in medicine has increased dramatically over the last decade. It was first employed in joint replacement components, orthopaedic implants, total hip replacements, and as an occluder for an artificial heart valve [6].

Many thermoplastic materials including nylon, acetal resin, polypropylene, polycarbonate and polyethylene terephthalate could be used in dentistry to produce preformed clasps, occlusal splints, implant abutments. Fracture strength, wear resistance, and flexibility are all characteristics of thermoplastic resins. Because of these properties, they can be used for premade clasps and partial denture frameworks [2].

Acetal resin is a biocompatible material can be used with patient allergic to Co-Cr alloys and have good physical properties make it suitable for construction of removable partial dentures component. Also, it has a sufficiently high resilience and modulus of elasticity to allow its use in the manufacture of retentive clasps. Acetal resin is also strong, resists fracturing, and is flexible so, does not wear during occlusal forces and consequently will maintain vertical dimension over long periods of time [7].

Instead of metal alloys and conventional denture base acrylic resins, acetal resin can be utilized as an alternate denture base and clasp material [6]. The aim of this study is to evaluate the clasp retentive force and deformation of cobalt chromium and acetal RPD frameworks.

MATERIALS AND METHODS

Model construction

For this study ten testing models were constructed. According to the framework material, the testing models were divided into two groups. Group I contain five testing model for Cr-Co while Group II contain five testing models for acetal resin, each testing model having extracted natural premolar with (0.25 mm undercut). The testing models were constructed from rectangular acrylic (Stellon, DeguDent Gmbh, England) blocks with a natural tooth vertically implanted in each[8] .

In each model a premolar tooth was inserted in a hole in one side of the block till the cementoenamel junction in a position perpendicular to the superior surface of the acrylic block and its long axis was made parallel to the analyzing rod of the dental surveyor (Ney surveyor, Dentsply, USA). The tooth was luted in position by a self curing acrylic resin. After the self-cured acrylic resin had set completely the excess was trimmed, Fig (1).

FIG (1) The testing model

Framework construction

The testing model's abutment was surveyed to confirm that there were adequate undercuts (0.25mm). Unwanted proximal undercuts were blocked out with softened wax to eliminate their effect on retention force, and then trimmed using a dental surveyor's wax trimmer. To establish a distal guide plane and mesial rest seat, little tooth preparation was performed. This rest seat was triangular in shape, with the triangular base resting on the marginal ridge and the rounded tip pointing toward the tooth's center. The width of rest seat was one half of the distance between the buccal and lingual cusp tips.

Duplication of the models with investment was carried out, Cast Co-Cr alloy (Kera C, Eisenbacher

Dentalwaren ED GmbH, Germany) and acetal resin material (Bio-Dentaplast, Bredent, Senden, Germany) frameworks with RPA clasps were constructed on the investment models as follows: with a cross section that is half-round (with a 1.0mm thickness) The wax patterns for the frameworks were constructed using the RPA clasp wax pattern (Polywax, Bilkim, Izmir, Turkey). Then, using softened wax, a small rectangular piece of wax (15 mm in length, 3 mm in height, and 6 mm in width) was placed on the superior surface of the investment cast, 2 mm from the abutment's distal surface. It was connected with the wax pattern of the guide plane and the clasp by wax. A small cylindrical plastic wax sprue (20 mm in length and 3 mm in diameter) was fixed at 90 degrees to the rectangular piece of wax (to create a testing column for the framework) and 3 mm distant from the wax pattern framework's proximal plate.. Fig (2)

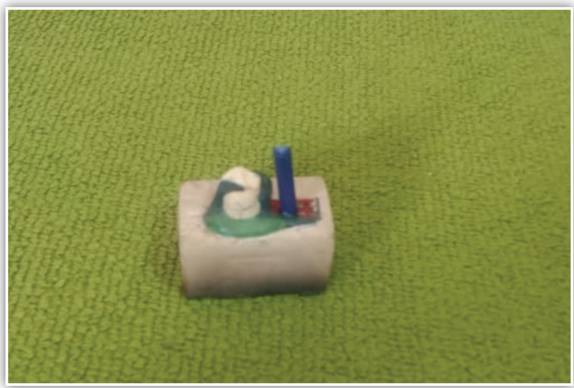

FIG (2) The investment model with RPA clasp wax pattern

Cast Co-Cr alloy (Kera C, Eisenbacher Dentalwaren ED GmbH, Germany) frameworkswith RPA clasps were constructed as conventional manner, then finished and polished.

The injection molding process of the acetal resin RPA clasps were carried out, then finished and polished as following: The flask that was used for this injection process composed of two separate parts and three holes, one part of the flask was filled with extra hard stone. The main hole of the flask was filled with wax through which the Acetal resin injection process was carried out. The framework was placed inside the unset stone while the wax sprue extended to the main flask hole. The stone and invested cast were painted with separating medium (Acrylic sep, Bredent, Senden, Germany). The counter part of the flask was placed over its corresponding part of the flask, then it was filled with mix of stone through the second flask's hole. After complete set of the stone, the flask was opened and the wax elimination process was carried out, then the flask was closed. The Acetal resin granules were placed inside the Aluminum cartridge (tube) of the thermopress 400 that was sealed by its cap. The cartridge was lubricated by cartridge lubricating material (Thermopaste 400, Bredent, Senden, Germany) and introduced into one of the two heating cylinders of the furnace. The cartridge membrane is pointed to the flask chamber.

The flask was placed over the flask heating disc of the furnace in the manner that permitted the flask's hole facing the cartridge injection hole through which the acetal resin was injected. The flask was mounted inside the furnace using the hand press of the furnace then the furnace was closed. The control panel of the thermopress (Thermopress 400, Bredent, Senden, Germany) was set so that the pre-injection temperature was reached 220 C0 within 15 minutes. The injection with heating process was performed at a temperature of 220 C0 for 1 minute, and the pressure inside the furnace was 7.5 bar.

Retention force measurement

A universal testing machine was used to measure the retention of each clasp at pretest (0 cycle) by applying withdrawal force to it (Lloyd instruments Ltd, England). The clasp removal and insertion cycling was carried out for 2920 cycles while the testing model was mounted inside the universal testing machine (corresponding to 24 months of simulated clinical use of a RPD). After 2920 removal and insertion cycles, the retention force was measured once again. At room temperature, the specimens were cycled. The machine was set to 5mm/min with a loading of 3 kg. The retention force was considered as the maximum load that required to remove the clasp at 2920 continuous cycles, and it was recorded by the computer software (Nexygen-MT; Lloyd instruments).

Clasp deformation

A digital caliper was used to measure the distance between the tips of the retentive and reciprocal arms of each clasp before and after the 2920 cycles to evaluate clasp deformation.

Statistical analysis

Data was collected, tabulated, and statistically analyzed by SPSS© 20 for windows. The data distribution of normality was done by using Kolmogorov-Smirnov test. The test showed parametric distribution of data for clasp deformation and retention force. Comparison of the two groups (Cobalt chromium and Acetal) for the parametric data was done by independent t-test and one-way ANOVA. Post hoc turkey test was used for comparison between the different times. For the non-parametric data, comparison between the two groups was done by Wilcoxon signed rank test, and Friedman test with post-hoc Dunn was used for comparison between different time. The level of significance was set at 0.05 alpha level ($p<0.05$).

RESULTS

Retentive force and clasp deformation:

Mean values of retentive force and clasp deformation for different groups are shown in table (1). It was found that group I (cobalt chromium) record higher mean value than group II (acetal). Independent t-test showed significant difference between the two groups. Regarding the effect of cycling on retention in each group the results revealed that cobalt chromium showed signifigant reduction in retention on cycling up 2920 cycles while acetal showed non significant reduction in retention after cycling. ($p<0.05$).

TABLE (1) Mean values for retentive force (kgm) and clasp deformation (mm) with Inde-pendent t-test for comparing between the two group ($p<0.05$).

Group		Mean± SD	T	P
Cobalt chromium clasp	Retention before cycling	0.953±0.019	2.364	0.00*
	Retention after cycling	0.7451±0.0038		
Acetal clasp	Retention before cycling	0.601±0.267	2.364	0.375
	Retention aftercycling	0.512±0.0816		
Retentive force of cobalt chromium clasp Vs acetal clasp before cycling			2.234	0.00267*
Retentive force of cobalt chromium clasp Vs acetal clasp after cycling			2.144	0.0389*
Clasp deformarion (mm)	Cobalt chrom	0.04230±.019	2.144	0.00005*
	Acetal	0.006120±.0004		

*t: Independent t-test   p: p-value for comparing between each group *: Statistically significant at (p≤0.05)*

DISCUSSION

The demand for esthetic dental restorations has been increased due to an importance on physical appearance in modern society. Materials for clasps and frameworks of RPDs need to have enough flexibility for the clasps and rigidity for other framework components. Therefore, CoCr is the most popular alloy for the frameworks of RPDs. The biggest disadvantage of CoCr clasps is their poor esthetic appearance. Tooth colored clasps made of thermoplastic resins have been developed to overcome the aesthetic problems [(9)].

Based on the results of the present investigation, the retention forces of group I (cobalt chromium) record higher mean value than group II (acetal). With significant difference between the two groups. This could be due to the flexibility and the lack of stiffness of acetal when compared with cobalt-chromium. These results indicate that the properties of the different materails used have an effect on stress values [(10)].

These results agree with a study compared the retentive force and deformation of acetal resin and cobalt-chromium clasps after 36 months of simulated clinical use. It was concluded that the retentive force of cobalt-chromium clasps remained much higher after deformation than the retentive force of acetal resin clasps of both thicknesses [(8)].

A study comparing the retentive force and deformation of acetal resin and cobalt-chromium clasps found similar findings. Cobalt-chromium clasps were shown to have a higher retention force than acetal resin clasps [(11)].

It was revealed in a study conducted to evaluate the retentive force of clasps constructed from three different materials (PEKK, acetal resin, and cobalt–chromium). Resin clasps had much lower retentive force in both dimensions than Co-Cr clasps [(12)].

According to the results of this study, the retention of cobalt chromium showed a significant reduction in retention after cycling for 2920 cycles, but the retention of acetal showed no significant loss in retention after cycling. This could be due to the cobalt chromium's permanent deformation and the acetal's resilience. These results agree with a study that evaluated the effect of cycling on the retentive force of cobalt-chromium and acetal clasps and found that acetal showed no change in retention after 1,200 cycles, while cobalt-chromium showed a significant reduction in retention after more than 800 cycle. In spite of this reduction in retention in cobalt chromium, it is still higher than that in acetal. It was concluded that cobalt-chromium clasps showed higher retention than acetal resin clasps despite the deformation encountered in the former[(13)] .

A study was conducted to evaluate the retention qualities of the cobalt-chromium clasp. The mean value of tensile force required to dislodge Akers cobalt-chromium clasp was 1,785 gm, according to Soo and Leung (1996) [(14)]. According to Morris et al (1983)[15] a cast circumferential clasp with different dimensions and a 0.25 mm deflection can create 970 to 3,140 gm of force under stress and it was found to be 3,085.5 gm by Cameron and Lyons (1996)[(16)]. The differences in retention forces between these investigations could be due to variances in the dimensions of the wax pattern used to make the clasp, the amount of deflection, the clasp's elasticity, and the type of testing model used. Wear did not seem to be the reason for retention loss, as in a study by Helal (2004) [18,] who mentioned that there was no significant effect of both the wear of different abutment materials and different clasp designs on the retention loss after 16,000 cycles.

In the present study it was found that the clasp deformation of group I (cobalt chromium) record higher mean value than group II (acetal). With significant difference between the two groups. This could be due to acetal resin and Co–Cr materials have different modulus of elasticity. These findings support Arda and Arikan's findings that, despite the presence of evidence of deformation in the Co–Cr clasps, no deformation was observed in the acetal resin clasps over a simulated 36-month period [8] **.**

Another study that conducted that acetal resin has superior flexibility which allows its use in larger retentive undercuts such as in inter-proximal area[11]**.**

At the same time, these results were disagree with Lopes et al., who found that acetal resin clasps had a higher deformation value than Co–Cr clasps, and Wu et al., who found that acetal resin direct retainers had higher deformation after 3 years of simulated use [18,19]**.**

CONCLUSION

Taking into account the limitations of this study, it can concluded that cobalt-chromium clasps had significant clasp deformation and retentive force more than acetal resin clasps.

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