Flexibility and Fatigue Behavior in Metallic and Esthetic Clasps: A Comparative Study

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Abstract

This study compared flexibility and fatigue behavior for Cobalt Chromium (CoCr) and Acetal Resin (AR) clasp materials In-vitro.

Forty straight half-round specimens were used with 1.2 mm thickness, 1.5 mm width, and 20 mm length. Twenty samples for each of CoCr and AR. Each group was divided into two groups equally to evaluate flexibility and fatigue.

A masticatory simulator was used to evaluate the static fatigue, while the flexural strength was measured by equation 3FL/2bd2.

The data was collected by software connected to the testing machine using SPSS version 20. The obtained data were statistically analyzed using an unpaired t-test. The level of statistical significance was $P < 0.05$

The result revealed a statistically significant difference in the flexibility between Cobalt chromium and resin as clasp materials. While for the fatigue test, there was no statistical significance difference between CoCr and AR.

The fatigue behavior of AR clasp material was relatively the same for Co-Cr. In contrast, AR material showed higher flexibility than CoCr.

AR clasps might be used to fabricate RPD as they provide high fatigue resistance, high flexibility, and adequate retention with fewer compression forces on the abutment teeth.

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Introduction

A removable partial denture (RPD) is one of the treatment options for replacing missing teeth. The RPD Clasps are essential components in improving denture retention. Metal clasps were the first to use, but the increasing esthetic demand increased the need for a non-metal clasp.

Achieving an optimum esthetic, retention, and maintaining the integrity of the health of the abutment are the most significant factors for clinical success[1].

Many ways can be used to improve the esthetic, e.g., lingual positioned clasps, mesiodistal clasps, gingival approach instead of occlusal approaching clasps, and via tooth-colored resin clasps [2].

The physical and mechanical properties and clinical situations play an essential role in selecting prosthetic materials and esthetic criteria. RPD retention depends on the amount of undercut engaging the abutment tooth and the flexibility of the clasp. Flexibility depends on the material and length of the clasp [3].

Fatigue is a critical property, as it is the most significant cause of failures in RPD clasps. Permanent deformation can cause fatigue fracture under repeated flexures during denture insertion and removal [4].

The most common alloy used for RPD is cobalt-chromium (CoCr) for its physical and mechanical properties and biocompatibility with oral tissue [5].

Acetal resins (AR) is thermoplastic resin material available in the market since 1971 and has significantly grown in dentistry in the last decade for agreeable physical and mechanical

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properties and biocompatibility. Many patients appreciate AR resin due to its esthetic properties (tooth-color).

Previous studies had revealed apparent data regarding the flexibility and fatigue behavior of Esthetic resin clasps.

The present study assessed and compared the flexibility and fatigue behavior of metallic and nonmetallic (esthetic) clasps.

Materials and methods

Acetal resin (AR) and conventional Co -Cr alloy were evaluated in this study. The composition of Acetal Dental is Polyoxymethylene (Dental Srl, San Marino, Italy). CoCr alloy composition is Co 64%, Cr 28, 6%, and Mo 5% (Bego, Bremen, Germany).

Samples fabrication: The in-vitro study was conducted to evaluate the flexibility and fatigue behavior of AR and Co-Cr clasp materials. Forty straight half-round specimens were used with 1.2 mm (about 0.05 in) thickness, 1.5 mm (about 0.06 in) width, and 20 mm (about 0.79 in) length. Twenty samples for each tested material (CoCr and AR) were divided into two groups; each subgroup was ten samples.

A laser-melting machine was used to prepare and standardize the samples.

Test procedures: compression stress was applied using a masticatory simulator to perform the flexibility and fatigue test (Willytec, Munich, Germany) (Fig.1). Each specimen was fixed to the upper part of the machine with auto-polymerizing acrylic resin. The test conditions were maintained at room temperature (23±2 °C). The fatigue test was carried out until permanent deformation was detected.

The equation for measuring the flexural strength was 3FL/2bd2, which was used to determine the flexibility. Where (F) is the maximum load in Newton, (L) is the distance in millimeters between the supports, (b) is the width in millimeters of the specimen, and (d) is the thickness of spacemen in millimeters.

Software connected to the testing machine was used for data collection.

Statistical analysis: Data was statistically analyzed using an unpaired t-test, SPSS version 20. The level of statistical significance was $P < 0.05$.

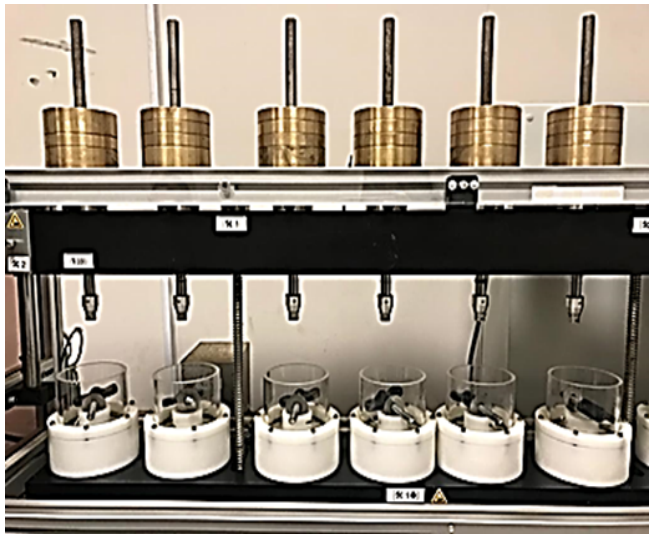

Figure 1. Masticatory Simulator Machine.

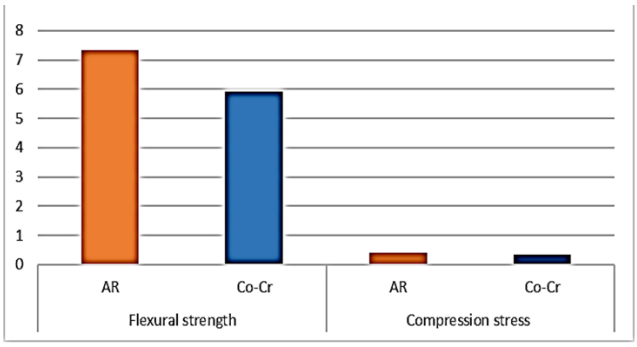

Figure 2. Flexure strength and compression stress for flexibility test.

Results

In the present study, 40 samples were evaluated for the flexibility and fatigue behavior of Acetal resin (AR) and Cobalt chrome (Co-Cr) as clasp materials using the fracture load and compression stress as an indicated value for flexibility and fatigue.

Flexibility test: The mean flexural strength of Co Cr was 5.93 + 1.10, while for AR was 7.34 + 1.07, with P-value = 0.01, which means that there was a statistically significant difference in the flexibility between Cobalt chromium and resin as clasp materials for RPD. In addition, the mean compression stress of Co Cr was 0.336 + 0.062, and resin was 0.416 + 0.060. Despite the differences in withstanding the compression stress for tested samples, the result displayed a statistically significant difference between the compression stress for Co-Cr and resin samples; the P-value was 0.01 (Table 1& Fig.2).

	Type of material	Sample no	Mean	Std. Deviation	P-value
Flexural strength	AR	10	7.34	1.074	*0.01
	Co-Cr	10	5.93	1.101	
Compression stress	AR	10	0.41	0.062	*0.01
	Co-Cr	10	0.33	0.060	

Table 1. The mean and standard deviation (SD) of flexural strength and compression stress for the flexibility test.

	Type of material	Samples number	Mean	Std. Deviation	P-value
Fracture load	AR	10	53.46	2.672	0.5
	Co-Cr	10	56.58	2.293	
Compression stress	AR	10	3.02	0.151	0.5
	Co-Cr	10	3.20	0.129	

Table 2. the mean and standard deviation (SD) of fracture load and compression stress for the fatigue test.

Fatigue test: The mean fracture load of resin and Co Cr samples were 53.46 + 2.67 and 56.58 + 2.29, respectively. The result revealed that there was no statistical significance difference. In addition, the mean value for compression stress of resin samples was 3.02 + 0.15, and Co Cr was 3.20 + 0.12. The results showed no statistical significance difference between the tested materials; the p-value was 0.5 (Table 2 & Fig.3).

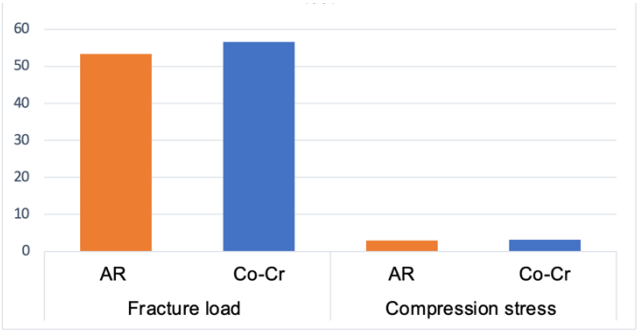

Figure 3. Fracture load and compression stress of AR and CoCr.

Discussion

Materials for removable partial denture (RPD) clasps should have sufficient flexibility to avoid permanent deformation. Co Cr is the most popular alloy for RPD. The main disadvantage of CoCr clasps is their poor esthetic. Thermoplastic resin clasps have been developed to overcome the esthetic problems in metal clasps [6].

In this study, Co-Cr alloy served as the control group. In contrast, AR served as a test group to evaluate the fatigue and flexibility properties as a fracture load and flexural strength. Whereas the flexibility of a clasp depends on its section, length, thickness, and material, the dimensions of the samples for control and test groups were the same to compare the flexibility and fatigue for Co Cr and AR.

All previous studies had used dynamic fatigue and reported edge fractures that affected the data and results. Cyclic fatigue tests have a wide range of different designs, making the results hardly comparable. Many factors could influence the dynamic fatigue test, e.g., temperature, the direction and forces applied during insertion and removal of RPD, amount of undercuts, and types of clasps [7].

In the present study, static fatigue was used to overcome the previous factors and get reliable data Fatigue is the particular cause of failures when Clasps undergo permanent deformation. Fatigue in CoCr clasps is estimated at 90% of failures; polymers are also liable to fatigue failure. Fatigue results from stressing due to repeated flexures during denture insertion and removal and masticatory actions [8]. Permanent deformation and fatigue fracture caused by the stress created in the clasp [9-10].

The stress distribution may depend on the material's elastic modulus and the clasp's dimensions. In addition, RPD clasps should induce less stress on the abutment teeth to avoid destructive forces on them. The results revealed that Acetal resin had higher values of flexibility than Co Cr samples, enabling Acetal to withstand higher deflections in clinical uses[11-12].

The null hypothesis was rejected based on the obtained results; there was no significant difference in fatigue between AR and Co-Cr clasp materials, but there was a statistically significant difference in flexibility.

Turner et al. 1999examined the flexural properties of thermoplastic resin to determine the appropriate designs for the RPD clasp. They suggested that the resin clasp must have a diameter of approximately 1.4 mm to have a stiffness similar to a cast CoCr clasp of 1 mm in diameter. The results of the present study verify that the diameter does not affect fatigue or flexibility [13].

In the current study, the mean of flexural strength for testing the flexibility of AR samples was 7.34548 and for CoCr samples was 5.93942. The result confirmed that AR clasp material might

give less compression load on the abutment teeth and improve the health of the abutment health.

These results showed that AR clasps might be used in the fabrication of RPD as they provide high fatigue resistance, high flexibility, and adequate retention with fewer compression forces on the abutment teeth.

Conclusions

The present study clarified that the fatigue behavior of resin clasp was the same for Co Cr clasps. In contrast, Acetal resin material showed higher flexibility than Co Cr.

Acetal resin clasps might be used in the fabrication of RPD as they provide high fatigue resistance, high flexibility, and adequate retention with fewer compression forces on the abutment teeth.

Declaration of Interest

The authors report no conflict of interest.

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