# Retentive forces, tensile strength and deflection fatigue of Acetal thermoplastic clasp material in comparison with cobalt-chromium alloy

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## ABSTRACT

**Background**: Nowadays there is an increasing of the emphasis on aesthetic, dentist have been concerned about providing aesthetics and functional removable partial dentures to their patients and this was make the mission more difficult because of the goal now is achieving optimal aesthetic of the denture - while maintaining retentive, stable, and conservative to the health of supporting tooth and supporting tissue. The traditional use of metal clasp like cobalt-chromium, gold, stainless-steel and titanium hampers esthetics because of its obvious display conflicts with patient's prosthetic confidentiality. Acetal resin (poly oxy methylene) may be used as alternative denture clasp material. This material was promoted primarily on the basis of its superior esthetic.

**Material and method:** In this study, Acetal resin of Flexite and co-cr alloy of Wirocast companies were used. Four metal models of two premolars and two molars were surveyed to have 0.25mm and 0.5mm undercut depth for each one of the materials. eighty clasps were prepared and tested by testing machine to measure the load required to dislodge Acetal and co-cr clasps of 2mm. thickness (for premolar and molar). Tensile test were utilized for both Acetal resin and co-cr. tensile values will be used in special formula to calculate the amount of deflection.

**Results**: The results of this study revealed that Acetal resin clasp of molar with 0.5mm undercut depth have the higher retentive force, and premolar with 0.25 mm undercut depth have the lowest retentive force as compared to co-cr. Also Acetal had lower values of the tensile strength as compared to co-cr alloy but it had higher deflection value than co-cr and it can withstand higher deflections than those of co-cr before having permanent deformation or fracture

**Conclusion**s: Acetal resin can be used with limitation as an alternative to co-cr alloy clasps in removable partial dentures.

**Key words**: Acetal resins, aesthetic, fatigue, tensile strength. **(J Bagh Coll Dentistry 2014; 26(1):59-66).**

## INTRODUCTION

Patient demands a removable partial denture for health, anatomic, psychological or financial reasons. Patients often cite lack of retention and poor esthetics as a reason for not wearing their partial dentures. Metal display on anterior teeth was often unacceptable [1]. Aesthetically pleasing removable partial denture (RPD) is a partial denture that blends in with the natural dentition and the one that does not show any indications of being a removable partial denture. Removable partial dentures made without a metal substructure are more aesthetically pleasing. The use of metal clasp on anterior teeth may cause esthetic problem. Many methods to overcome this dilemma include the painting of clasps with tooth colored resins [2,3], use of lingual positioned clasp [4,5],engaging of mesial rather than distal undercut [6] ,and use of gingival approaching clasp.

The most common alloys used for clasp are chrome-cobalt alloy, gold and titanium alloy, although these may be retentive but not esthetic [7]. So the need of alternatives nowadays to overcome esthetic problems was increased. Many alternatives had been introduced.

Acetal (POM) is one of the materials that used to replace metal clasps. This material had superior aesthetic and BioCompatible which make it considered in the treatment of patients who are allergic to Co-Cr alloys or acrylic [8], but also it should provide appropriate retention when it used as alternative clasp to many others like Co-Cr, gold, acrylic removable prostheses. Also it should have enough mechanical properties to withstand forces and environment of oral cavity and have appropriate life time within this environment because clasp of any removable prosthesis will subjected to many forces and cyclic bending during insertion, removal and during mastication which make the retentive clasp arm the most part to be damaged [9].

## MATERIALS AND METHODS

Four wax models were prepared by taking silicon impression to premolar and molar models. Then the impression was poured with crown and bridge wax, four wax models of two premolars and two molars were surveyed to have 0.25mm and 0.5mm undercut depth for each one of them. These wax models was casted to metal. Then these models was duplicated with poly vinyl siloxsane duplicating material and then poured with type IV stone for waxing and injecting of Acetal clasps, while it was invested with

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phosphate- bonded investment material, for waxing and casting of co-cr.

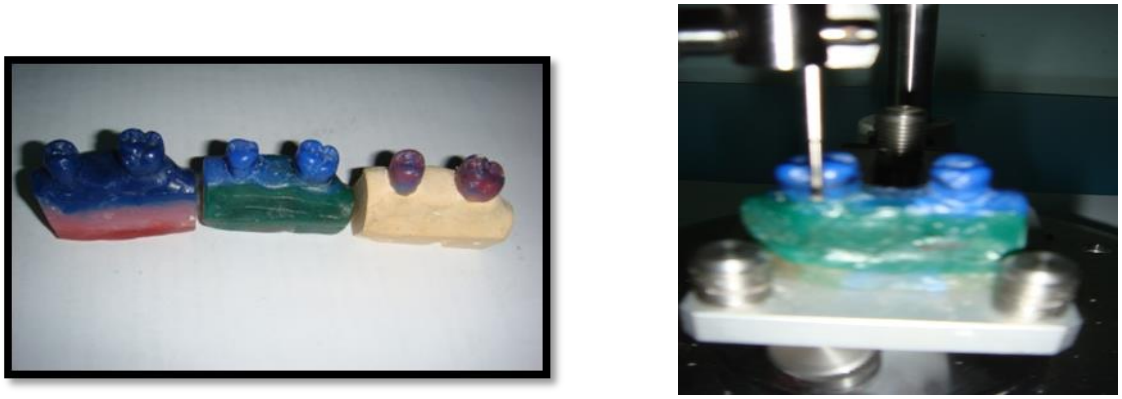

**Figure 1: Wax models and surveying on the dental surveyor for undercut adjustment.**

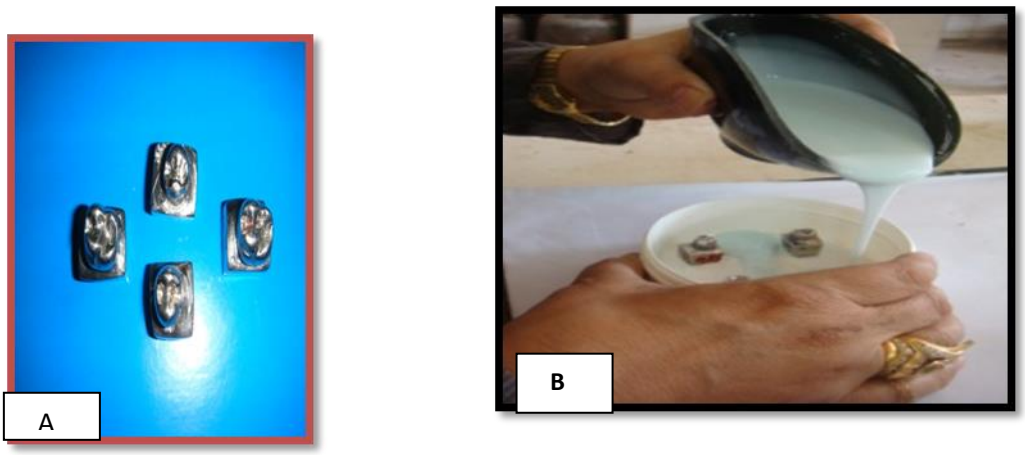


**Figure 2: Wax models after casting by crown and bridge metal. B. Duplication of the metal models by poly vinyl siloxane duplicating material.**

Ready-made clasps of 2 mm thickness were waxed on the stone and investment models. Stone models with readymade clasp have been flasked with the special flask of the device and boiled in hot water for about 30 minute injected with Acetal by Thermoplastic injection machine. (Flexite, U.S.A., GN 30 Pneupress).


**Figure 3: Acetal flexite injection machine.**

The phosphate bonded investment models have been flasked and casted with co-cr metal type wirocast-Germany. Eighty clasps were prepared, forty clasps of Acetal and forty for co-cr clasps.

The clasps were tested with Tinius-Olsen universal testing machine to measure the load required to dislodge Acetal clasps and co-cr clasps of 2 mm. thickness (for premolar and molar) and two different undercut depths (0.25 and 0.5mm) from the metal models. The values for both materials were compared.

Beside the retentive force, a comparison of the tensile test and the amount of deflection needed to deform Acetal resin and co-cr samples was done. Tensile Dumbbell shape samples were prepared for both Acetal resin and co-cr according to ASTM 638/type V/2. The samples were prepared in the same technique of clasps preparation. Ten samples have been prepared five for Acetal group and five for co-cr.

**Figure 4: Testing procedure of Acetal and co-cr clasps,**

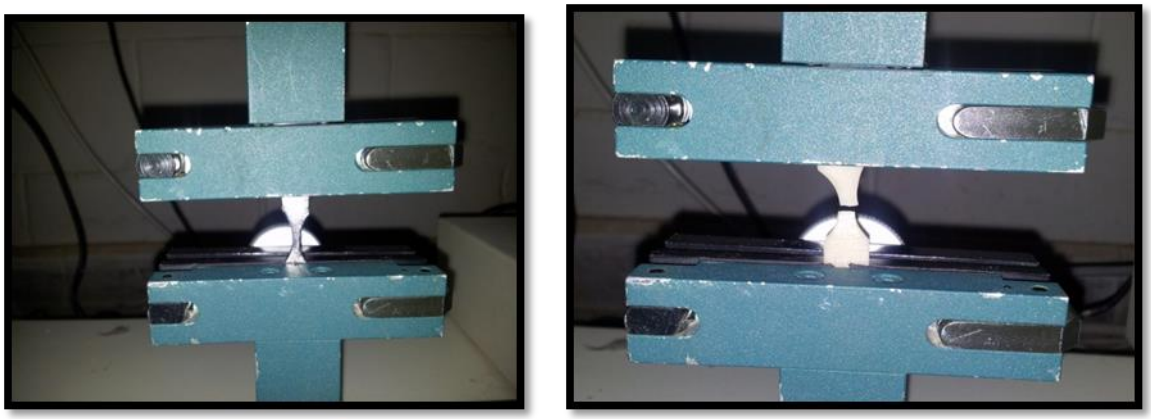

**Figure 5: Testing procedure of Acetal and Co-Cr tensile samples.**

## RESULTS

The results revealed that Cr-Co alloy clasp had higher retentive force values in comparison with Acetal thermoplastic clasp.

For co-cr group, results showed that retentive force mean were 13.05N and 17.61N for premolar teeth with 0.25mm and 0.5mm respectively. While for molar teeth it was 16.96N and 24.79N for 0.25mm and 0.5 mm undercut respectively. The premolar group showed that 0.25mm undercut premolar had the lowest value of (13.05N) of the retentive force.

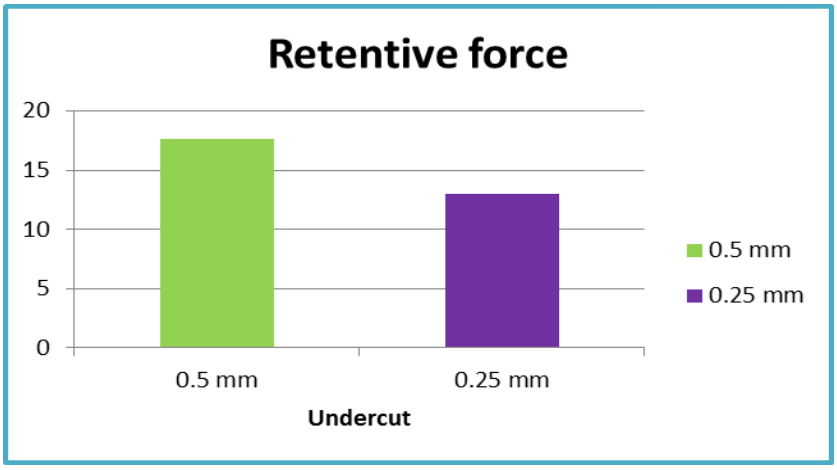


**Figure 6: Histogram show subgroup difference of premolar teeth with different undercut in Co-Cr type.**

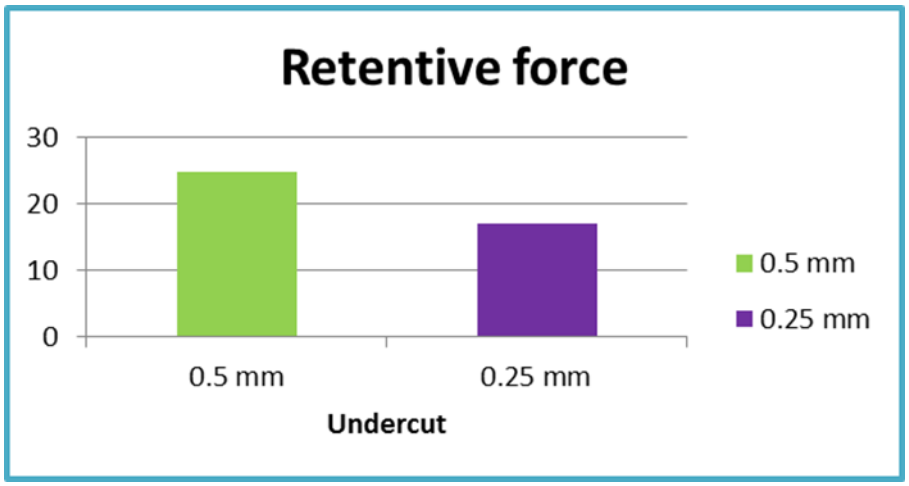


**Figure 7: Histogram of subgroup difference of molar teeth with different undercut in Co-Cr type.**

For acetal group specimen, Also molar with 0.5 mm undercut showed the higher retentive force while premolar with 0.25 mm undercut showed the least one. Careful analysis by t-test was used also to compare the retentive force. The statistical analysis showed also a very highly significant difference in the retentive force of Acetal clasp between 0.25mm and 0.5mm under cut depth for both premolar and molar groups.

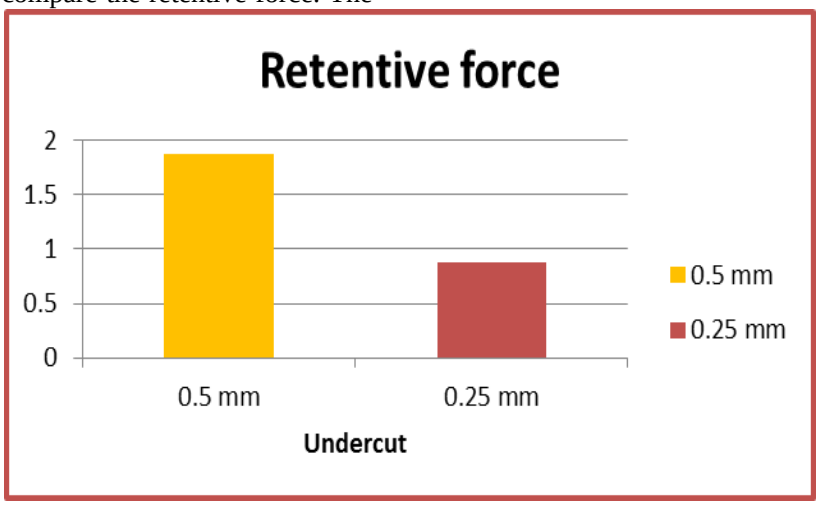


**Figure 8: Histogram of show subgroup difference of premolar teeth with different undercut in Acetal type.**

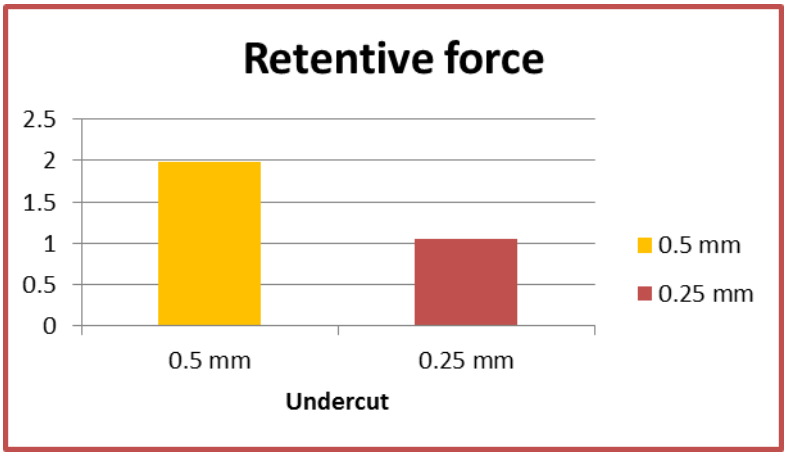


**Figure 9: Histogram show subgroup difference of molar teeth with different undercut in Acetal type.**

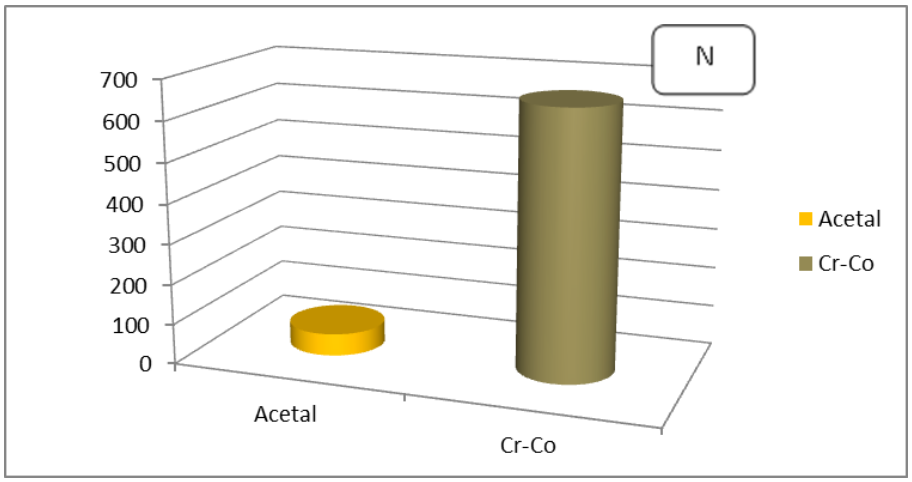


**Figure 10: Tensile strength difference between Co-Cr and Acetal.**

**Tensile strength of Cr-Co and Acetal samples**

Co-Cr samples was showed higher tensile strength mean (659.2 MPa) while Acetal samples showed lesser values of (55.232 MPa).

**Deflection of co-cr and Acetal**

The resulted data showed that metal co-cr have lesser mean deflection (0.65mm) as compared to Acetal that had higher mean deflection (4.22mm).

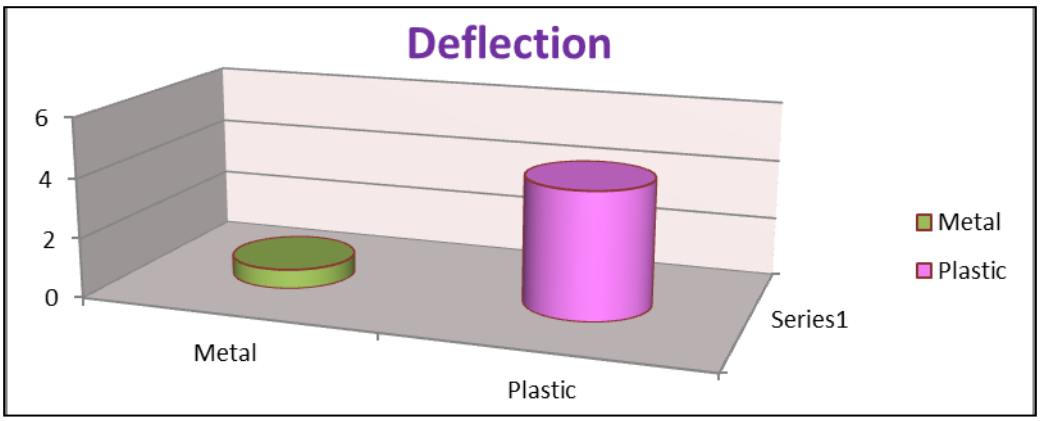


**Figure 11: Histogram showed deflection difference between acetal and co-cr.**

# DISCUSSION

**Retentive force**

Acetal resin is marketed for direct retainers attached to co-cr R.P.D.f ramework, as well as supportive frame in R.P.D. Acetal resin has a relatively high proportional limit with little viscous flow, enabling it to behave elastically over a large enough range to be used as a material for clasp fabrication [10] .

According to Fitton et al who stated that to gain adequate retention from Acetal clasps, the clasp should have a greater cross- sectional area than metal clasp and this study was confirm these findings. Therefor a 2mm thickness of clasp was used for comparison in this study.

The thicknesses of clasps were used with the same length of clasp for both Acetal and co-cr due to several reasons: a, to standardize the study group .b, to give Acetal clasps diameter greater than 1.4mm In diameter. C, this diameter was used for both Acetal and co-cr because there was a theory of that a greater retention would be expected for Acetal resin clasps in the proposed models since reciprocal arms were made in co- cr alloy. It would be a new way to use Acetal resin to make R.P.D. clasp [11]

According to Bates [16] who stated that the assessment of stress in the retentive clasp arm would depend on the degree of undercut used together with the form of the clasps, and the mechanical properties of the alloy used. Therefore two gauges of the undercut have been used 0.25 mm and 0.5 mm in molar and premolar.

In concerning the retentive force of Acetal resin clasps in the present study, it was found that molar with 0.5 mm. undercut of Acetal clasp had the higher mean retentive force (1. 99N.) And this value was not very higher than retentive force in premolar with 0.5mm. (1.87N.) and it was higher than premolar with 0.25mm. (0.88N.).

So this study was partially agreed with Turner et al [8] who suggested that in clinical use, Acetal resin clasps should have shorter length, a relatively larger cross-sectional area and engage deeper undercut to have adequate retention. That mean premolar clasp should have greater retention force according to Turner et al theory, But the results of this study showed that decreasing of the length in premolar than that of molar has constricted effect not very highly effect and values of the retentive force for both premolar and molar which were still within the same range. Also this study was not agreed with Arda and Arikan [11] who suggested that the retentive force of premolar with 0.5 and 0.25mm is higher than molar teeth because of the shorter length of clasp. Conversely there was non-significant difference between molar and premolar Acetal clasps in both groups of undercut depth 0.5 and 0.25mm.

For the effect of different tooth types molar or premolar, In molar teeth, Acetal clasp had higher retentive force than those in premolar teeth in both depth of undercuts 0.25 and 0.5mm that mean the longer the clasp was the more retentive force, but Turner et al [8] and Arda and Arikan [11] and stated that because of the flexibility of Acetal resin clasp, it should be shorter than co-cr conventional clasp and higher cross-sectional area. They stated that in premolar teeth, Acetal had higher retentive force than molar teeth, so this study was not agreed with the theory of Turner et al [8] and Arda and Arikan [11] who focus on the flexibility of acetal which constrict the shortening effect of the clasp and agreed with this study. According to these theory multiple Acetal clasp can be used in R.P.D. design to reach the needed amount of retention and this was agreed with Lekha et al [12] conclusions statement that acetal resin provide less retention compared to cr-co. so further studying have to be done regarding various thickness and designs of clasps and frame work for its successful dental application [13].

**Tensile strength**

In concerning the result showed that the mean tensile force of Acetal was lower than that of cr-co samples. According to Craig's and power, the microstructure of any substance is the basic factor that its control properties. A change in physical properties of a material is a strong indication that there must have been some alteration in its microstructure.

Acetal resin as a polymer had a behavior fundamentally different from both ceramics and metals, so when chains of polyoxymethylene are aligned parallel to one another are subjected to tensile stress along their long axis. The stress required to stretch the atoms in the chains was surprising high. But if the stress perpendicular to the long axis of the chain it would be very low. The higher stress in the first case was caused by strong bonds between atoms within polymer chain, but the low stress in the second case because of the weak bonds between adjacent chains [14]**.** While cr-co in the cast condition is inhomogeneous, consisting of matrix composed of a solid solution of cobalt and chromium in a cored dendritic structure. [15]. Cobalt and chromium are body –centered cubic unit cells which have densely packed planes of atoms in their lattice to allow plastic deformation at yield stress, thus a greater resistance to slippage is created. When this complex process was imagined, there was impression of the higher stresses needed to elongated and fracture cr-co samples [14].

**Deflection of cr- co and acetal**

The amount of undercut used must be less than the deflection of the clasp at which the proportional limit will not exceeded and then permanent deformation would result. This is suggested by Bates who found that the minimum workable undercut is 0.25mm.An optimal degree of undercut that should be engaged by any particular clasp depend specially on the material of the clasp, other wise there will be ability to traumatize tooth upon insertion and removal and permanent deformation of the clasp [16].

According to the definition, the clasp would be deflected multiple times each day and there is a large relation between the amount of deflection and number of deflections on the fatigue of the clasp because the amount of deflection and number of cycles affect the propagation of fatigue process and fatigue process is an acumulative process. clinically repeated deflection of the clasp is occur during insertion and removal of the clasp from the tooth. This may cause clasps fatigue and fracture [7,17]. Results showed that the mean deflection of acetal resin (4.22 mm.) was higher than those of co-cr samples (0.65mm).

In this study, the results were revealed that if a cr- co clasps was subjected to cyclic bending in minimum deflection, fatigue and fructure failure is not likely to occur which is in agreement with previous clinical observations of Harocourt and Brock and other fatigue testing like Earn show, Asgar and Peton, Morris et al, Bridgeman et al [21,22,9,19]. But adeflection of 0.5-0.6 could cause permenant deformation in the clasp especially with increasing number of stress during insertion and removal of the denture and this will give another disadvantages of using co-cr in deep undercut according to Bates [16] not only because of increase stress of the abutment tooth. But it would cause permenant deformation of the clasp because the amount of deflections during insertion and removal will exceed the proportional limit of the material [16,18,19].

On the other hand acetal resin clasps have higher flexibility and higher deflections which represent greater resistance to fatigue of clasps during daily insertion and removal; because of its wide range of deflection below acetal proportional limit when compared to cr-co ones which allow the retentive clasp arm to be placed in deeper undercuts on abutment. these results were agreed with Sykes et al [1] and Arda –Arikan [11]. Also, this greatest deflection without stress on the abutment of acetal resin could be good property to indicate its ability to be used on periodontally compromised teeth and this is agrement with Sykes et al and Vondenbrink et al [1,20]

As conclusions

1. Acetal resin can be used with limitation as an alternative to co-cr alloy clasps in removable partial dentures.
2. The mean retentive force required to remove Acetal resin clasp was found to be significantly lower than those required to remove co-cr clasp.
3. Acetal resin can be used as an alternative for co-cr clasp in periodontally compromised patients because Acetal has lesser stress on the abutment tooth.
4. Acetal resin clasps can be used as an alternative for co-cr clasp in molar tooth with 0.5mm. Depth of undercut where the use of co-cr clasp may lead to unwanted tooth movement.
5. Acetal resin samples had less tensile strength as compared to co-cr samples.
6. Acetal resin samples had higher values of deflection ranges as compared to co-cr samples which enable acetal to withstand higher deflections in clinical uses without changes or permanent deformations or fracture.

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