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COMPARISON BETWEEN TWO DIFFERENT UNILATERAL MANDIBULAR PARTIAL DENTURE DESIGNS RETAINED BY EXTRA-CORONAL ATTACHMENT. AN IN-VITRO STUDY

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ABSTRACT

Objectives: The objective of this study was to compare the strain induced around the abutment teeth that support unilateral mandibular removable partial dentures with two different designs retained by extra-coronal attachment.

Materials and methods: This in-vitro study was performed on one epoxy resin Class II mandibular partially edentulous model. The last two abutments were prepared using tapered diamond stone with round end to receive a PFM bridge. The wax pattern of the bridge was then carved and the plastic pattern of the male part of the attachment was attached to the distal surface of the second premolar. The assembly was then casted, finished and polished and then cemented to the abutments. Two unilateral partial dentures with two different designs were then constructed on the model. The model was prepared around the abutments to receive the strain gauges. Force was then applied on the prosthesis using the universal testing machine and strain induced around the abutments was assessed.

Results: The results of this study showed that the strain induced around the abutment teeth supporting the unilateral removable porcelain bridge retained with extra-coronal attachment was higher than that induced when using a unilateral skeletal partial denture with combined denture base.

Conclusion: The material and design of the partial denture, whether acrylic resin or porcelain, had an effect on the strain induced around the abutment teeth. The unilateral skeletal partial denture with combined denture base might transfer less stresses to the supporting abutments than the unilateral removable porcelain bridge. But the results might differ when applying this study in-vivo due to the presence of other variables like the presence of the periodontium and the soft tissue covering the alveolar ridge which is not simulated in our study.

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INTRODUCTION

Partial edentulism is a problem that affects a wide range of the population leading to functional, esthetic and psychological problems and hens affecting quality of life. In the past the only rehabilitation for those patients was conventional partial denture [1].

Class I and II Kennedy class are the most problematic classes that requires special attention. The main problem of these classes is support due to difference in resiliency between the teeth and soft tissue covering the edentulous ridge. This will produce stresses on the residual ridge and abutments thus with time, irreversible and progressive residual ridge resorption occurs with unfavorable loading of abutment teeth[2-5].

There are different treatment options that are available for treatment of free end saddle cases including conventional clasp retained removable partial denture, attachment retained partial denture and implant- supported or retained partial denture[6,7,8-11].

Patient acceptance of clasp-retained RDPs has been negatively affected by unaesthetic metal display, poor retention and technical errors. Attachment provides an effective alternative to clasp as it provides satisfactory retention, stability and high esthetics so it is very acceptable for the patients. There are many types of extracoronal attachment that could be used for unilateral free end saddle cases that provides better stress distribution as well as high esthetics[12,13].

The main goal of any prosthetic rehabilitation is improving the quality of life for the patients together with improving in the overall health of the patient and preserving the remaining oral tissues [14,15].

There are many methods and techniques that applies mechanical and engineering principles to analyze the patho-physiological changes of the oral and maxillofacial region which allows analysis of stress and strain which are necessary to study the mechanics of oral components [16,17].

Methodology

Study design: This in-vitro study was performed on Class II mandibular partially edentulous epoxy model. Two unilateral removable partial dentures with two different designs retained with extra-coronal attachments were constructed on the same model. Force was then applied on the partial dentures and strain induced around the abutments was assessed using the strain meter.

Research question

Will the design and material of the unilateral attachment retained removable partial denture affect the strain induced around the supporting abutments teeth or not?

Preparing the epoxy model

An epoxy resin model with unilateral partially edentulous span was used in this study with the second premolar as the last standing abutment. The last two abutments (lower right premolars) were prepared using tapered diamond stone with round end (Mani Inc, Rs-11, Japan) to reduce 2mm from the occlusal surface and 1.5mm from each axial surface to receive PFM bridge.

Addition silicone (Replisil 22 N addition curing duplicating silicone, Germany) was used to duplicate the study model into extra hard dental stone. Dowl pin were prepared, and the removable dies were detached from the cast using diamond separating disc.

Bridge construction with the extracoronal attachment

The wax pattern of the crowns was prepared, (Renfert grey wax, Germany) with a lingual ledge carved on its lingual surface with the help of dental surveyor. The two patterns of the two abutments were connected as one unit.

The male part (matrix) of the rk-1 unilateral extra-coronal attachment was attached to the distal surface of the wax pattern of the lower right second premolar using blue casting wax (Renfert blue wax, Germany) using the paralleling mandrel on a surveyor. A 2 mm space was left beneath the ridge.

The wax patterns and the matrix were then sprued, flasked, and invested with phosphate bonded investment material (Bellavest T.Bego, Bremer Gold Schlagerei Wilhelm, Bermen, Germany). The conventional casting procedures were then followed to obtain a Co-Cr bridge. Porcelain was then fired as buccal facings over the metal crowns of the abutments. The prosthesis was cemented on the epoxy resin cast by glass ionomer (Medifil, Promedica, Germany).

Preparation of the metal frameworks for Group I (Figure 1):

After blocking the space under the matrix of the attachment using utility wax, a 2-step impression was taken for the cast using putty and light addition silicon material (Zetaplus, Zhermach, Germany). The impression was poured using hard stone type III. The resultant cast was modified by placing the relief and the block-out wax to create the modified cast that was duplicated into refractory cast later.

The wax pattern of the metal framework was made on the refractory cast using contouring wax (Wax patterns, Bego, Bremen, Germany). The pattern was made so that it covers the edentulous area and extended lingually to the lingual ledges of the cemented splinted crowns as a side plate. The ready-made female part (matrix) of the attachment was connected to the wax pattern in relation to the position of the patrix part to be soldered with the metal framework as a one unit. The conventional procedures of casting were followed to obtain the final metal framework.

After verification of accurate seating of the framework on the epoxy resin cast, the conventional steps of partial denture seating and processing was done to construct the final partial denture.

The final partial denture was then checked over the epoxy resin cast and interferences were removed then the nylon cap was attached to the fitting surfaces using the plastic positioner tool.

Fig. (1): Group I unilateral partial denture design

Preparation of the removable bridge for group II (Figure 2)

The prosthesis in the second group is a removable porcelain bridge that has no buccal or lingual flanges like that in the first group. This means that the support is mainly from the abutment teeth and partially from the ridge unlike the first group which has flanges and denture base fully extended so the support is gained mainly from the ridge and partially from the abutment teeth.

The ready-made female part of the attachment was inserted over the male part that was previously attached to the bridge on the abutments. The conventional procedures of casting were followed to obtain the final removable porcelain bridge.

Model preparation for strain gauge installation (Figure 3)

Four strain gauges (KFGS-2N-120-C1-11L1M2R, Kyowa electronic instruments co., Japan) were glued using cyanoacrylate adhesive on the cast around the abutments on the buccal, lingual, mesial and distal epoxy resin surfaces corresponding to the roots of the abutment teeth. These proposed

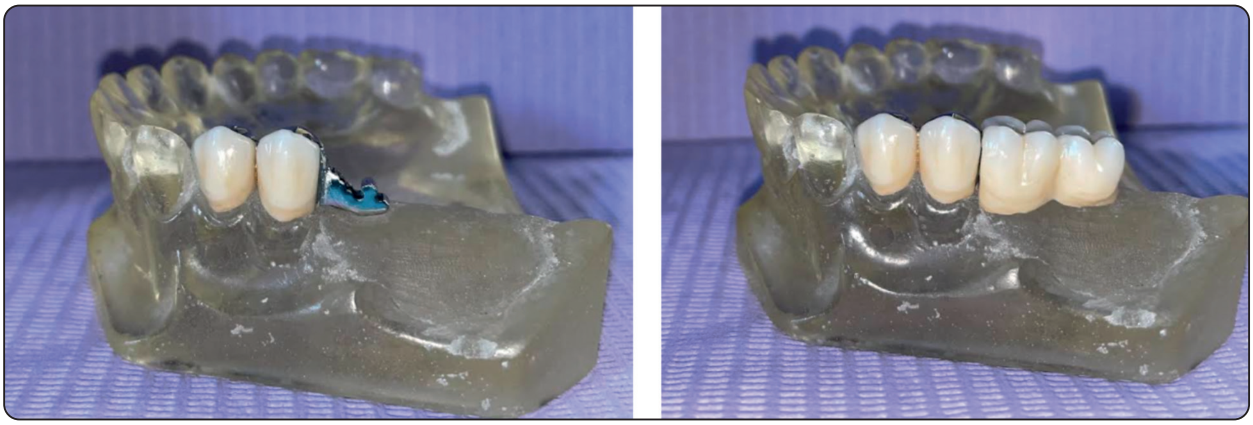

Fig. (2) : Group II unilateral partial denture design

sites were first prepared to receive the gauges by reduction of the epoxy resin buccally, lingually, mesially and distally around the abutments to a thickness of approximately 1 mm.

A notch was created on the first molar tooth of the two partial dentures to accommodate the tip of the load applicator of the universal testing machine (Lloyd LR5K Test Machine, tts Ltd, UK) which was used to apply vertical static load range (0 to 70 N) over the partial dentures.

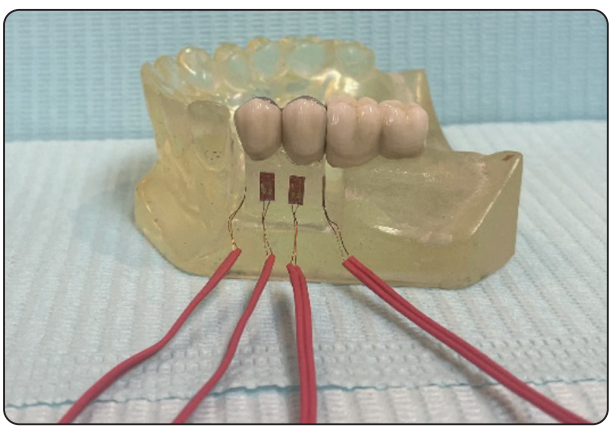

Fig. (3): Model with the strain gauges installed

Load application and strain gauge measurement (Figure 4):

The machine was connected to a computer and controlled by the software (Nexegen ver.4.3 material testing software, AMETEK, China), which allows the collection and analysis of data. The cast was fixed in position on the table using a lock. The strain-meter used in this study was a multi-channel digital device.

Strain was measured twice, one time at the beginning of the test and the other one after 2000 insertion and removal cycles. Each measurement was repeated twenty times (T1: zero and T2: after 2000 cycles). The load was applied gradually from zero to 70 N at speed 100 mm/s. Once the load was applied, the micro strain readings were recorded on a monitor connected to the strain-meter.

All the previous steps were made again for the strain measurements for the second group

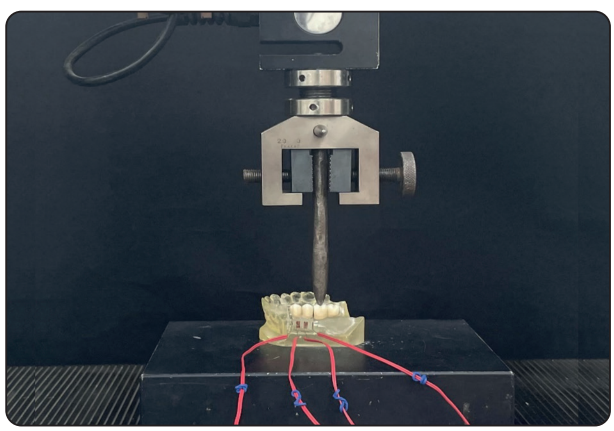

Fig. (4): Loading application using the universal testing machine

RESULTS (Figure 5 Table 1)

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, data showed parametric (normal) distribution

Paired sample t-test was used to compare between the two groups in related samples. Independent sample t-test was used to compare between the two groups in non-related samples. Two-way ANOVA test were used to test the interactions between different variables.

The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

Strain results:

I) Effect of cycles:

i) Group I (Acrylic resin):

There was a statistically significant difference between (Zero) and (After 2000 cycles) groups where (p<0.001).

The highest mean value was found in (After 2000 cycles), while the least mean value was found in (Zero) groups.

ii) Group II (Porcelain):

There was a statistically significant difference between (Zero) and (After 2000 cycles) groups where (p=0.001).

The highest mean value was found in (Zero), while the least mean value was found in (After 2000 cycles) groups.

II) Effect of material:

i) Zero:

There was a statistically significant difference between (Group I) and (Group II) where (p<0.001).

The highest mean value was found in (Group II), while the least mean value was found in (Group I).

ii) After 2000 cycles:

There was a statistically significant difference between (Group I) and (Group II) where (p=0.001).

The highest mean value was found in (Group II), while the least mean value was found in (Group I).

TABLE (1): The mean, standard deviation (SD) values of strain of different groups.

Variables	Strain				p-value
	Group I (Acrylic resin)		Group II (Porcelain)		
	Mean	SD	Mean	SD	
Zero	153.75 ^{bB}	7.13	537.50 ^{aA}	13.66	<0.001*
After 2000 cycles	380.50 ^{aB}	26.69	466.95 ^{bA}	28.65	0.001*
p-value	**<0.001***		**0.001***		

Means with different small letters in the same column indicates significant difference, means with different capital letters in the same row indicates significant difference ****; significant (p<0.05)***

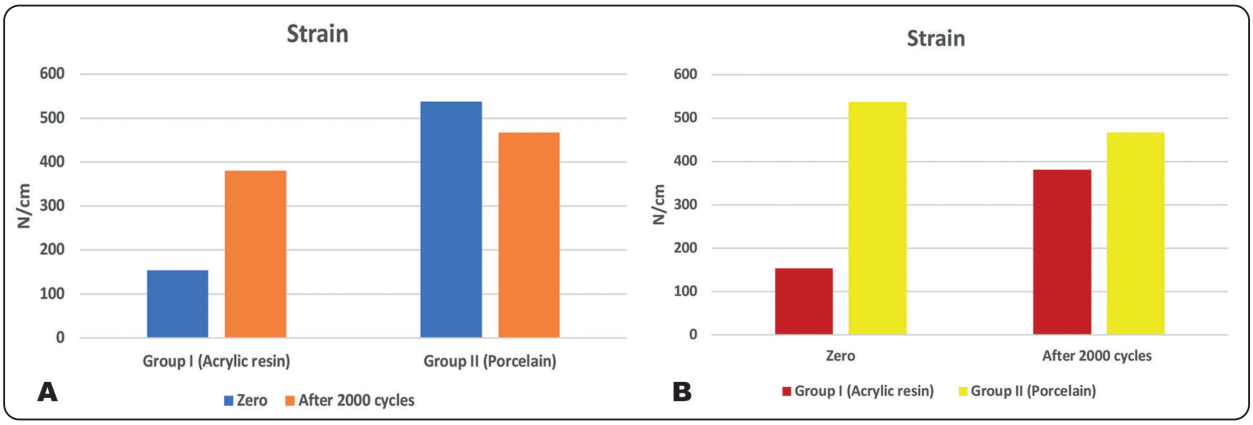

Fig. 5 (A and B): Bar chart representing strain induced in the two groups

DISCUSSION

Many companies that manufacture the extra coronal attachments for unilateral partial denture design usually try to invent new designs that allow for more comfortable partial denture for the patients and at the same time protect the abutment teeth from overloading. It is claimed that the attachment design that was used in the current study (rk-1 uni) allows for constructing a unilateral bridge without flanges as it has a specific feature in its design that allows for better stress distribution which protect the abutment teeth from being overloaded. So, this study was conducted to see whether this is true or not.

The results of this study showed that the stresses around the abutments where higher after 2000 cycles of insertion and removal in group I (acrylic resin group). This result seems logic as it might be attributed to the behavioral changes of the attachment after insertion and removal of the prosthesis and denture settling. Insertion and removal might also lead to wear of the attachment and loss of its retentive capacity leading to increased movement of the prosthesis during loading with the universal testing machine that will eventually transfer more stresses to the abutment teeth. On the contrary, for group II the stresses around the abutment teeth were much higher before the cyclic loading than after loading. This might be attributed to the difference in the prosthesis design as in this group it is a removable bridge with no extensions on the alveolar ridge like group I which included full extension of the denture base to the depth of the buccal and lingual vestibule. So, after the cyclic loading and the inevitable loss of retention due to the attachment wear led to increased movement of the prosthesis, but the prosthesis design in this group is much smaller than the first group so this will transfer less stresses to the abutment teeth[18].

When comparing between the two groups, the highest mean value was found in group II (porcelain group) in both zero and after 2000 cyclic loading. This might be attributed to the different material and design of the prosthesis in both groups. In group I, the partial denture design included full coverage of the edentulous ridge with the denture base. This design allows for more favorable stress distribution on both the abutment teeth and the edentulous ridge. In addition, the acrylic resin is a resilient material that absorbs some of the stresses so will decrease the strain induced around the abutment teeth. On the other hand, the design and material (porcelain fused to metal) of the prosthesis in group II might initiate higher strain values around the abutments due to the smaller area of ridge coverage and the stiff nature of the porcelain material[19].

CONCLUSION

The strain induced around the abutment teeth supporting a unilateral removable porcelain bridge retained with extracoronal attachment is higher than that induced when using a unilateral skeletal partial denture with combined denture base. So, still the conventional unilateral skeletal partial denture with the standard design of full extensions that covers as much as area as possible is the gold standard in terms of biomechanical advantages. But the results might differ when applying this study in-vivo due to the presence of other variables like presence of the periodontium and the soft tissue covering the alveolar ridge which is not simulated in our study [20].

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