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STRESS ANALYSIS TO THE FORCE INDUCED BY TWO DIFFERENT MANDIBULAR PARTIAL DENTURE DESIGN OVER THE ABUTMENTS AND SUPPORTING STRUCTURE (STRAIN GAUGE IN VITRO STUDY)

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ABSTRACT

Introduction: Kennedy Class II removable partial dentures problem is the difference in the degree of elasticity between the tooth and the tissue, resulting in a difference in the viscoelastic response. It can also lead to rotational movements of the RPD that can generate excessive torque forces on the abutment teeth and soft tissues. The combination of a partially removable denture with a telescopic crown or external attachment could provides adequate support and preserves the supporting structures.

The aim of the study: The purpose of this study is to analyze the stresses induced by two different RPD designs; Telescopic teeth retained on one side of the lower jaw retained on a removable partial denture versus an external fixed RPD retained on one side of the mandible .

Materials and methods: 10 acrylic mandibular model Kennedy class II were constructed ,removable partial design were fabricated as follows: Group A unilateral tooth supported telescopic retained removable partial over denture. Group B unilateral extracoronal attachment retained RPD,

Four linear strain gauges were bonded to the acrylic resin model at the buccal and lingual surface of each abutment tooth. Strains were measured on each model. Micro Strain measurements were performed under vertical and oblique loading using a universal testing machine.

Result: The result revealed that there was insignificant difference as P-value > 0.05 between the two different groups

Conclusion: Unilateral partial dentures can be used with a telescopic retainer or a crown retainer without exerting too much pressure on the supporting structures.

KEYWORDS: Telescopic over denture, extracoronal attachment retained unilateral partial denture, strain gauge.

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INTRODUCTION

Removable partial dentures with distal extensions mainly consist of two different types of tissue with different degrees of mobility: the teeth, which provide relatively immobile support, and the mucosa overlying the edentulous residual alveolar ridge. Get support from When the denture base is loaded, it partially rotates around the distal-most abutment tooth about its axis of rotation, resulting in torque on the abutment tooth and subsequent degradation of the supporting bone tissue. This problem is more pronounced in the mandibular arch, where less tissue support is available [1].

Rehabilitation of partially edentulous patients can be achieved using a wide range of prosthetic treatment options, including simple conventional removable partial dentures, overdentures, fixed partial dentures and dental implants [2].

The use of dental implants that provide partial support for removable partial dentures is a practical choice for achieving functional stability, preserving remaining alveolar bone, and minimizing resulting rotational forces. Provide an aid. However, if your bone supply is inadequate, this is not recommended. For economic reasons, the use of combination dentures as removable partial dentures with precision fitting or telescopic tooth-supported partial dentures is the best treatment option in this situation [3].

Using a precision-attachmet RPD improves both aesthetic and mechanical functions. Precision attachment is a connector that consists of two components. The male part is attached to the root, tooth, or implant, and the corresponding female part is incorporated into the prosthesis, forming a mechanical connection between them. These attachments allow prostheses to combine the advantages of removable and fixed restorations [4,5].

It is also considered an effective alternative to less aesthetic braces, offering a high level of aesthetics. There are many types of external coronary fixation available for cases with one free end of the saddle, providing better stress distribution and better esthetics [6].

RPD retained on the remaining dentition by a telescopic crown (TRPD) is also an alternative treatment option to traditional clasp RPD[7,8].

Telescoping crowns have been successfully used for decades to connect dentures to natural teeth and/ or implants. Due to the telescopic crown concept, masticatory forces are always take place transmitted axially to the abutment [9].

A strain gauge is a device used to analyze the strain of an object. The most common type of strain gauge consists of an insulating flexible substrate with a metal foil pattern. The gauge is attached to the object with a suitable adhesive. When the object deforms, the foil also deforms, changing its electrical resistance[10] .

This Invitro study used to study the hypothesis whether the use of unilateral tooth supported telescopic retained removable partial over denture is more advantage than removable partial denture retained by extracoronal attachment regarding stress reduction on supporting structures or not .

MATERIALS AND METHODS

Research question

In case of unilateral removable partial denture, does using PEEK telescopic retainer unilateral removable partial denture induce less stress than the extracoral attachement partial denture. Or not ?

According sample size calculation based on a previous study [12]. A minimally accepted sample size was 5 casts per group. Group 1 (removable partial denture retained with telescopic peek retainer Group 2 removable partial denture retained with extracoronal attachment).

Cast fabrication:

A unilateral cantilever saddle was used to make a partially edentulous epoxy impression, the last standing tooth being a premolar (Kennedy class II). two silicone rubber molds for Kennedy Class II casting was made.

Epoxy resin is injected into the silicone rubber impression using a mechanical vibrator and allowed to polymerize. Then removed the model from the rubber cast and removed the foil around the base. A light rubber base was injected into the alveoli, after which the tooth was reinserted. To simulate the alveolar mucosa, two layers of wax on the baseplate were applied to the saddle area of the free end, then a gypsum index was applied over it, then the wax was removed and rubber glue was applied to the saddle area. After application, the rubber base was attached and repositioned the index to even out the shape and thickness of the gum. After the gum had set, the gypsum index was removed.

Unilateral Partial denture with the extracoronal attachment fabrication

A premolar was prepared to receive a bridge and a wax model of the crown with sculpted lingual processes on the lingual surface was made with the help of a dental technician (Renfert-Grauwachs, Germany).the two samples of two abutments were connected to form a unit bridge

The external coronal attachment of the male matrix was attached to the distal surface of the wax model of the right lower second premolar with blue casting wax (Renfert-Blauwachs, Germany) using Surveyor parallel mandrels. A 2mm gap was left under the ridge. The wax model and matrix were then sprued, molded and embedded with a phosphate-bonded investment material (Bellavest T.Bego, Bremer Gold Schlagerei Wilhelm, Bermen, Germany). Porcelain-coated Co-Cr bridges were then obtained according to conventional casting procedures. The bridge was cemented onto cast epoxy resin using a glass ionomer (Medifil, Promedica, Germany).

Preparation of the metal frameworks with lingual ledge

After sealing the space under the matrix of the attachment with utility wax, putty and an adition silicone material (Zetaplus, Zhermach, Germany) were used to create a two-step impression for casting. The impression was Type III hard rock. The resulting casting was modified by applying a relief and blocking out the wax to produce a modified casting which was then replicated into a refractory casting. A wax model of the metal framework was made using contour wax (Wax Model, Bego, Bremen, Germany) on a refractory mold. This pattern was created to cover the edentulous area and extend lingually to the lingual ridge of the cement-retained bridge. I attached the female part of the attachment made in advance to the position of the male part, attached it to the wax model, and soldered it together to the metal frame. The final metal framework was obtained following traditional casting procedures. Figure 1]

Fig. (1) Removable partial denture with lingual ledge retained with extracoronal attachment

Unilalateral PEEK telescopic denture fabrication :

The premolar was reduced with conversion degree 6 and a primary PEEK crown was obtained. The main telescope was waxed. After wax removal was performed, wax was injected into his PEEK telescope which was cemented to the abutment.

A unilateral metal partial denture was fabricated by the conventional method, and a PEEK abutment was incorporated into the acrylic denture base using self-polarized acrylic resin. Figure 2]

Fig. (2) Removable partial denture retained with Peek telescopic attachment

Installing the strain gauges

The strain gauge wire used in this study was 3 mm long, 1 mm wide and had a resistance of 120 ohms. The strain gauge was connected to a 100 cm long lead wire. A small longitudinal groove was made on the toothless side of the epoxy resin model. Strain gauges were attached to the gypsum around the abutments at the buccal, lingual, mesial, and distal epoxy surfaces corresponding to the roots of the abutments using cyanoacrylate adhesive.

Load application and strain gauge measurement

The machine was connected to a computer and controlled by software (Nexegen version 4.3 Materials Testing Software, AMETEK, China) that allows data collection and analysis. The cast was fixed to the table with a lock. The strain gauges used in this study were multichannel digital devices. Elongation was measured twice. One at the beginning of the study and another after 2000 cycles of insertion and withdrawal. Each measurement was repeated 20 times (T1: Zero and T2: after 2000 cycles). The load was applied stepwise from 0 to 70N at a speed of 100 mm/s. As the load was applied, microstrain values were recorded on a monitor connected to the strain gauge. For the second group of strain measurements, we repeated all the previous steps.

RESULT

Sample size calculated depending on a previous study[12]. According to this study, the minimally accepted sample size was 5 per group, when mean ± standard deviation of group I is 26.3±15.3, the estimated mean difference was 15, when the power was 80% & type I error probability was 0.05. Independent t test was performed by using PS power 3.1.6.

Statistical Analysis

All data were presented as means and standard deviations. Data were presented in two tables and two graphs. Statistical analyzes were performed using SPSS 16® (Statistical Package for Scientific Research), Graph Pad Prism, and Windows Excel.

Inspection of the given data was performed using the Shapiro-Wilk and Kolmogorov-Smirnov tests for normality. The significance level (P-value) was found to be non-significant as the P-value was > 0.05, indicating that the data were from a normal distribution (parametric data). Therefore, comparisons between two different groups were performed using independent t-tests, and comparisons between two intervals were performed using paired t-tests. Percent of change was calculated using the following formula:

$$= \frac{after\ 2000\ cycle\text{-}at\ zero}{at\ zero} \ X\ 100$$

Comparison between effect of design on both groups was performed by using independent t test which revealed that: at zero: group 2 (153.75±7.13) was significantly higher than group 1 9140.23±4.04) with MD (13.52) as P=0.006. After 2000 cycles: there was insignificant difference between both groups as P=0.83.

Comparison between effect of time different intervals was performed by using Paired t test which revealed that: In group 1: there was a significant increase from (140.23±4.04) at zero to (377.45±15.71) after 2000 cycle as P < 0.0001. In group 2: there was a significant increase from (153.75±7.13) at zero to (380.5±26.69) after 2000 cycle as P < 0.0001.

Changes of strain in both groups:

Differences and percentage changes between cycle 0 and 2000 onwards for both groups were calculated. Comparisons between both groups were performed using independent t-tests and revealed non-significant differences in differences and percentage changes with P = 0.51 and 0.11.

TABLE (1) Mean and standard deviation of strain in both groups at different intervals and comparison between them:

Groups	Group 1 Telescopic Peek Retainer		Group 2 Extracoronal Attachment		Difference (Independent t test)				
					MD	SEM	95%CI		P value
	M	SD	M	SD			L	U	
Zero	140.23	4.04	153.75	7.13	13.52	3.66	5.09	21.97	0.006*
After 2000 cycle	377.45	15.71	380.5	26.69	3.05	13.85	-28.89	34.99	0.83 ns
P value (Paired t test)	<0.0001*		<0.0001*						

*M: Mean SD: standard deviation *Significant difference (P<0.05). ns: non-significant difference as P>0.05*
MD: mean difference SEM: Standard error mean CI: confidence interval L:lower arm U:upper am

TABLE (2) Mean difference and percentage of change in both groups and comparison between them:

Groups	**Group 1** **Telescopic peek**		**Group 2** **Extracoronal attachment**		**Difference (Independent t test)**				
					MD	SEM	95%CI		P value
	M	SD	M	SD			L	U	
Difference	237.22	15.23	226.75	29.45	10.47	14.83	-44.66	23.72	0.51 ns
% change	169.27	11.84	148.09	23.60	21.18	11.81	-48.42	6.04	0.11 ns

*M: Mean SD: standard deviation *Significant difference (P<0.05). ns: non-significant difference as P>0.05*
MD: mean difference SEM: Standard error mean CI: confidence interval L:lower arm U:upper am

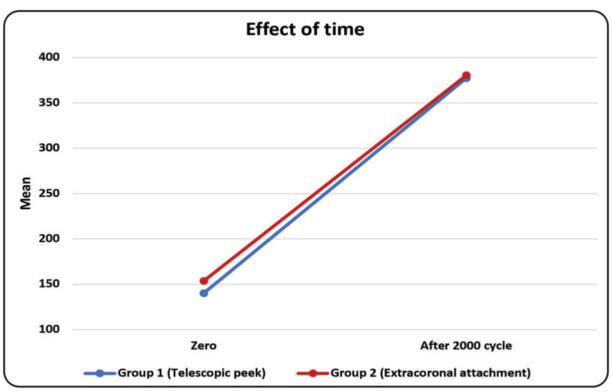

Fig. (3) Line chart representing effect of time on strain gauge in both groups.

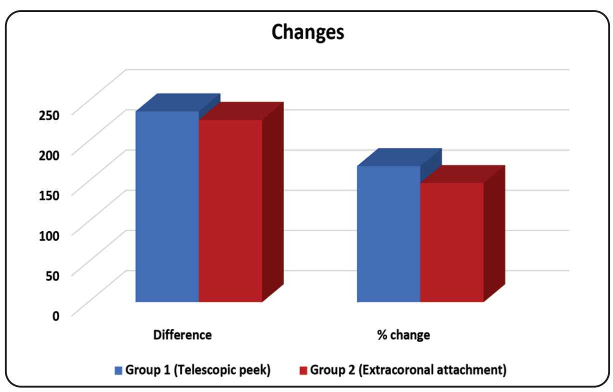

Fig. (4) Bar chart representing effect of difference between at zero and after 2000 cycle and percentage of change in both groups.

DISCUSSION

This study is intended as an in vitro study to overcome the limitations of unilateral partial dentures, as unilateral distal extension restorations typically require crossing the dental arch. Arch stabilization across the entire dental arch contributes to the stability of the prosthesis and resists horizontal and rotational forces, thus contributing to the overall support of the prosthesis, but unfortunately causes discomfort to the patient.

Rehabilitation of partially edentulous cases without a distal abutment presents a challenge for prosthetic dentists, as imperfect prosthesis design compromises force distribution between the abutment and the remaining alveolar ridge. This may increase the mobility of the abutment or absorb any ridges left under the denture saddle. [11-13]

So, this study was conducted to evaluate the influence of the modified unilateral distal extension partial denture over the abutment to control stress

In this study, telescoping retainers were chosen because of their advantages of ~6 mm vertical height, parallel walls, and limited rotational movement under load. In addition, the increased friction surface between the primary and secondary crowns improves retention and stability values and can solve the problem of transverse arch stabilization[14] .

A retrospective study evaluating telescoping overdenture abutments found that 96.2% of the abutment teeth were still in good condition. The use of removable partial dentures with telescoping retainers has superior biomechanical advantages as it directs stresses towards the longitudinal axis of the abutment and minimizes the stresses transmitted to the residual ridge , reported to be a perfect treatment option [13].

PEEK is considered a suitable material for primary crowns regardless of cone. This can be explained by the fact that PEEK is a soft and ductile material that yields and conforms easily, resulting in a good edge fit [15].

Previous article demonstrated that the use of PEEK telescopes improved denture and associated abutment longevity in most unilateral partial denture designs with cruciate arch stabilization. Poor research has been done to investigate the effectiveness of his PEEK telescopic retainer without cross-arch stabilization. [15]

The results showed in the telescopic retainer group, there was a significant increase in stress from zero up to 2000 cycle . Percent of change was calculated between both group to examine the stress effect difference between both groups. The result reveled insignificant difference between groups.

Precision attachment has exceptional feature of being a removable prosthesis with improved aesthetics as it eliminates the appearance of metal clasps, less post-operative adjustments, better patient comfort and overcome disadvantages of (RPD) .[16,17]

One of the disadvantages of using an extra coronal attachment is the high torque applied to the farthest abutment. This resulted in the need to brace the abutmets to reduce the stress and torsional action acting on them. It was found that reducing the number of splint teeth from two to one caused a significant increase in micro-strains by 52% [18,19] .

The lingual plate bracing incorporated in our research design counteracts adverse lateral forces, thereby reducing adhesion stress. It has also been reported that fabricating a ledge on the inner surface of the fixed bridge covering the abutments stabilizes and strengthens the denture and eliminates the need to cross to the other side of the arch.[20]

The centralization of the extracoronal attachment buccolingually is important for equal distribution of the stresses of the attachment prosthesis. A clinical study, concluded that the one-sided OT attachment with two ends at two different levels (horizontal and longitudinal planes), allows for a better distribution of stresses applied under occlusal force and improved prosthetic stability, maintainability, comfort and enabling the ability to bite without fear. Lose the ability to retain.[21-23].

There are no articles comparing the peek telescopic retainer versus extracoronal attachment . The study results showed that the load transmitted to the ridge of the missing teeth increased significantly in both groups after 2000 cycles of attachment and removal. This could be because the plastic cap of the attachment wears down after cycles of insertion and removal, resulting in loss of the prosthesis's ability to hold and move on the ridge under load. The plastic cap also helps to distribute the load favorably between the abutment and the ledge, as it undergoes structural changes due to wear and loss of elasticity, transferring additional stress to the ridge.[24,25].

The conventional partial denture design is often uncomfortable for some patients due to the discomfort caused by the mucosal covering of the base and edges of the denture and the accumulation of food under the denture base, although it known for its wider coverage of dentures. ridges lead to a more favorable stress distribution and preservation of load-bearing structures. These findings explain the results of this study showing a negligible difference between the two designs as both designs represent a good treatment modality for distal extension RPD with good stress distribution. and the stress transmitted to the abutment teeth is minimal. [26-28].

However, the lack of statistical significance between the two groups makes it possible to consider the possibility of using a unilateral removable bridge as a possible solution.

CONCLUSION

It was concluded that both types of unilateral attachment show minimal effect on supporting structures of the abutments, but the unilateral peek telescope and unilateral extracoronal attachment with its modification can be a good alternative to conventional partial removable dentures, so there is no importance of extending the restoration to the other side .It has the added advantage of requiring no additional preparation of abutment teeth, minimizing the bulk of the material in the mouth and, therefore, reducing the area of soft and hard tissues.

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