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Stresses Induced By Integrated and' Nonintegrated Extracoronal Semi-Precision Attachments For Maxillary Distal Extension Bases

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ABSTRACT

Purpose: The aim of the present study is to compare the stresses induces on the splinted abutments by two different reciprocation designs in conjunction with extra-coronal semi-precision attachments retained removable partial denture (RPD) using strain gauge analysis.

Material and methods: For this study, two RPD designs were made A, and B. representing maxillary bilateral distal extension edentulous area. The two abutments, canine and first bicuspid was fixed splinted on both sides with porcelain facing crowns. For design (A) an extra coronal attachment with integrated interlock was used at the distal aspect of the splinted first bicuspid and canine. For design (B) a parallel interlock extra coronal attachment was used with a conventional lingual bracing arm. A strain gauge was used for this study to measure the micro-strain induced on the apical and lateral sides of the canine and first-bicuspid abutments.

Results: SPSS software program was used in the statistical analysis of the results. The results revealed that maximum stresses induced at the apex of the canine and first-bicuspid abutments were in case of design (B). While no significant difference between the two designs when the lateral load was applied

Conclusion: A more favorable stress applied on the canine and bicuspids obtained with integrated interlock attachment.

KEYWORDS

Stress analysis,
extracoronal semi-precision attachments,
Removable partial denture,
strain gauge

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INTRODUCTION

Rehabilitation of a partially distal extension base(s) is the main challenge for the prosthodontist. Implant-retained is an option but sometimes not possible due to insufficient bone or patients preference[1-3].

Numerous studies had conducted to test the effect of distal extension partial dentures on both abutments and residual alveolar ridge [4, 5].

Attachment provides an important psychological and mechanical union in treating patients. Extracronal attachments may be useful for treating class I, class II and bounded partially edentulous patients when comparing with clasp assemblies, they provide more esthetics and retention [6]

Several methods were used to control stresses occurred with semi-precision or precision attachments with distal extension base(s) including splinted abutment teeth, stability of denture base, broad tissue coverage, resilient design of the prostheses, occlusal harmony, loading techniques and shimming [7]. Shohet [8] compared the greatest destructed forces on abutment with rigid design and other resilient retainers.

Resilient extracoronal attachments do not always supply suitable support and bracing because of their resilient nature. Therefore, they require specially designed bracing arms on surveyed crowns. Besides, they increase unfavorable cantilever forces on the abutment teeth[9]. During function, a lever action is developed at the most distal portion of the removable partial denture (RPD). The more downward force on the RPD, the greater tipping action on the abutment tooth, which suggests a stress breaking action incorporated into the design to control the stress on the periodontal attachment of the abutment tooth[10].

The palatal surface of the splinted crowns should have preparations for the bracing arm prolonged to the proximal area to secure tooth support, stability and indirect retention and transmit forces along the long axis of the tooth [11] and minimizing wear of key or keyway during insertion [12]. Making a groove for the free end arm will aid retention and resist, any tendency to distort the attachment in mesio-distal direction[9]. Also, using of bracing arm is a best way of overcoming the length of the attachment.

Saito et al, [13] showed in their study that the attachment denture with a lingual stabilizing arm produced more stress to the abutment teeth.

A strain gauge is a device attached to the object by a suitable adhesive to record its deformation when subjected to stress. As the object is deformed, the gauge deformed, causing its electrical resistance to change. [14-17]

A strain gauge can be widely applied in dental research ,it can be used alone to assess in vivo and in vitro stress in prostheses, implants, and teeth [18,19], other authors use the strain gauge technique with photoelasticity or FEM techniques [20-23]. It can guide further research and clinical studies by predicting some disadvantages and streamlining clinical time.[24]

The aim of this study is to compare the stresses induces on the splinted abutments by two different reciprocation designs in conjunction with extracoronal semi-precision attachments retained removable partial denture (RPD).

MATERIAL AND METHODS

For this study a typodent* model was used. Preparations for crowns were performed on the maxillary canines and first bicuspid on both sides (Fig.1)

The roots were surrounded by 1-mm thickness addition- type silicone** layers to simulate periodontal ligament. The edentulous ridge was covered with 2-mm thickness silicone impression material to simulate resiliency of the mucosa.

The typodent model was duplicated with a reversible hydrocolloid material and poured in improved dental stone.

On the resulting cast, the wax pattern of the splinted crowns of the canine and first bicuspid on both sides was constructed as one single unit with

* *DPS Model UK U 13 www.kavo.comMat.N2/NO O.623.1921*

** *Silicon impression material, Zhermack, 45021 Badia Polestine (Rovigo0, Italy* the adaptation of the plastic castable patrix of the attachments. One cast received extracoronal semi-precision attachment with integrated interlock on both sides (design A), while parallel interlock (design B) was done on the other cast with lingual bracing arm, on both sides also (Fig. 2, 3) .

After waxing up the copings of the crowns, the male part of each abutment was aligned to its respective crown using a Milling Machine * with paralleling mandrel. The patrix (male part) should be mounted parallel to the path of insertion, over the center of the residual alveolar ridge.

For design (B) a step (ledge) was prepared in the lingual surface of the waxed- up crown on the first bicuspid to accommodate a conventional bracing arm and an occlusal rest seat was created to receive a metallic extension from the lingual bracing arm.

The wax pattern of the crowns was casted, the porcelain facing was constructed and the crowns were temporary cemented ** to the prepared abutments. Then the removable partial denture was designed and casted with cobalt chromium alloy. The yellow plastic female component (matrix) was placed in the metal frame work (Fig. 4).

The following two RPD designs were used in this study.

Design (A): An extra coronal attachment with integrated interlock (Vario- Stud- Snap) *** was used at the distal aspect of the splinted first bicuspid and canine (Fig. 5).

Design (B): An extra coronal attachment with parallel interlock (Patrix sg) *** was used at the distal aspect of the splinted first bicuspid and canine with a conventional lingual bracing arm (Fig. 6).

Fig. (1) Typodent model with prepared teeth

Fig. (3) The porcelain crowns with parallel interlock attachment.

Fig. (2) The porcelain crowns with integrated interlock attachment.

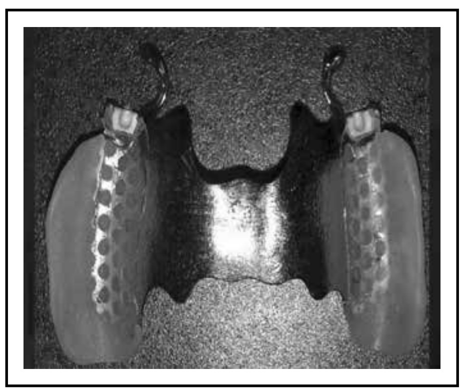

Fig. (4) Matrix was placed in the metal frame work.

**Bredent company, GmbH & CokG. Weissenhorner Str.2.89250 Senden. Germany.*

*** Cavex temporary cement BV, 852 RW Haarlem (Holland)*

**** Bredent company, GmbH & CokG. Weissenhorner Str.2.89250 Senden. Germany.*

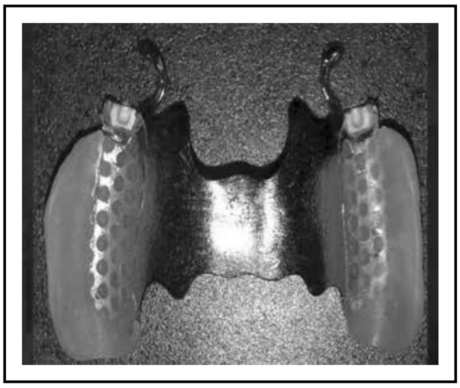

Fig. (5) Metallic RPD without bracing arm

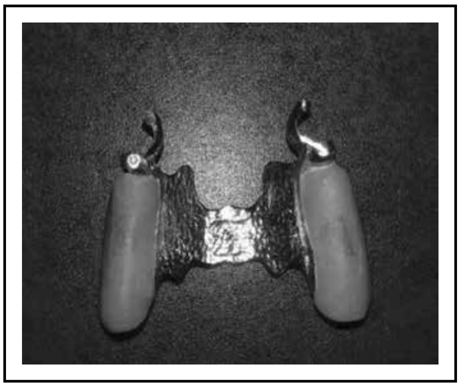

Fig. (6) Metallic RPD with a lingual bracing arm

The root surfaces of the abutment were prepared on the model which receives strain gauges. Two holes were drilled in the model corresponding with the root surface on the abutment teeth which permit wires of strain gauges to pass through the model. Two channels were made at each hole to permit lead wire cable of strain gauges to pass out of the model without tension; the wire was secured with adhesive. Strain gauges were oriented parallel to the long axis of each abutment and were hold in their sites using Teflon sheets supported with gauges. An insulation coat was applied to the outer surface of the strain gauges for protection.

The compressive properties were characterized using computer controlled universal testing machine*. The (apical or lateral) strain gauge was attached to the silicon periodontal ligaments at portion of the canine and first bicuspid. The used strain gauges is foil type ** with 2 gauge factor, 120 W gauge resistance, 5x1.8 mm^2 gauge dimensions and 9x3.5 mm^2 backing dimensions.

The strain gauges were wired with coaxial cables to minimize the signal interference noise. The compression tests were performed at constant cross–head speed of 0.5 mm/min (= 50 N), the load was applied at 15 mm distal to the first bicuspid representing the position of the first molar. The strain gauges were connected to PC via 4-channel data acquisition *** to monitor and record the strains during the compression tests. The PC of the testing machine draw and record the load-displacement/time of the test specimen, while the other PC draw and record the time-strain relationship (Fig. 7).

The data was collected, tabulated and statistically analyzed using SPSS software program.

RESULTS

Figures (8& 9) show the mean of micro-strain values around the two abutments teeth.

The micro-strain value at the apical portion of the canine for design- B was found to be more than those of design- A under the compressive load. This values was found to be significant according to (t-test), (p=0.0010).

On the other hand the difference was not statistically significant at the apical portion of the bicuspid abutments in design A and B (p=0.4103).

There was no significant difference between the mean values of micro-strain in the canine and first bicuspid abutments in the two designs when the lateral load was applied, the p= (0.1387) and (0.5234) respectively.

* *Instron model 8872 kN.*

** *model RS 632-180*

****model 9237 NI*

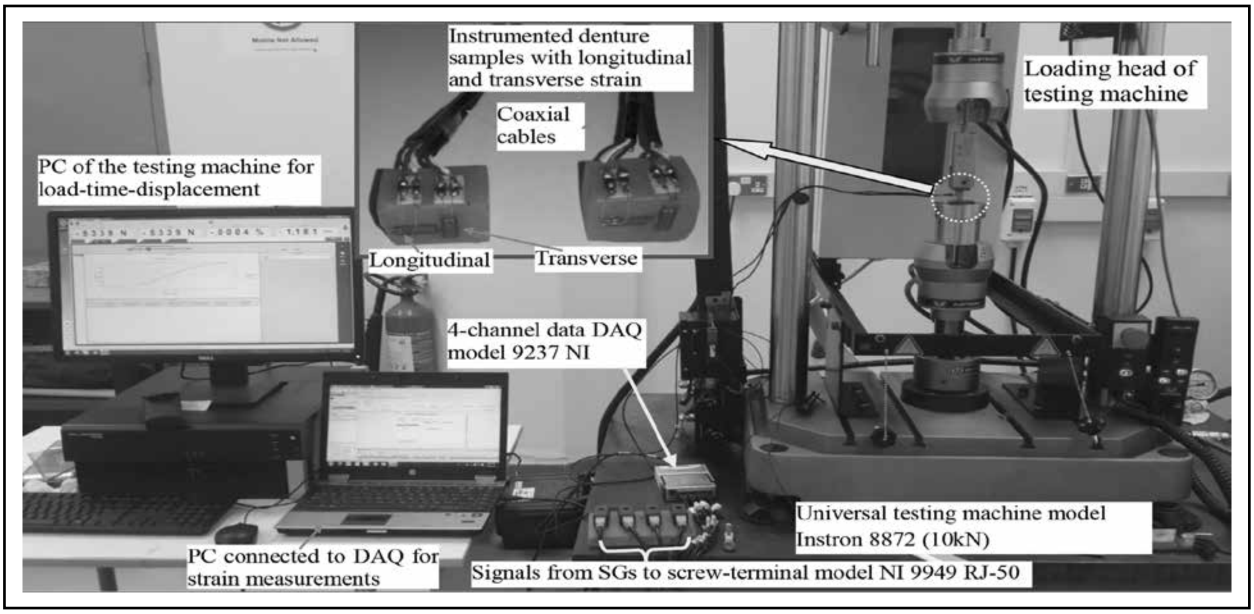

Fig. (7) Experimental setup

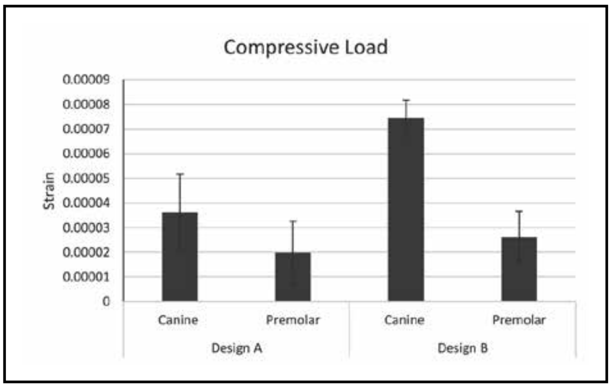

Fig. (8) The micro-strain measurements at the apex of the abutments under the two different designs.

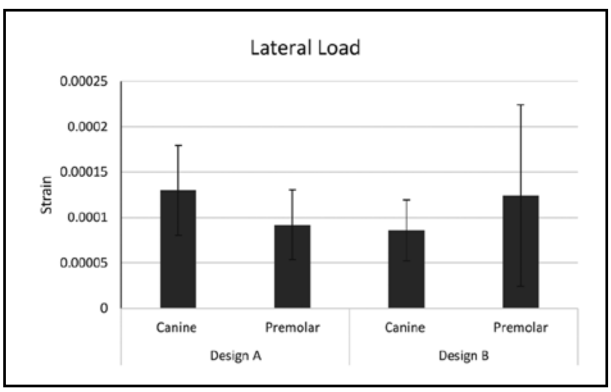

Fig. (9) The micro-strain measurements at the lateral side of the abutments under the two different designs.

DISCUSSION

Posterior distal extension partial denture bases present a number of design challenges, particularly is the distribution of forces to remaining alveolar ridges and teeth to provide function and comfort.[25,26]

Understanding the difference in nature and behavior of the tissues supporting RPD is critical for long term success of the prosthesis. These differences multiplied by the function, create major stresses on the tooth-tissue prostheses.[27] so, it is necessary for an attachment used in conjunction with RPD to be in proper design of reciprocation to reduce the lateral load to which the abutment is subjected.[5]

The aim of this study was done to compare the effect of two different designs of reciprocation in conjunction with extra coronal semi-precision attachment retained regarding the response of compressive and lateral loads applied on the maxillary distal extension bases.

In this study we suggest the use of extracoronal resilient attachment retained RPD in maxillary distal extension ridges, which is agreed with some authors [28, 29] but with certain limitations to avoid excessive torque applied to the most distal abutment.

Moreover, extracoronal attachments are castable attachment with plastic retentive portion. With its elasticity, it is possible to control flexure and construct a resilient and shock absorbing prostheses, [30] so providing less torque to the abutment teeth. [31]

Fixed splinting of adjacent abutment teeth is an important factor when attachment retainers are used for an extension removable partial denture.[32] So, in every attachment designed RPD case especially the distal extension prostheses require a minimum of two splinted abutment on either side placed in crowns in order to aid in distributing the forces.[33] In this study, canine and first premolars at each side were splinted anterior to edentulous span to aid in better distribution of stresses.

From the results of this study, the configuration of integrated interlock attachment applied less compressive load on the canine and bicuspids, with no significant difference regarding the bicuspids between the two designs, which probably due to the neighboring stress breaking effect of the attachment and favorable less compressive forces on the canine. This result is in agreement with Saito et al, [13] who found that attachment denture to which a lingual stabilizing arm had been added produced more stress on the abutment teeth than without a stabilizing arm. It seems reasonable to assume that with lingual stabilizing arm, there was more rigidity inducing more stresses.

No significant difference was found by applying lateral load either on the canines or bicuspids between the two designs. This is due to the shear distributor within the confines of the integrated interlock attachment itself that directs leverage along the long axis of the tooth eliminating the need for RPD component of reciprocation. This result is consistent with those of Wang *et al,* [34] who stated that the integrated interlock can counteract the lateral force which has the greatest effect on the terminal abutment in distal extension base RPDs with universal hinge attachment.

Moreover, the extracoronal attachment reduces the lever arm in relation to the root length as it places the support for RPD closer to bony support of abutment teeth.

Fixed splinting of abutment teeth for attachment retained RPD provides increased resistance only to antero-posterior forces, and the RPD anchored on both sides of the arch can provide cross arch stabilization to forces operating in a buccolingual direction.[35] This support the results of this study that the lingual bracing arm is not mandatory for reciprocation in attachment retained RPD. Furthermore, integrated interlock design (design A) can afford the required reciprocal effect.

CONCLUSIONS

With the limitations of this study, we can conclude that

A more favorable stress applied on the canine and bicuspids obtained with integrated interlock attachment.

The configuration of the integrated interlock attachment provides a nearly equal reciprocation effects as the parallel interlock attachment

The strategic position of the canine with parallel interlock attachment design withstand the higher compressive forces.

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