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STRESS ANALYSIS EVALUATION OF COMBINING RESILIENT ATTACHMENTS WITH DIFFERENT CANTILEVER BAR LENGTH ON SUPPORTING STRUCTURES OF IMPLANT SUPPORTED OVERDENTURE IN-VITRO STUDY

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ABSTRACT

Four screw type implants(Pitt-easy Implant System, SIS, Germany) were placed in the interforaminal region of mandibular acrylic model then the abutments(Titanium sleeve abutment,Pitt –easy, Germany) intimately fitted over the hex of the implant. Two bar-ball designs were constructed on single model; **Design I:** Bar with yellow colored clips(Vario- Soft bar- Pattern VSP) connecting four implants with 8 mm distal cantilever bar extension with distally placed ball attachment (Patrix VKS - SG,Bredent,Germany) **Design II:** Bar with yellow clips connecting four implants with 16 mm distal cantilever with distally placed ball attachment. Two bar-ball designs were constructed on single model as follow: The bar connecting the abutments were held with mandrel, so that it's rounded surface facing occlusally and its flat surface facing to the ridge. The wires of the strain gauges(Kaywan, Electronic Instrument, Tokyo, Japan) were embedded in specially prepared channels in the base of the model. The straight load applicator bar of the universal testing machine(LLyod Instruments, Japan) was allowed to touch the denture teeth. Vertical unilateral loading was applied unilaterally at the central fossae of the left second premolar. All data of the study were collected and statistically analyzed. Using student T test to compare between two designs, it is found that there is statistically significant difference between design I and design II. The result obtained from this study showed that there is increase in the stresses applied to the nearby abutment this was due to the distal extension that act as hidden cantilever which add to bending moment and the fact that in design II the bending moment will decrease, thus decreasing the amount of force on the abutment.

INTRODUCTION

Implant reconstruction and rehabilitation provide the patients with the opportunity to recapture lost masticatory function restore esthetic compromised and achieve a greater sense of well being of thousands of seriously debilitated edentulous mouths that have been dramatically rehabilitated using osseointegrated fixtures that maintain fixed and removable appliances [1].

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Four to six implants were usually required to provide support for the overdenture. Bar was usually used to rigidly connect the implants in the anterior region. Bar clip was placed in housing made in the fitting surface of the denture, to overly and fit the bar [2].

The use of stress breaker attachments was indicated for periodontal compromised teeth to release the stress and direct it to the distal alveolar ridge. The use of rigid attachment was reserved for periodontally sound teeth because they can support a large amount of stress.

The resilient attachments can be unidirectional or multidirectional, and may involve both bar and the telescopic stud attachment.

A compensating factor in resilient attachments allows the tissue rather than the tooth to support the denture base entirely. This type should not be used if possible because they require more space and were mechanically complex[3].

Bar attachments have been used, because they provide a splinting mechanism between the overdenture abutments and increase the stability and retention of prosthesis. Bar attachment consists of a sleeve, incorporated in the overdenture with clips over a bar attached to the abutment teeth. The overdenture bar attachments were classified by their biomechanical behavior into rigid and resilient attachment. In an attempt to minimize the undesirable forces transmitted to the overdenture supporting structures, a short (5-7 mm) and long (13-15 mm) distal cantilever extension bar have been suggested.

Cases that require increased retention such as compromised ridge and cases exhibiting high muscle attachments, prominent mylohyoid ridges, or extreme gaggers have been indicated for cantilever bars. The cantilever design may satisfy the increased demand for retention and tissue protection providing a more economic treatment approach [4].

In spite of the functional advantages offered by cantilever supported prosthesis, the distal cantilever bar may cause bending moments which may lead to mechanical failure and subject the abutments and their supporting structures to excessive bone resorption. Many experimental stress analysis methods have been employed to evaluate biomechanical loads. These techniques compromise photo elastic stress analysis, strain gauge analysis, holographic interferromtry and finite element stress analysis [5]. Overdenture should be considered a preferred alternative to complete denture therapy especially in patients with badly worn down teeth. Overdenture was indicated for the treatment of cases, suffering from severe attrition associated with Dentinogenesis Imperfecta. The use of cast coping will protect the soft remaining dentition without exerting excessive stresses on the abutments [6, 7]. Although, long term studies have been published evaluating the generalized effect of overdenture attachment on denture supporting structures, however there was rareness of studies on the effect of the length of distal extension cantilever bar retained design on the overdenture supporting structures. Thus this study was done to evaluate the effect of using resilient attachment on different cantilever bar length on the supporting structures of implant supported overdenture[8, 9].

Implant supported overdenture enhance masticatory function and proprioception, reduces trauma of overlying tissues and allows for making maxillary overdenture without complete palatal coverage. Lip and facial support can be improved together with phonetics and speech. It attains more patient tolerance. The use of implant supported overdenture help in reducing the rate of bone resorption. An existing overdenture can be easily converted to conventional overdenture. Long term maintenance and complications were reduced when implant supported overdenture were used [10,11].

However, infrequent replacements of retentive components allow potential movement of denture followed by tissue irritation, and the need to maintain and adjust the prosthesis by tissue conditioner [12, 13].

MATERIALS AND METHODS

This in-vitro study was performed on completely edentulous acrylic mandibular model with four implants (Pitt-easy Implant System, SIS, Germany) positioned in the inter-foraminal region.

The overdenture castable abutments(Titanium sleeve abutment, Pitt-easy, Germany)(head height 6mm) were gently tightened to fit the abutment intimately over the hex of the implant.

The model was placed on the table of the milling machine and fixed in position within the machine.

The abutments were overbuilt with castable acrylic resin (Pi-Ku-PlastHP36, Bredent, Germany) in increments. The abutments were then prepared to15-degree inclination.The abutments were adjusted to be 6 mm above the gingival margin. Fig. 1

Two model designs were used:

Design I: The bars (Vario-Soft-Bar-Pattern VSP, Bredent, Germany) were fixed in position using castable acrylic resin. They were placed 1mm away from the edentulous ridge. Cantilever extension bar of 8 mm length was added distal to the distal abutments at the end of these extensions; ball attachments were held with the mandrel, adjusted and sealed with castable acrylic resin.

Design II: The abutments were replaced by another four abutments and they were prepared as in design I with the same bar position except that cantilever distal extension of 16 mm length was attached to each distal abutment, with ball attachment was attached at its end was adjusted and sealed with pink wax. At the end of these extensions ball attachments were held with the mandrel, adjusted and sealed with castable acrylic resin. Fig. 1

Spruing, investing, burn out and casting using chrome Nickel alloy (Brealloy F 400, Bredent, Germany) were performed for both designs Abutments were finished and polished.The bar connecting the abutments were held with mandrel, so that it's rounded surface facing occlusally and its flat surface facing to the ridge.

The putty body rubber base impression in properly selected tray was made for the cast while the design I was screwed in place, then poured in dental stone. Another rubber base impression in well fitted impression tray was taken while the design II was screwed in place then poured in hard dental stone to produce second stone cast. The bar design in both casts was blocked out with hard stone.

Fig. (1)

Fig. (2)

Overdentures for both designs were made from heat cured acrylic resin Posterior teeth(Thermopress, Bredentan, Biodentblast, Germany).Round bur of 2 mm diameter was used to decrease the height of edentulous ridge. The reduced edentulous area was painted by rubber adhesive. Vertical unilateral loading was applied using universal testing machine (LLYOD Instrument, Japan) at the central fosse of the left first molar. The applied load started from zero up to 100N. All data of the study were collected and statistically analized

RESULTS

(A) Effect of each design on microstrains induced to the abutments and ridge:

Design I (Short cantilever):

Using Anova test, statistically significant difference was found between microstrains induced on different sites where the microstrains induced on right abutment was highest followed by left abutment, left ridge, and the right ridge. Using Bonferrioni correction test reveal statistically significant difference between right ridge and right abutment, right ridge and left abutment, right ridge and left ridge, right abutment and left abutment, right abutment and left ridge and left abutment and left ridge.

Design II (long cantilever):

In deign II (long cantilever) the microstrains induced at right abutment was highest followed by left ridge, left abutment and the right ridge. Using Bonferrioni correction reveal statistically significant difference between right ridge and right abutment, right ridge and left abutment, right ridge and left ridge, right abutment and left abutment, right abutment and left ridge and left abutment and left ridge.

Comparison of recorded microstrains between the two design:

The results obtained showed that the greatest strain was induced on the left abutment in design I while the least strain was induced on the right ridge in design II.

Using student T test to compare between design I and design II, it is found that there is statistically significant difference between design I and design II. Fig.3,4

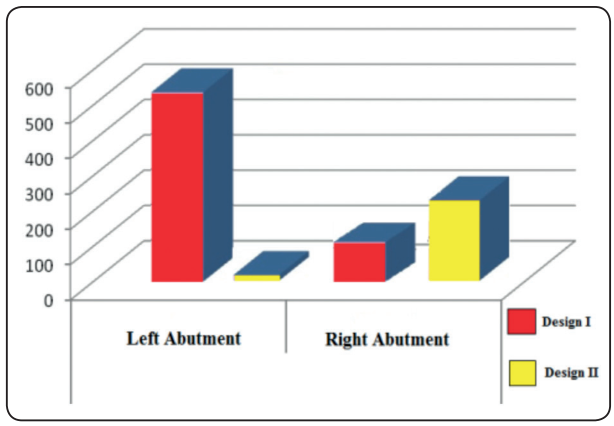

Fig. (3)

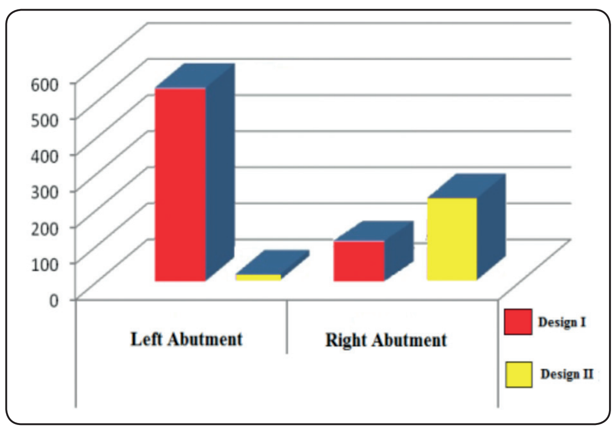

Fig. (4)

DISCUSSION

Unilateral loading of the dentures was performed to simulate the clinical situation as much of the chewing activities are carried out unilaterally [14].

The results obtained from this study showed that in unilateral loading, using design I of rigid interconnecting bar, distal extension cantilever bars, and the use of resilient attachment reduce the strains delivered to the supporting alveolar bone under the overdenture base and directing the stress to the abutment. This was in agreement with previous mechanical study[15].

This achieves one of the main objectives of overdenture treatment which is the preservation of the supporting ridge. The presence of overdenture abutments offers support and stability to the denture, thus reducing the amount of stresses transmitted to the supporting bone[16].

Thus under loading the abutments act as a fulcrum, inducing excessive amount of stresses on the abutments. In addition, the significantly increased amount of strains delivered to the abutment supporting structure is most probably due to the use of rigid bar, with a resultant excessive force on the abutment teeth This explanation is consistent with previous mechanical stresses that have demonstrated that the use of rigid bar supports a large amount of stresses and induces excessive stress concentration on the abutment supporting structures [17].

Thus regarding the health of the abutments this study recommends the use of long cantilever bar that extends to the distal aspect of the first molar. This was in agreement to a study reporting that if a short cantilever bar extension was used and the artificial teeth extends distal to this bar, the prosthesis extension distal to this bar acts as a hidden cantilever that adds to the bending moment with a resultant excessive force on the abutment teeth. This may explain the stress concentration pattern on the abutments in overdenture supported with short distal cantilever bar extension and the results that in design II was decrease in stresses on the abutments as result of decreasing the bending moment[18].

This finding was emphasized by a study that suggests the use of distal extension cantilever with the short length would subject the abutments to excessive bone resorption after considerable time[19].

This was in opposition to a study claimed that the use of long distal cantilever bar extension caused favorable load distribution to the residual ridge, and shifting the stresses to the abutment supporting structures[20, 21].

The result obtained from this study showed that there is increase in the stresses applied to the nearby abutment this was due to the distal extension that act as hidden cantilever which add to bending moment and the fact that in design II the bending moment will decrease, thus decreasing the amount of force on the abutment. Micro-strains were recorded at each site of the strain gauge during unilateral loading with enough time elapsed between each loading to allow complete rebound of the resilient structures.

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