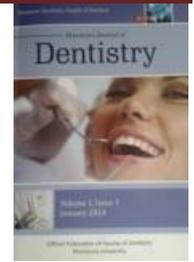




In Vitro Stress Analysis of Force Transmitted By Mandibular Bilateral Free End Saddle Using Four Millimeter Short Implant Retained Removable Partial Overdenture



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Abstract:

Purpose: The aim of the study is in vitro stress analysis of force transmitted by mandibular bilateral free end saddle using extra short dental implant (four millimeters) retained removable partial overdenture.

Material and methods: For this study ten educational epoxy resin models were made representing mandibular bilateral distal extension edentulous area with the only six anterior teeth remaining and the mandibular canine as the main abutment, the implants were placed at the site of the second molar. A self-protected linear strain gauge was used for this study to measure the micro-strain induced on the buccal, lingual, mesial and distal sides of the implant.

Results: during unilateral loading on the loading side, There was a significant difference in total stresses between groups combination clasp recorded significant higher total stress than RPI and there was a significant difference in peri-implant stresses between groups for all gauge positions. during unilateral loading on the non-loading side, There was a significant difference in total stresses between groups combination clasp recorded significant higher total stress than RPI.

Conclusion: Implant retained mandibular partial overdenture with combination clasp transfers more stress than RPI clasp because of the flexibility of the combination clasp more than rigid connection of RPI clasp and therefore transmits more stress during loading than RPI and there was a significant difference in stress between strain gauge positions in both groups.

Introduction

Removable partial denture (RPD) continues to be an essential prosthetic consideration in many oral reconstructions, especially when edentulous ridges posterior to a patient's remaining teeth are to be restored.⁽¹⁾

Rehabilitation of a partially edentulous patient can be established using a wide range of prosthetic treatment options including simple conventional removable partial denture, overdenture, fixed partial denture or dental implants.⁽²⁾

Most of these problems could be attributed to the absence of the posterior abutment. ⁽³⁾ Since, the difference in displacement between the mucosa and the periodontal ligament of last standing abutment was estimated to be up to 25 times. ⁽⁴⁾

Consequently, when functional pressure is applied to the distal extension base removable partial denture, the resultant forces are extremely damaging to the abutment teeth and must be controlled if clinical treatment is to be successful. ⁽⁵⁾

The use of dental implant as a distal abutment can convert a distal extension removable partial denture from a tooth- and tissue-supported prosthesis to a tooth- and implant- supported and retained prosthesis. A posterior placed implant provides a definite stop that increases stability and eliminates the problems often associated with a tooth- and tissue-supported distal extension removable partial denture. ⁽⁶⁾

Distal implant with a resilient frictional abutment complex (the abutment with extra coronal attachment) retentively provides stability and eliminates the problems often associated with a tooth and tissue supported RPD by converting distal extension RPD base from a tooth and tissue-supported prosthesis to a tooth and implant supported and retained prosthesis and so the extension of the RPD can be reduced. ⁽⁷⁾

However, anatomical consideration may prevent implant placement and position in the existing clinical condition as that the position of the mandibular canal and the maxillary sinus, the width of the cortical plate, the existing bone density. ⁽⁸⁾ Reduced bone

height frequently presents a challenge for implant-assisted tooth replacement in partially edentulous patients. ⁽⁹⁾

So, the aim of this study is to evaluate in vitro stress analysis of force transmitted by bilateral free end saddle Implant Retained removable partial denture and to compare in vitro micro-strain induced by different prosthetic options using a single posterior implant in lower bilateral distal extension saddle

Material and methods

This in vitro study was done on mandibular heat cure acrylic resin model with only remaining six anterior teeth (Kennedy class I).

Construction of the clear heat cured acrylic resin models by:

1-A mandibular stone cast with only remaining six anterior teeth was selected for this experimental study.

2-Duplication of the mandibular stone cast as follows:

An impression was made to the stone model with silicone rubber base impression material to create a rubber base impression mold, molten base plate wax was poured inside the silicon rubber base mold to obtain a waxed model. The models were inspected and any discrepancies were adjusted and excess wax was removed, the waxed model was flaked to produce a stone mold in which a clear heat cured acrylic resin was packed, cured, finished and polished in conventional manner to obtain a mandibular heat cure acrylic resin model.

Simulation of oral mucosa covering the residual ridge :

According to Dahab et al.⁽²⁰³⁾ the edentulous area of mandibular bilateral distal extension clear heat cure acrylic resin model was covered by auto-polymerized silicon soft liner material to simulate the oral mucosa covering the model residual ridge. By the using of the plaster index; the auto-polymerized silicon soft liner was packed over the acrylic resin model with firm hold by any fixation methods until complete polymerization.

Construction of acrylic guide stent for implant installation: For determining the implants position in the area of the second molar teeth acrylic guide stent was fabricated to be used as a guide for implants positions.

Implant installation:Two implants single piece tut manufactured in egypt four millimeters length and four millimeters width with ball and socket attachment were installed at the area of the second molar region In the mandibular heat cured acrylic resin model by the dental milling machine.

Construction of retained mandibular partial

verdenture:According to the clasp used to retain mandibular partial overdenture,two groups were used:

G1:Five mandibular partial overdenture with vertical reciprocal arm connecting mesial placed cingulum rest on canines teeth with RPI clasp and double lingual bar.

G2: Five mandibular partial overdenture with vertical reciprocal arm connecting mesial placed cingulum rest on canines teeth with combination clasp and double lingual bar.

A-Construction of the metallic framework:Sufficient openings in the meshworks were placed corresponding to the implant either mesial or distal to accommodate the implant abutments,fitness of the metallic frameworks was done on the educational models.

B-Denture construction:

1-After fitness of the metallic framework over the educational models remove them and readapted on the master casts then tentative wax occlusion rim with suitable width and length are made .

2-Set up of artificial teeth according to the same size and shape of the study model teeth and according to distal marginal ridge of the canine teeth anteriorly and anterior 2/3 of the retromolar pad posteriorly.

3-Opposing stoneindexes were made resemble the maxillary cast for relation on articulator.

4-Mounting of the lower cast on asemi-adjustable articulator with the trial denture.

5-Mounting of the upper stone index over the lower trial denture bases.

6-The dentures were waxed up, flasking for wax elimination,deflasking,packing of clear heat cured acrylic resin,processed along curing cycle, then finished,polished.

7-Adjusting of the dentures over the educational clear heat cured acrylic resin models.

8-To facilitate the load application procedures,the occlusal plane of the lower RPOD was modified by placing thin layer of clear self cure acrylic resin over the occlusal surface of the artificial teeth,to provide even and flat surface.

C-Picking up of the ball attachment matrix:

1-A smart matrix of the ball abutment was selected according to the manufacture catalog of the ball abutment.

2-Clearing of sufficient amount of the acrylic resin of the fitting surface corresponding to the ball abutment.

3- Vents holes were made in the lingual of surface of the dentures as they allow for the verification of housing denture clearness and to allow the escape of excess material. The prepared area was

activated area was activated by monomer application directly before the picking up.

4-The impression spacers were positioned into its place on the ball attachments. This spacer is important to allow for the resiliency of the attachments and also to block out ball abutment to avoid entering of the acrylic resin.

5-The matrixes were seated into the ball attachment and tested for easy rotational movement.

6-The model was fixed into the loading device to provide force of 70N during the pickingup procedure to simulate clinical functional pickup.

7-Autopolymerized acrylic resin was packed into the relived area to hold the matrix while the overdenture was held firmly into position by applying acenral load.

Installation of strain gauge:

Eight self-protected linear strain gauges 1mm length, strain gauge resistance was $120.4 \pm 0.4 \Omega$ gauge factor was $2.13 \pm 1.0 \%$ and, Adabtable thermal expansion $=11.7 \text{ ppm}/^{\circ} \text{c}$, temperature coefficient of gauge factor $+0.008\% / \text{c}$, with fully in capsulatedgrid and attached wire

A- gauges were installed mesially and distally,buccally and lingually to each implant on the mandibular acrylic resin model to monitor the effect of applied load

B- Implant sites receivd the strain gauges were smoothened with fine sandpaper to develop a surface texture suitable for strain gauge bonding.

C-A tunnel related to each fixture was prepared through the model base for passing the wire of the strain gauge, and the base of the model was prepared with grooves to accommodate the wire.

D- Lead wire cables were secured to the tunnels in the model using resin adhesive to avoid any possible movement of the wires that may affect the accuracy of the readings.

E- The eight gauges were bonded to their respective sites on the simulation model by using adhesive recommended by the manufacturer,The strain gauge wires were marked with a code to identify them during measurements and during analytical and statistical procedures.

F- A protective insulating coat was applied to the outer surface of the eight strain gauges for protection against moisture. Eight channel strainometer device as used to assess the stress induced to the implant fixtures.

The loading device :

- Digital loading device was used to apply vertical static compressive load (60 N) on the selected loading points in this experiment.this device is formed of four main component: the base,the digital control panel ,the PC digital control panel and the loading tool The strain meter device:

-The strain meter device was connected to a PC converting it into ameasurement instrument used for measuring the microstrain around the implant with a strain gauge.



Some of figures

Strain gauge calibration :

The aim of calibration is to determine the relationship between the load applied and the strain signals received by the strainometer

A calibration experiment to the gauges was made to assess the linearity of the gauges and the repeatability of force measurements .

Load ranging from 0 to 60 N was applied in 10-N steps to ago the gauges.

Stress-strain measurements :

The strainometer device was adjusted to conform to the gauge factor. This adjustment was checked at regular intervals to assure that there is no deviation.

Every time the experiment was under taken the circuit was balanced and those of strain gauges , the unilateral first load

for about 60 N was applied at the right first molar tooth , then the reading of the eight strain gauges was recorded at the second load(60 N) is applied at the same area and recorded again at least to minutes were taken between each reading, for the central (bilateral)loading at a metal bar is used to adjust the knob then 60 N is applied at the center of the denture and the reading was recorded

Relation between stress and strain is derived from the following equation "stress/strain = modulus of elasticity" where the modulus of elasticity for the acrylic resin is 3.2

Result:

I. During bilateral loading

Comparison of stresses between groups

- No significant difference in total stresses between groups was noted
- There was a significant difference in peri-implant stresses between groups for distal and buccal gauge position only .
- Combination clasp was associated with significant higher stress than RPI clasp
- At lingual and mesial gauges no difference in peri-implant stresses was noted.

II. During unilateral loading on the loading side

- There was a significant difference in total stresses between groups Combination clasp recorded significant higher total stress than RPI
- There was a significant difference in peri-implant stresses between groups for all gauge positions .
- At distal and buccal gauges, RPI recoded higher stress than Combination clasp
- At mesial ang lingual gauges, Combination clasp was associated with significant higher stress than RPI clasp

III. During unilateral loading on the non-loading side

- There was a significant difference in total stresses between groups Combination clasp recorded significant higher total stress than RPI
- There was a significant difference in peri-implant stresses between groups for mesial ang lingual gauges .
- At distal and buccal gauges, no difference in stresses between groups was noted.
- At mesial ang lingual gauges, Combination clasp was associated with significant higher stress than RPI clasp

Discussion:

The acrylic resin was used in the construction of the mandibular model because of the similarity in modulus of elasticity between the compact bone and acrylic resin as suggested by Ichikawa et al.,(Ichikawa et al., 1997)

Freitas et al. stated that implant placement on the molar region can provide better biomechanical configuration, changing Kennedy class I or II to class III (De Freitas et al., 2012).

As reported in several invitro strain gauge studies(Uchida et al., 1989; Ichikawa et al., 1996; Porter et al., 2002; Prombonas and Vlissidis, 2006; Gonda et al., 2007; Elsyad et al., 2013), silicone soft lining material with a thickness of 2mm was used to simulate masticatory mucosa on all edentulous areas to approximate elastic of moduli of soft tissue.

A clear acrylic drilling guide stent has been used to mark implant placement sites on the model to facilitate the implant positioning in an accurate and standardized way for the model(Vogel, 2008).

In this study, the strain gauge analysis was used to evaluate the peri-implant strain due to the electrical strain gauges have been used extensively for quantitative analysis of the stresses around implants supporting a mandibular overdenture(Heckmann et al., 2001; Akca et al., 2002; Tokuhisa et al., 2003; Akca et al., 2007; Cekic et al., 2007; Maeda et al., 2008). This technique is one of the common methods used for dental stress analysis that can overcome many shortcomings of the application of other methods(Cehreli and Iplikcioglu, 2002). Stafford and Glantz(Stafford and Glantz, 1991) advocated using of strain gages for measuring strains and deformation due to their small size, linearity and their minimal interference during function. On the other hand,

A gradual static central load was applied from 0-100 Newton using the universal testing machine. This load amount was selected because it is within the range of normal occlusal mastication and close to maximal loads for implant overdenture patients, depending on the dentition of the opposing arch(Mericske-Stern and Zarb, 1996; Porter et al., 2002).

LLOYD digital loading device was used to deliver ascending load in this study. It is digital and easy to use. Besides, it offers high accuracy position measurement, rapid data acquisition and full personal computer integration (Hegazy et al., 2013)

Load was applied both bilaterally and unilaterally corresponding to the first molar to simulate two different functional situations in the oral cavity. The load was applied bilaterally to reproduce centric occlusion in vivo and unilaterally to reproduce unilateral chewing on the working side.

Narrow-diameter implants (< 3.75mm) are indicated in cases of alveolar bone loss prior to tooth extraction as a result of periodontal disease or when the buccolingual width of the edentulous ridge is insufficient. When attachment systems are used to apply retentive forces, lateral forces will occur around the implants. However, the relationship between the retentive force of unsplinted anchorage attachments with inclination and the lateral force to the implant has not been fully evaluated. An ideal attachment system should provide a higher retentive force with a lower lateral force to the implant during recurrent dislodging. (Yang et al., 2011) to place conventional implants (Degidi et al., 2009; Arisan et al., 2010)

Conclusion:

Implant retained mandibular partial overdenture with combination clasp transfers more stress than RPI clasp because of the flexibility of the wrought wire clasp more than rigid connection of RPI clasp and therefore transmits more stress during loading than RPI. And there was a significant difference in stress between strain gauge positions in both groups.

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