MJMR, Vol. 34, No. 1, 2023, pages (314-318).

Open Access
ISSN:2682-4558

Research Article

Stress Analysis For Ball and Socket Attachments In Implant-Retained Mandibular Overdenture.

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DOI: 10.21608/MJMR.2025.152194.1148

Abstract

Purpose: The aim of this study was to evaluate the stress distribution of ball and socket attachments in three implant retained mandibular overdenture. **Methodology:** Completely edentulous model was constructed by using resin. Three implants were inserted in intraforimnal region two in canine and one in the left central incisor. Three ball attachments were screwed to the implants for creating a model of study. The strain gauges used in this were bonded on the prepared surfaces around middle and right implants to monitor the effect of the vertical load . A universal testing machine was used to apply a vertical static loads (0-150N) on the loading points, Data were collected and statistically analyzed.
Results: There was a significant difference between the middle and the right implant, The values of micro strain in the middle implant was higher the right implant at Bilateral central loading and the right implant was higher than middle one in unilateral loading. At the middle implant the buccal wall recorded the highest micro strain at different loading point except in the Bilateral central loading the micro strain was the same at the buccal and lingual wall .At the right implant lingual wall recorded the highest micro strain at different loading point. **Conclusion:** Within the limitations of this study, it can be concluded that there were different patterns of stress-strain distribution around three implant retained mandibular overdenture. The middle implant has recorded a higher statistically significant mean micro-strain than the right implant.

Keywords: Implant, overdenture, stress analysis, attachments, ball and socket.

Introduction

Complete denture patients facing many challenges due to its poor support and retention precipitated by advanced bone resorption, xerostomia , loss of attached keratinized tissue and neuromuscular degeneration .[1]

Several attempts have been done for those patients to optimize both patient satisfaction and performance. The most successful treatment option to solve these challenges are using implant to support/retain an overdenture using bar, solitary attachments or magnets.[2]

Placing implants in the interforaminal region could enhance stability, retention and function because of favorable local bone quality and quantity.[3]

Using implants with both splinted and unsplinted attachment systems designs have unique advantages and disadvantages and exert direct effects on clinical variables, making it difficult for dentists to select the proper design for each case. Unsplinted systems are easier to use in terms of hygiene maintenance; in addition, they are less technique sensitive.[4]

The concept of three implants to support a mandibular denture with separate stud attachments or splinted implants has been introduced since1980s, and this modality of treatment has been widely used.[5]
Among these, ball attachments are the simplest, most commonly used, lowest cost attachment systems compared to other attachment systems.[6]

Several in-vitro methods have been used to evaluate the stress on implants such as photo elastic, finite element and strain gauge stress analysis. Electrical strain gauge has been used widely for analysis of the stresses around

implants supporting a mandibular overdenture.[7]

A universal testing machine is used to exert a vertical compressive and tensile force. It is used to apply a compressive force on implant supported overdenture to simulate occlusal force. On the other hand, the tensile force is applied to the overdenture to simulate the dislodging force.[8]

Material and Methods

1. Study design.

This in vitro study was designed to evaluate the stress distribution of ball and socket attachments around three implant retained overdenture by using the strain gauges which bonded on eight of the prepared surfaces around two implants middle implant and right one to monitor the effect of the vertical load applied on ball and socket attachments.

2. Study model preparation:

A completely mandibular edentulous rubber mold (Trimould, Tokyo, Japan) was poured first with epoxy resin (Kemapoxy 150,CMB International, Giza, Egypt) and second with stone to obtain 2 models with the same size and dimension, following the manufacture instructions. Acrylic denture was constructed on a stone model with artificial teeth as a template guide during implant insertion.

3. Implant insertion:

Three identical implants (Flotecno SRL. Turati, 38 Milano, Italy) (3.7mm diameter / 11.5 mm length) were inserted at the canine regions bilaterally and the left central incisor region. The implants were inserted parallel to each other by using a milling machine and parallometer. A mix of small amount of epoxy resin was poured to the osteotomy sites and the implants were inserted.

4- The prosthetic phase:

Three ball attachments were screwed to the implants to be scanned later for fabrication of the overdenture framework.

5- Skeleton metallic frameworks construction

Skeleton metallic framework design was constructed to be attached to the ball and socket attachments.

6- Overdenture construction:

Fully contoured waxed up mandibular overdentures were constructed around the metallic framework using stone cast duplicated from ball and socket attachment system. Duplication was made using adupli-cation material (Superb jelly, Mestra, Talleres Mestraitua Sl, Txorierri Etorbidea 60,48510 vizcaya, spain). The waxed-up dentures were flasked, wax was eliminated, Heat activated acrylic resin was packed and cured using conventional method.

7- Simulation of the mucosa covering the residual ridge

A Series of holes 2mm deep holes, were created in the residual ridge of the epoxy resin model by a number 5 round bur .The epoxy resin between the holes was removed using a cylindrical carbide cutter bur. creating a space of 2 mm for a mold cavity for simulation of soft tissue.Selfl-cured silicon soft liner (Mollosil Detax GmbH & Co.KG Carl-Zeiss Str.4.76275Fttlingen/Germany.)was packed in this space. This produced a resilient layer simulating the mucosa in edentulous area with even thickness.

8- Picking- up procedure:

Nylon caps and their metal housing were placed over the ball attachments. The fitting surface of the overdenture was reduced to ensure seating properly with enough clearance between denture fitting surface and the metal housing. Pick-up was made using chemically activated acrylic resin at dough stage.

9- stress analysis:

The epoxy resin around two implants in the left central and the right canine was reduced using fissure bur to leave labial , Lingual, mesial and distal surfaces 1mm thickness all around each implant , the implant in left canine are not prepared because the right and

left implant were contralateral to each other so we used one of them . After such preparation the Surfaces were ensured to be flat and parallel to the long axis of the implants.

The prepared sites were smoothened using 400 grit silicon carbide paper and a fine Sand paper to develop a surface texture suitable for strain gauge bonding.

The strain gauges used in this study had a gauge length 1mm .Resistance was 120.4 Ohm and gauge factor2.09.strain gauges were bonded by using a cyanoacrylate based adhesive on eight of the prepared surfaces around two implants middle implant and right one to monitor the effect of the vertical load applied on ball and socket attachments.
A universal testing machine was used to apply a vertical static loads (0-150N) on the loading point .it had the advantage of applying the load every time in the same magnitude and direction.
The terminals of the lead wire of the strain gauges were connected to a multi-channel strain meter ((EDX-10A series, Chofugaoka, Chofu, Tokyo 182-8520, Japan))in order to calculate the microvoltage out-put which was converted into microstrain using special software."Fig1"

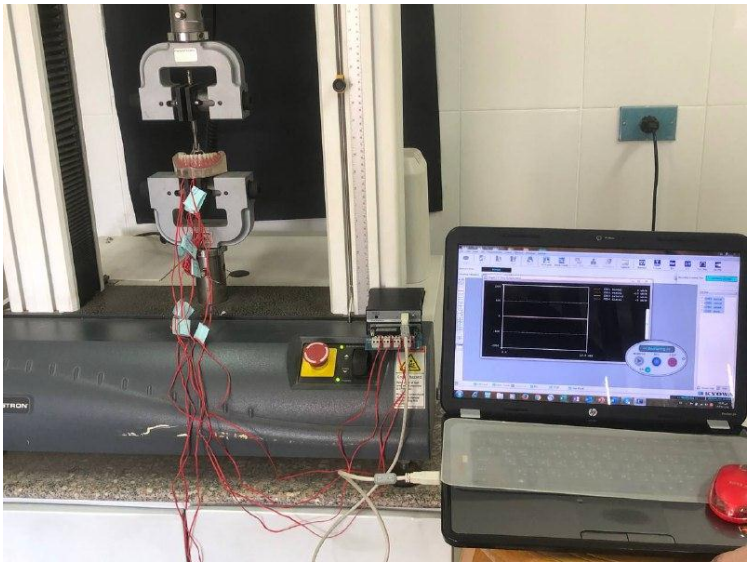

Fig. 1 : showing the universal testing machine was used to apply a load in different point

Results

Relation between middle and right implant in ball and socket attachment:

Load Bilaterally at geometric center

A statistically significant difference was found between (Middle) and (Right) implants where (p=0.027). Table (1)

Load unilateral at Right working side:

No statistically significant difference was found between (Middle) and (Right) implants where (p=0.050). Table (1)

Load unilateral at left balanced side:

No statistically significant difference was found between (Middle) and (Right) implants where (p=0.249). Table (1)

Table 1:

Variables	μ-strain					
	Solitary ball attachment					
	Bilateral		Unilateral (Right)		Unilateral (Left)	
	Mean	SD	Mean	SD	Mean	SD
Middle implant	89.59	19.30	65.78	12.81	30.35	6.37
Right implant	62.83	10.05	141.01	43.25	38.12	8.35
p-value	0.027*		0.045*		0.249ns	

**; significant (p<0.05) ns; non-significant (p>0.05)*

Table (1): The mean, standard deviation (SD ±) values of micro strain results of each implant in solitary ball attachment at different loading point.

Discussion

The concept of three implants to support a mandibular denture with separate stud attachments or splinted implants has been introduced since1980s, and this modality of treatment has been widely used[5].

The surface of the denture bearing area was replaced by a 2-mm thickness layer of self-cured silicon soft liner to simulate the viscoelastic behavior of mucous membrane covering the residual ridge [9].

During model preparation for strain gauge installation, 1mm of acrylic resin was left all around the implants, this was recommended to maintain sufficient rigidity around these structures, and allow for placement of the measuring grit of the gauge closer to the load carrying structures, thereby enhancing its sensitivity to the microsrtrain changes that occurred as a result of load application.[10].

After each loading cycle a five minutes pause was allowed to the successive one as recommended[11] this allowed for rebound of the deformation that occurred in the acrylic resin and the soft liner material simulating the mucosa following load application that would have affected the results.

The universal testing machine was used to test the retention forces because of its accuracy, reliability and reproducibility[15].

A universal testing machine was used to apply a vertical static loads (0-150N) on the loading point to apply the load every time in the same magnitude and direction. The moderate masticatory forces for implant retained over-denture patients was found to be about ‘- 150 N hence, the strain meter was set to record the micro strain readings produced by such a load [13,14.]

Load was applied at bilaterally (at geometric center) and unilaterally (at right side that simulate working side and left side that simulate balanced side). The universal testing machine was used to make forces because of its accuracy, reliability and reproducibility. I–shaped load applicator was utilized for obtaining the loading readings where the load applicator was applied on the prepared notch. A notch was made at the point of load application using a diamond bur to accommodate the tip of the loading pin for reproducibility and also to prevent slippage.

In the present study when application of load bilaterally (central loading) it was found that the middle implant have recorded a higher statistically significant mean micro-strain than the right implant, when the load applied unilaterally (right working side) the micro-strain at right implant was higher than middle one.

During application of the unilateral load,higher stresses were observed in the loaded side than those in unloaded side. This might be due to the denture base contact the top of the coping at the loaded side after load application which became a fulcrum of concentrated stresses, as in agreement with Dong et al.,[15].

Conclusion

Within the limitations of this study, it can be concluded that there were different patterns of stress-strain distribution around three implant

retained mandibular overdenture. The middle implant has recorded a higher statistically significant mean micro-strain than the right implant.

References

1. Allen PF. Association between diet, social resources and oral health related quality of life in edentulous patients. J Oral Rehabil. 2005 Sep;32(9):623–8.
2. Thomason JM, Lund JP, Chehade A, Feine JS. Patient satisfaction with mandibular implant overdentures and conventional dentures 6 months after delivery. Int J Prosthodont. 2003;16(5):467–73.
3. Liu J, Pan S, Dong J, Mo Z, Fan Y, Feng H. Influence of implant number on the biomechanical behaviour of mandibular implant-retained/supported overdentures: A three-dimensional finite element analysis. J Dent. 2013;41(3):241–9.
4. Seo YH, Bae E Bin, Kim JW, Lee SH, Yun MJ, Jeong CM, et al. Clinical evaluation of mandibular implant overdentures via Locator implant attachment and Locator bar attachment. J Adv Prosthodont. 2016;8(4): 313–20.
5. Zarb, G. A., Bolender, C. L., Eckert, S. E., Jacob, R., Fenton, A.,& Mericske-Stern, R. E. Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prostheses. 12 ed. 2004;
6. Alsabeeha NHM, Payne AGT, Swain M V. Attachment systems for mandibular two-implant overdentures: a review of in vitro investigations on retention and wear features. Int J Prosthodont. 2009;22(5):429–40.
7. Ramadan R, Mohamed F, Gepreel M. Evaluation of Implant-Assisted Mandibular Overdenture With New Metal To Metal Interface Attachment System (in Vitro Study).Alexandria Dent J.2020;45(1):106-11
8. Yoda N, Matsudate Y, Abue M, Hong G, Sasaki K. Effect of attachment type on load distribution to implant abutments and the residual ridge in mandibular implant-supported overdentures. J Dent Biomech. 2015;6(0).
9. Agamy E. Stresses transmitted to the principle abutment in unilateral distal extension base partial denture. Sc Cairo Univ Egypt. 1997;
10. Stresses EOF, Two RIN, Types D, Bar OF, Used A, Implant IN, et al., Different Types of Bar Attachment Used. 2017;63:907–17.
11. Tokuhisa M, Matsushita Y, Koyano K. ln Vitro Study of a Mandibular Implant Overdenture Retained with Ball, Magnet, or Bar Attachments: Comparison of Load Transfer and Denture Stability. Int J Prosthodont. 2003;16(2).
12. Fromentin O, Lassauzay C, Abi Nader S, Feine J, De Albuquerque Junior RF. Testing the retention of attachments for implant overdentures - Validation of an original force measurement system. J Oral Rehabil. 2010 Jan;37(1):54–62.
13. Porter Jr JA, Petropoulos VC, Brunski JB. Comparison of load distribution for implant overdenture attachments. Int J Oral Maxillofac Implants. 2002;17(5).
14. Rismanchian M, Bajoghli F, Mostajeran Z, Fazel A, Sadr Eshkevari ; P. EFFECT OF IMPLANTS ON MAXIMUM BITE FORCE IN EDENTULOUS PATIENTS.
15. Dong J, Ikebe K, Gonda T, Nokubi T. Influence of abutment height on strain in a mandibular overdenture. J Oral Rehabil. 2006;33(8):594–9.