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DIFFERENT LOCATIONS OF POSTERIOR IMPLANTS USED FOR ASSISTING MANDIBULAR COMPLETE OVERDENTURE (PERI – IMPLANT STRESS ANALYSIS)

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ABSTRACT

Statement Problem: When the posterior implants cannot be inserted in the posterior residual ridge areas of the mandible what about the success of inserting the posterior implants in the buccal shelf areas for assisting mandibular complete overdenture.

The aim: This in-vitro stress analysis study was done to evaluate and compare the stresses around 4 implants inserted for assisting mandibular complete overdenture with differently located two posterior implants, (in the residual ridge areas of second molars versus in the buccal shelf areas for assisting mandibular overdenture).

Materials and Methods: Acrylic resin model of complete edentulous mandibular arch was fabricated. Four implants (2 canine implants and two posterior implants) were anchored into the model. According to the locations of posterior implants two groups were studied Group I: where the two posterior implants was inserted into the second molar areas. Group II: where the two posterior implants was inserted into the buccal shelf area .The surface of the model covered with a layer of silicone soft liner material to stimulate oral mucosa and a removable overdenture was fabricated. A unilateral vertical force was applied to the occlusal surface of the first molar and gradually increased from 0 to 70-N in 5-N steps. The resultant stress distribution around implants was measured with each group.

Result: The results of this study showing recorded stresses around all studied implants. Inspite of the insignificant difference between recorded stresses around anterior implants in loading side of the two groups, more significant stress were recorded in the non- loading side of group II. When comparing between the mean of stresses around all implants in loading side of the two groups, statistically insignificant difference was recorded while a statistically significant more stresses were found in non-loading side of group II.

Conclusion: Within the limitations of this laboratory study, the results of stress analysis concluded that: Regarding the stresses around the 4 implants used for assisting mandibular complete overdenture, the insertion of the two posterior implants in the 2nd molar areas is better than in the buccal shelf areas.

KEY WORDS: Overdenture, 4-implant assisted complete overdenture, Locator attachment, Strain guage analysis.

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INTRODUCTION

Although the majority of completely edentulous patients are satisfied with conventional dentures, many others report problems such as difficulties with mastication, pain, and discomfort associated with wearing their dentures [1].

Implant assisted overdentures have been widely used to solve these problem by to improving retention and stability of conventional complete dentures. The implant assisted complete overdentures also improves neuromuscular activity and adaptation and thereby substantially improves masticatory function in edentulous patients [2].

The use of more than two implants has been recommended to assist a mandibular overdenture in clinical situations that require increased retention and stability. Adding two posterior implants is recommended to prevent rotational movements of the prosthesis [3].

Implant attachments improves support, stability and retention of these overdentures and increases patient satisfaction. Locator attachments are indicated in cases of complete overdentures assisted by 2-4 implants[4].

Locator attachment is self-aligning, has dual retention, and is available in different colors with different retention values, they are resilient, retentive, and can compensate for angle correction. [5,6].

The primary stress bearing area in the mandible is the buccal shelf area. The buccal shelf is bounded medially by the crest of the residual alveolar ridge, laterally by the external oblique ridge, anteriorly by the buccal frenum, and posteriorly by the retromolar pad. This area is important because of its right angle relationship to the vertical occlusal forces and large dense cortical bone support [7]. Moreover, due to the histological structure, the buccal shelf of bone shows less degree of bone resorption. This nominate the importance of the buccal shelf of bone to be the main supportive area under prostheses especially in severely resorped or unfordable ridge condition [8,9].

To analyze the effectiveness and reliability of endosseous implants, revealing possible risks of implant failure, stress analysis of bone–implant mechanical interactions is important [10,11].

Considering bone factor and some anatomical limitations and when the posterior implants cannot be inserted in the posterior residual ridge areas of the mandible what about the success of inserting the posterior implants in the buccal shelf areas for assisting mandibular complete overdenture ?

So this in-vitro stress analysis study was done to evaluate and compare the stresses around 4 implants inserted for assisting mandibular complete overdenture with differently located two posterior implants.

MATERIALS AND METHOD

This in-vitro study was carried out on acrylic resin model of complete edentulous mandibular arch was fabricated. Four implants (2 canine implants and two posterior implants) were anchored into the model. According to the locations of posterior implants two groups were studied Group I: where the two posterior implants was inserted into the second molar areas. Group II: where the two posterior implants was inserted into the buccal shelf area **(13mm in length and 3.5mm in width) (Implant Direct Sybron manufacturing. USA).** According to **(El charkawi et al 1994)**[12] The model was covered by auto-polymerizing silicone soft liner **(Acroston Relining material, Egypt)** material to simulate the oral mucosa covering the ridge. Then the denture were constructed by setting of teeth anatomically, flasking and curing then finishing and polishing.

After denture construction, the female housing was picked up to the intaglio of dentures by using auto-polymerized acrylic resin **(Acroston, Egypt)** and on finger pressure [13].

Four linear strain gauges were installed to the acrylic resin surface at mesial, distal, buccal, and lingual aspect of each implant (Fig 1 a,b). Lead wire from each active strain gauge was twisted against a wire from each dummy gauge and connected to form a half circuit Wheatstone bridge. Unilateral load of 70N was applied over the artificial teeth of mandibular overdenture using a Universal testing machine (Fig 1,c) that was run in compression mode at a cross head speed 0.5 mm/sec. The load was applied at first molar region unilaterally (Fig 1,d). Sixteen channel digital strain meter was used to collect data from the sixteen strain gauges attached to the model. The strain data was collected at rate of 2Hz (2 reading/sec) by the aid of KYOWA PCD software.

All the measurement was repeated five times for each loading impact. The mean average was calculated. These procedures were done for all groups and the stress was calculated from the equation.

$$\text{Stress} = \text{Strain} \times \text{Modulus of elasticity.}$$

As the modulus of elasticity of acrylic resin is 2700 MPa.

Statistical analysis

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. One way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between subgroups. Student t-test was done between post types with each ferrule length. Statistical analysis was performed using Graph-Pad Prism4 statistics software for Windows. P values ≤0.05 are considered to be statistically significant in all tests.

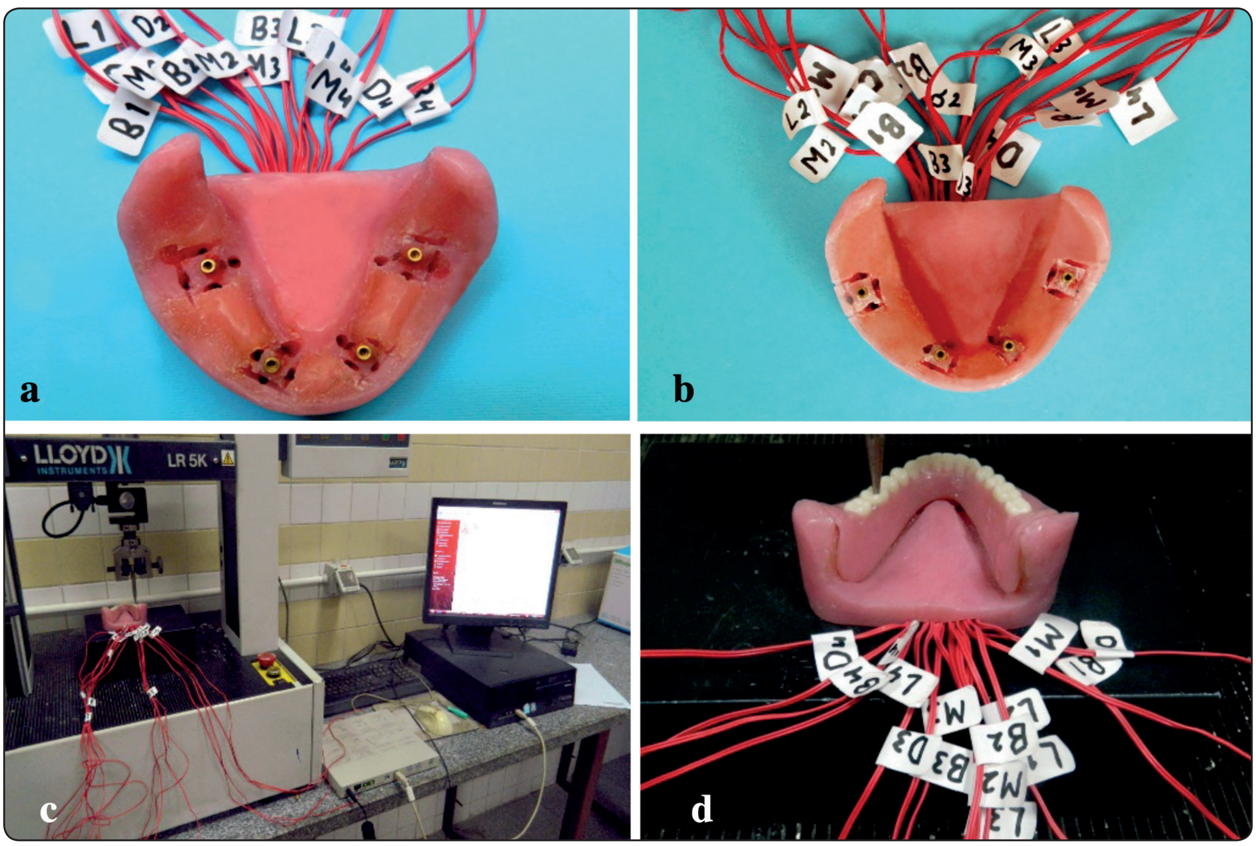

Fig (1) **a)** The installed and labeled strain gauges (in group I). **b)** The installed and labeled strain gauges(in group II). **c)** The digital multichannel strainometer and the universal loading device attached to the computer. **d)** The pointed tool attached to the universal testing machine during applying unilateral load.

RESULTS

I. Posterior implants inserted in 2nd molar areas and buccal shelf areas :

The means of stresses around canine implants in loading side were 28.35±4.5 Mpa. The means of stresses around 2nd molar implants in loading side were 28.0125±4.725 Mpa. The means of stresses around canine implants in non-loading side were 11.1375±2.475 Mpa. The means of stresses around 2nd molar implants in non-loading side were 12.4875±2.025 Mpa (Group I). The means of stresses around canine implants in loading side were 23.9625±5.9903 Mpa. The means of stresses around buccal shelf area implants in loading side were 30.375±8.325 Mpa. The means of stresses around canine implants in non-loading side were 36.7875±10.35 Mpa. The means of stresses around buccal shelf area implants in non-loading side were 28.35±9.3 Mpa (Group II). **(Tab 1).**

B. Analytical statistics:

I. Comparison of stresses around posterior implants in both groups (Loading and Non Loading side):

The difference between the means stresses around posterior implants of the two groups in loading side was found to be insignificant where t= 0.1659 at p= 0.87628. The difference between the means of stresses around posterior implants of the two groups in non-loading side was found to be insignificant where t= 1.74 at p= 0.07871. (**Tab 2).**

II. Comparison of stresses around anterior implants in both groups (Loading and Non-Loading side) :

The difference between the means stresses around anterior implants of the two groups in loading side was found to be insignificant where t= 0.8420 at p= 0.4472. The difference between the means of stresses around anterior implants of the two groups in non-loading side was found to be significant where t= 10.1 at p= 0.0005. (**Tab 3).**

TABLE (1) The means of stresses around implants (canines and 2nd molars areas) in loading and non-loading sides of group (I) and (canines and buccal shelf areas) in loading and non-loading sides of group (II).

Side	Group I		Group II	
	Canine	Molar	Canine	Buccal shelf
Loading Side	28.35±4.5	28.0125±4.725	23.9625±5.9903	30.375±8.325
Non Loading side	11.1375±2.475	12.4875±2.025	36.7875±10.35	28.35±9.3

TABLE (2) The comparsion between the means of stresses around posterior implants of group (I) and group (II) in loading and non-loading side.

Side	*Posterior implant*			*Statistics*	
	Area	*Mean*	*SD*	*t-test*	*P value*
Loading side	*Group I*	28.0125	4.725	0.1659	0.87628
	Group II	30.375	8.325		
Non loading side	*Group I*	12.4875	2.025	1.74	0.07871
	Group II	28.35	9.3		

III. Comparsion stress analysis between Group I and Group II (loading and non-loading side) :

The difference between the means of stresses around all implants of group (I) and group (II) in loading side was found to be insignificant where t= 0.5462 at p= 0.6139. The difference between the means of stresses around all implants of group (I) and group (II) in non-loading side was found to be significant where t= 8.415 at p= 0.001. **(Tab 4).**

TABLE (3) The comparsion between the means of stresses around anterior implants of group (I) and group (II) in loading and non-loading side.

Side	*Anterior implant*			*Statistics*	
	Area	*Mean*	*SD*	*t-test*	*P value*
Loading side	*Group I*	28.35	4.5	0. 8420	0.4472
	Group II	23.9625	5.9903		
Non loading side	*Group I*	11.1375	2.475	10.1	0.0005
	Group II	36.7875	10.35		

TABLE (4) The comparsion between the means of stresses around all implants of group (I) and group (II) in loading and non-loading side.

Side	*Group*	*Mean*	*SD*	**t-test**	**P value**
Loading side	*Group I*	28.18125	4.5	0.5462	0.6139
	Group II	27.16875	3.99375		
Non loading side	*Group I*	11.8125	2.475	8.415	0.001
	Group II	32.56875	1.575		

DISCUSSION

The results of this study showing a recorded stresses around all studied implants.This result concurred with **Borchers et al.,**[14] who stated that an implant supported overdenture is subjected to various types of axial and nonaxial stresses, including the masticatory forces. The resultant of these forces is transmitted through the superstructure and the attachments to the implants and may lead to concentration of stresses in the different parts of the implants. Also, this result is in agreement with **Akca et al.,**[15] and **Petrie et al.,**[16] who explained that the implant bone interface is rigid and transmits all loads directly to the adjacent bone. This condition produces a high level of stresses which can be counterproductive for long term survival of the implants.

These stresses may be due to the effect of loading type, material properties of the implant & prosthesis, and implant geometry. **Mohie Eldin**[17] and **Geng et al.,**[18] said that stress and strain fields around osseointegrated dental implants are affected by a number of biomechanical factors, including the type of loading, material properties of the implant and the prosthesis, implant geometry, surface structure, quality and quantity of the surrounding bone, and the nature of the bone-implant interface. Most efforts have been directed at optimizing implant position to maintain a beneficial stress level in a variety of loading scenarios. Vertical loads from mastication induce axial forces and bending moment and result in stress gradients in the implant as well as in the bone.

Although the recorded means of stresses around posterior implants of group II were more than those of group I in loading and non-loading sides this result was found to be statistically non- significant.

Inspite of the recorded stresses around anterior implants in loading side of the two groups, more significant stress were recorded in the non- loading side of group II. The recorded stresses around anterior implants in loading side of the two groups may be due to the largest force concentration in the area around implants close to the application of vertical load. This fact showed that the implant closest to the point of load application on the prosthesis always suffers greater mechanical stress in overdentures, both in great deployment situations as in agreement with **Daas et al.,** [19] the results in previous studies with finite element .

The result of this study may be explained as the unilateral loading on overdenture may cause great stress applied on the implant abutment situated at the loading side than non-loading side, this in agreement with **Dong et al.,** [20] who stated that during application of unilateral load, higher stresses were observed around abutments in the loaded side than those in unloaded side. This might be due to the denture base contact the top of the copping at the loaded side after load application which becomes a fulcrum of concentrated stresses. The more significant stresses recorded around anterior implants of non-loading side of group II may be due to the effect of horizontal stresses (non-axial forces) resulting from the buccal location (not under occlusal table) of posterior implants in group II.

When comparing between the mean of stresses around all implants in loading side of the two groups, statistically insignificant difference was recorded while a statistically significant more stresses were found in non-loading side of group II. This result may be due to the buccal location of posterior implants in group II which may induce, under unilateral loading , a complex multidirectional forces on all implants. The effect of non-axial forces on the implants in the non-loading side may be the cause of more stresses in group II.

Lateral occlusal forces produced a lateral bending moment that significantly in creased the strain and implants stress values when compared with axial loads force regardless the different areas and implant length. During the mastication process load transferred was mainly supported by the mucosa of the denture bearing surface, the working side of the overdenture was shifted down under the action of the food stuff, this motion involved a lift of the non-working side of overdenture leading to compression of the mucosa of the denture bearing area, in this study the stresses in non-loaded side was greater than that in the loaded side as reported by **Menicucci et al.,**[21] who used Finite Element Analysis (FEA) to evaluate transmission of masticatory load in mandibular retained overdentures.

CONCLUSION

Within the limitations of this laboratory study, the results of stress analysis concluded that: Regarding the stresses around the 4 implants used for assisting mandibular complete overdenture, the insertion of the two posterior implants in the 2nd molar areas is better than in the buccal shelf areas.

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