Med. J. Cairo Univ., Vol. 90, No. 3, June: 895-905, 2022
www.medicaljournalofcairouniversity.net

Evaluation of Strains Around Distally Inclined Implants Retaining Mandibular Overdenture with Ti Si Snap Attachment

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Abstract

Background: Implant-assisted removable overdentures had fewer difficulties than traditional full dentures in the rehabilitation of a totally edentulous arch. A two-implant overdenture should be the minimal standard of care for an edentulous mandible, according to the McGill consensus statement.

Aim of Study: To compare strain around two implants retained mandibular overdenture with different degrees of distal inclination 0°, 17.5, 35° and different types of retention sil, for the Titanium Silicon snap attachments.

Material and Methods: The sample size was calculated using the following assumptions: Alpha error=5% and study power=80%. The sample size for each group was projected to be four, however this will be raised to five to account for laboratory processing inefficiencies. The total sample size required to detect the effect of distal inclination of implants at different angles using Ti-si snap attachment=numbers of groups x numbers per group=6 X 5=30, A total of 3 ready made completely edentulous epoxy models were used. To imitate robust edentulous ridge mucosa, an approximately 1.5-mm thick layer of auto polymerized resilient silicone soft lining material was employed for each model.

Results: Shapiro-Wilk tests were employed to determine whether data were normally distributed. Parametric and regularly distributed data were found in the analysis. Descriptive data for peri-implant strain values comprised the mean, the standard deviation of the range, the lowest, and the highest value. Different groups (0º,17.5º, and 35º implant inclinations) and measurement locations (RD, RM, LM, and LD) were studied using a general linear model (two-Way ANOVA), with post hoc tests and least significant differences (LSD) for multiple comparisons.

Conclusion: As the angle of distal implant inclination rises, the peri-implant strain surrounding two implants put in the canine region to hold mandibular overdentures with TiSi attachments increases. This means that the implants should be placed perpendicular to the top of the ridge, so that tension is transferred as little as possible into the peri-implant area. The effect of different retention sil used, strain increased when retention sil with higher shore hardness values was used in all inclinations.

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Key Words: *Overdenture – Ti Si – Attachments – Dental implants.*

Introduction

IMPLANT-ASSISTED removable overdentures had fewer difficulties than traditional full dentures in the rehabilitation of a totally edentulous arch. A two-implant overdenture should be the minimal standard of care for an edentulous mandible, according to the McGill consensus statement [1]. On overdentures. This kind of prosthesis is far less costly to make, is simpler to clean, and can easily satisfy a wide range of aesthetic and phonological preferences. It's also less costly, more stable, and less risky for individuals who are medically compromised to utilize just two osseointegrated implants to hold their overdentures in place; these are just a few benefits [6].

For optimal stress distribution, an implant should be inserted perpendicular to the long-axis of occlusal loading. As a result, when an inclined implant is necessary in specific clinical situations, such as mandibular bone depletion, lingual concavities, or a requirement to maximize the anterior-posterior distribution of implants, treatment with an inclined implant is unavoidable. Preventing implant misplacement using diagnostic and operational tools is possible, however anatomical constraints may occasionally restrict implant placement and angulation options [2,3]. Implant loosening and ultimate failure is caused by microcracks in the bone caused by excessive stress around tilted implants. Osteointegration may be lost due to severe pressure on the implant and supporting bone, which can result in microbial infection if there is a lack of osseointegration [4].

Implant-retained overdentures with ball anchors were shown to have larger stresses and less even stress distribution in peri-implant bone compared to all tilted implants (Hong et al., 2012) [13]. According to the researchers, distal angulation had the greatest mean increase in stress, whereas buccal inclination had the lowest mean increase.

Implant overdentures may be held in place by a variety of attachment devices now on the market. In order to link a denture to an interforaminal implant, many abutment types are typically employed, each with a unique set of biomechanical properties.

Since the prosthesis and implant are intertwined, the choice of an attachment mechanism is vital. When attaching implants, many attachment methods may be used. The most common is splinting (bar-clip structures with a variety of bar-shape patterns) (various ball type attachments, magnet attachments and attachments with telescopic copings). As a result, the unsplinted attachments are more sanitary and have less technical difficulties, may be used with a pointed jaw that allows limited tongue room for bar constructions, and can be utilized when the implants are positioned extremely distally or in a diagonal arrangement. Implant retained overdentures have been employed in medically incapacitated patients with unsplinted anchoring attachments because they demand less room inside prostheses, are easier to clean, are more cost effective, and are less sensitive to technique [6].

An alternative to splinting implants is a locator attachment that was launched in 2001 and may be utilized in situations when there is a limited amount of inter-arch space (Zest Anchors, Inc. site, Escondido, CA, USA). Various colors and retention settings accompany this attachment's self-aligning design and dual retention. There are a variety of vertical heights available for locator attachments, and their replacement is quick and simple [7].

Different degree of implant inclination were used, however the effect different inclinations on peri implant strain retention force and bone loss of implant supported fixed dentures is still occur especially during implant loading The influence of angled abutment on stress is a matter of debate. Implants that are inclined, on the other hand, make it more difficult to attach dentures since there is no common channel for the attachments to be inserted. However, evidence on the peri-implant strain surrounding two-inclined implant-retained overdentures is sparse [4].

These approaches include photoelasticity, finite element, and strain-gauge stress analysis in the in vitro environment. Overdenture implants supporting electrical strain gauges have been widely employed for quantitative analysis.

The retention needed, jaw morphology, architecture, mucosal ridge, oral function, and patient compliance for recall all play a role in the attachment's final design and final selection is up to you [4].

Since the early 1960s, implant overdentures have been fitted with ball attachments and bar units. It was previously thought that ball attachments were the simplest sort of attachments for clinical use with implant- or tooth-supported overdentures. On the other hand, it is well-documented that the retention of o-rings/sleeves degrades with time and necessitates their replacement. As for the bar attachments, there have been reports of greater sensitivity and costs but also of poor stability in terms of the method [5].

It's all down to the operator's ability to successfully implant, design, and position the implants [4]. Anathomy may restrict the use of diagnostic and surgical tools to avoid implant misplacement.

Laying interforaminal implants parallel to the frontal plane and the hinge axis is a straight forward procedure. As a result, it is often impossible or only partially viable to place the mandibular incisors perpendicular to the occlusal plane or in the direction of their physiologic location in the sagittal plane.

Inexperienced surgeons prefer to put implants that diverge from one other in the frontal plane (with a distal implant inclination) and have a larger facial or lingual inclination, according to Walton, et al., [5]. Their research also found a correlation between implant angulation and surgical experience.

Indeed, bone resorption and microcracks on the cortical bone of an overly tilted implant have been documented to develop under occlusal loading, which may cause implant failure [6]. Excessive loading pressures may lead to the loss of cortical bone, generating craters in which bacteria might lodge and induce perimplantitis, resulting in the failure of the implant itself. The use of angled implants may cause bending moments, interfere with denture assembly by obstructing the insertion of individual attachments along a common route, or complicate plaque maintenance. Extreme wear is inevitable when divergences or convergences are much more than around 10 degrees in distance between two unsplinted implants [7].

This study evaluated the stresses on three implants supporting a mandibular overdenture with other attachment systems, such as balls and bars with distally located balls, and found that the Locator systems had higher strains. Researchers found that loaded side implants with stud attachments underwent more stress when comparing locator attachments to bar and bar-ball designs for inclined implants [8].

Retention. sil (Bredent medical GmbH and Co. KG) is a In order to keep the denture in place, it is necessary to use a high-tensile silicone. While this abutment system does not have any specified retention or adequate denture guiding, it is an alternative to the previous one called "TiSi." Patients may eat and chew comfortably thanks to this combination, which keeps their dentures in place. The female component/metal housing alternative is also more cost-effective [32].

Selecting one of the three retention levels alters the denture's adherence to the TiSi.snap abutment. sil-soft-medium-hard. Retention As a result of the cushioning action of retention, sil surrounds the TiSi.snap, providing exceptional chewing comfort and a durable bite. Synthetic elastomer It's possible to lessen the danger of difficulties after insertion by utilizing retention. sil instead of metal housing/female component. Due to o-rings and sleeves increasingly losing their retainance, a research was decided to analyze and evaluate the retainment of retainance. sil is used in place of the traditional sleeve material [19].

We have not been able to completely assess or analyze the impact of varied implant angulations on peri-implant strain under retained mandibular over denture up to this point.

Strain gauge analysis on a mandibular over denture attachment with a Ti Si attachment was used to determine the influence of various implant angles on the peri-implant strain.

The null hypothesis was that stresses surrounding implants put at various degrees of implant inclination would vary significantly. The TiSi. snap abutments' high guide cone enables for secure denture attachment with only two implants thanks to their high guide cone. Thus, the denture's removal and insertion may be done with complete control.

Aim of the study:

Primary objective:

For the Titanium Silicon snap attachments, strain was measured around two implants maintained mandibular overdentures with varying distal inclination angles of 0 degrees, 17.5 degrees, and 35 degrees.

Secondary objective:

1- To evaluate strain around two implants retained mandibular overdenture with 0° implant inclination and titanium silicon snap attachments (Ti Si) with different retention sil 400g/4 Newton and 600g/6 Newton (control group).

2- To evaluate strain around two implants retained mandibular overdenture with 17.5 ° and 35° distal implant inclination and titanium silicon snap attachments (Ti Si) with different retention sil 400g/4 Newton, 600g/6 Newton (Test groups).

Material and Methods

Between September 2019 to September 2021 at Faculty of Dentistry, Pharos University in Alexandria:

Sample size calculation:

Assuming an alpha error of 5% and research power of 80 percent, the sample size was obtained using the following assumptions: To compensate for laboratory processing problems, the number of samples per group will be raised from 4 to 5. The total sample size required to detect the effect of distal inclination of implants at different angles using Ti-si snap attachment=numbers of groups x numbers per group=6 X 5=30.

Methods:

Preparation of epoxy models:

- A total of 3 ready made completely edentulous epoxy models were used.
- To imitate robust edentulous ridge mucosa, we employed a 1.5-mm thick layer of autopolymerized resilient silicone soft lining material on each model [9,10].

Fabrication of mucosal simulation:

In order to create a flexible mucosal cover, the following procedure was followed:

1- Using a base plate wax of approximately 1.5 thickness, the epoxy model's leftover ridge and retromolar portions were filled in.

2- A buccal and lingual plaster index was created and applied to the model. The wax was taken from the index after it had hardened.

3- The silicone soft lining primer was applied to the ridge, and the silicone separator was applied to the plaster index's fitting surface.

4- Rubber bands were used to keep a plaster index in place over the model while the autopolymerized silicon material polymerized over the model.

5- It was then removed from its plaster index, and the model was cut to eliminate the surplus autopolymerized silicon material.

6- The model has to be thoroughly cleaned once again to remove any traces of plaster.

Fabrication of the surgical guides:

The epoxy models were scanned using CBCT, the obtained DICOM data were converted into STL models.

The epoxy models were scanned using sordex machine

The 3D CAD planning software were used for planning implant location and distal angulations (0°, 17.5, 35°).

The designed 3D surgical guides were printed by 3D printer according to the distal implant angulations.

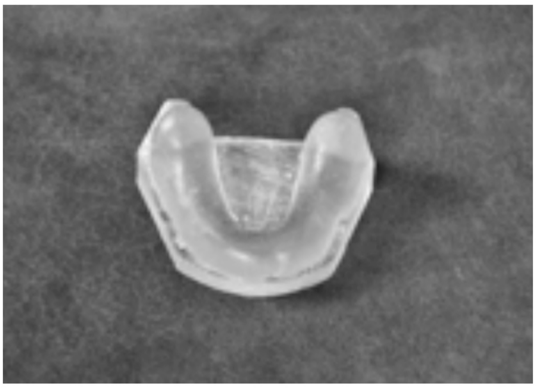

Fig. (1A): Epoxy model.

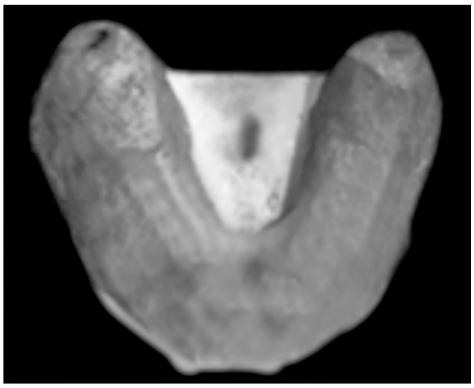

Fig. (1B): Epoxy model with mucosal simulation.

Fig. (2): Sordex machine to scan the epoxy model.

Implant installation:

- To aid with the placement of implants on each epoxy model, CADCAM Surgical Guides were utilized as a guide. Sleeves and surgical kits were used for implants installation.
- Implantation was carried out with the help of epoxy models that were put on a firm surface. Each model's anterior alveolar residual ridge occlusal surface was then leveled using a digital bubble level such that they were parallel to the floor.
- For each model the drills of the surgical kit were held perpendicularly to the anterior alveolar residual ridge occlusal surface by means of the surgical kit.
- The recesses were prepared as follows:

Group A (Control group):

- Implants were inserted with zero angulation (vertical) and straight sky Titanium snapabutments.

Group B:

- Implants were inserted with Distal angulation of 17.5° and angulated 17.5° sky Ti Si snap abutments.

Group C:

- Implants were inserted with Distal angulation of 35° and angulated 35° sky Ti Si snapabutments.

Strain measurement:

1- A horizontal occlusal plane was achieved by placing each model on the universal testing machine's compression grip and locking it in place.

2- In order to deliver a vertical static load to the predetermined loading sites, we employed a fully digitalized universal testing machine* [11,12,13].

3- The universal testing equipment was linked to a personal computer through computer assisted software, which allowed for the precise management of both the applied load and the length of the testing procedure. Using compressive stresses applied by the machine, researchers were able to gauge the ensuing stress surrounding the implants.

Central load application (Fig. 3):

• On the occlusal surface of the first molar right and left, at the mesial cusps, a metal bar (6cm long, 1cm wide, and 2mm thick) was placed.

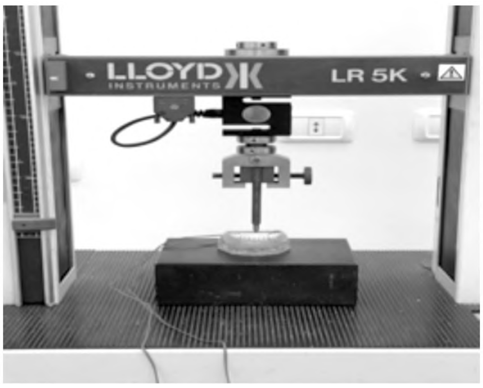

Fig. (3): Central loading application on a metal bar.

• Epoxy glue was then used to secure the bar in place.

• This device's loading pin (applicator) was used to apply forces directly to the metal bar's center [11].

In order to mimic moderate biting force on an implant-retained overdenture, a single point of compressive vertical (axial) static stresses of 60N were applied for 15 seconds [13,14]. At a cross head speed of 0.5mm.min, the load was applied continuously while in compression mode [15].

At a rate of 2Hz (2 readings per second), the electric signals from the four strain gauges were gathered, amplified by software, transferred, and recorded [10].

There were five separate measurements for each experimental overdenture that allowed at least five minutes for heat dissipation in between loadings [16].

For each and every experiment, the whole bridge circuit was balanced and corrected by altering each gauge's resistance and that of the device to achieve a stable zero position.

In order to do statistical analysis, we calculated the mean micro strain based on the five data [17].

Results

I- *Group A (0 (vertical) implant inclination group):*

- Parametric data was discovered via the Shapiro-Wilk test.
- Compression (negative) stresses were seen at all mesial peri-implant sites (right and left), whereas tensile (positive) strains were observed at all distal implant sites.
- Descriptive statistics of peri-implant strain for group A (0 implant inclination) at different sites of strain gauges (right distal, right mesial, left mesial and left distal) during central load application are presented in Table (1).
- Microstrain measurements at the different studied positions around the implants under central vertical loading for group A using retention sil 400 and retention sil 600.
- Data analysis showed statistically significant difference (student *t*-test, $p<0.05$) between the different studied positions, mesial, distal, at right and left side using tisi retention sil 400 and tisi retention sil 600 under central vertical loading.

Under central loading, using tisi retention sil 400:

1- The highest microstrain mean value was recorded at mesial side for both right and left implant.

2- Under central loading, using tisi retention sil 600 the highest microstrain mean value was recorded at mesial side for both right implant.

II- *Group B (17.5 implant inclination):*

- Parametric data was discovered via the Shapiro-Wilk test.
- Compression (negative) stresses were seen at all mesial peri-implant sites (right and left), whereas tensile (positive) strains were observed at all distal implant sites.

- Descriptive statistics of peri-implant strain for group B (17.5 implant inclination) at different sites of strain gauges (right distal, right mesial, left mesial and left distal) during central load application are presented in Tables (2,3).
- Microstrain measurements at the different studied positions around the implants under central vertical loading for group B using retention sil 400 and retention sil 600.
- Data analysis showed statistically significant difference (student *t*-test, $p<0.05$) between the different studied positions, mesial and distal sides of implants at right and left side using tisi retention sil 400 and tisi retention sil 600 under central vertical loading.

Under central loading, using tisi retention sil 400:

1- The highest microstrain mean value was recorded at mesial side for both right and left implant.

2- Under central loading, using tisi retention sil 600 the highest microstrain mean value was recorded at mesial side for both right and left implant.

III- *Group C (35 implant inclination):*

- Parametric data was discovered via the Shapiro-Wilk test.
- Compression (negative) stresses were seen at all mesial peri-implant sites (right and left), whereas tensile (positive) strains were observed at all distal implant sites.
- Descriptive statistics of peri-implant strain for group C (35 implant inclination) at different sites of strain gauges (right distal, right mesial, left mesial and left distal) during central load application are presented. In Tables (2,3).
- Microstrain measurements at the different studied positions around the implants under central vertical loading for group C using retention sil 400 and retention sil 600.
- Data analysis showed statistically significant difference (student *t*-test, $p<0.05$) between the different studied positions, mesial and distal sides of implants at right and left side using tisi retention sil 400 and tisi retention sil 600 under central vertical loading.

Under central loading, using tisi retention sil 400:

1- The highest microstrain mean value was recorded at mesial side for both right and left implant.

2- Under central loading, using tisi retention sil 600 the highest microstrain mean value was recorded at mesial side for both right implant.

Table (1): Comparison between the main strain around the implants at the different studied position with 400g/4N in the three groups.

Strain 400	RD (right distal)	RM (right mesial)	LM (left mesial)	LD (left distal)	F	ANOVA (*p*-value)
Zero angulation Mean S.D	98.00 5.70088	–118.00 8.36660	–119.00 6.51920	91.00 4.18330	18200.018	0.000*
17.5 distal inclination Mean S.D	370.000 23.0217	–501.00 75.8287	–485.00 3.53553	354.600 13.5388	8556.4847	0.000*
35 distal inclination Mean S.D	499.00 4.47214	–644.00 25.6417	–596.00 41.5932	406.000 5.47723	22059.596	0.000*
F Anova (*p*-value)	3723.5601 0.000*	600.3 870 0.000*	2317.6650 0.000*	6707.1612 0.000*		

Table (2): Comparison between the main strain around the implants at the different studied position with 600g/4N of in the three groups.

Strain 400	RD (right distal)	RM (right mesial)	LM (left mesial)	LD (left distal)	F	ANOVA (*p*-value)
Zero angulation Mean S.D	92.000 4.64488	–133.00 6.9999	–126.00 6.3224	87.000 3.8942	14879.387	0.000*
17.5 distal inclination Mean S.D	349.000 21.07143	–529.00 81.2251	–500.00 3.83653	322.1000 15.35783	55328.348	0.000*
35 distal inclination Mean S.D	422.0000 4.01214	-670.000 22.62024	-622.000 43.31320	389.0000 7.75523	19678.087	0.000*
F Anova (*p*-value)	3266.099 0.000*	565.7310 0.000*	2293.403 0.000*	4401.386 0.000*		

T: *t* student test, Significance at $p<0.05$.

Table (3): Comparison between the main strain around the implants with different retention sil level 400g/4N and 600g/6N in the three groups.

	Retention sil level			
Strain (µm/µm)	(400gm/4N) (n=5)	(600gm/6N) (n=5)	*t*	*p*
Vertical angulation:				
Mean ± SD	30±3.53	29.8±4.32	0.08	0.938
min-max	25-35	24-36		
Median	30	29		
17.5 distal angulation:				
Mean ± SD	22±11.5	23.2±12.07	0.161	0.876
min-max	10-40	12-43		
Median	20	20		
35 distal angulation:				
Mean ± SD	62.6±3.78	63±5.05	0.142	0.891
min-max	59-68	59-69		
Median	61	60		

T: *t* student test, Significance at $p<0.05$.

Discussion

Even though attachments have been studied extensively, few studies have examined the impact of implant angulation on the stress created around implants holding mandibular overdentures [8].

Studies [19,20] have shown that implant inclination affects the retention of locator attachments used to keep implant overdentures on implants. Such an angle on implants attached to overdentures with locator attachments was not thoroughly studied.

As a result, the purpose of this investigation. With the TiSi retention sil over denture, a strain gauge was used to measure the peri-implant strain in relation to various implant angulations. Null hypothesis was that the stresses surrounding implants with varying degrees of implant inclination would differ significantly.

Pre-made epoxy models were utilized to make the mandibular models since their modulus of elasticity is almost identical to that of compliant bone, as proposed by Ichikawa et al., [21].

Implant placement locations have been marked on the model using a CAD/CAM surgical guide stent to ensure accuracy and uniformity in the model's positioning. Using drills that began with a pilot drill, we drilled for implant sites to ensure that our first placements were correct. The last bit of drilling was carried out with a spade drill, ensuring a tight fit between implants and model materials, which will have a significant impact on how much weight is transferred from implants to supporting structures [22].

The degree of distal inclination was regulated using a 3D planning software for placement and distal angulation, which was more precise for planning CAD/CAM surgical guide, which was positioned on the occlusal surface of each model's anterior alveolar residual ridge and fastened at the buccal surface.

The following distal implant inclinations were employed in this study: 0 degrees, 17.5 degrees, and 35 degrees. Other studies [8,24,25] evaluating the impact of various implant inclinations on peri-implant strain and retention forces of different overdenture Ti Si attachments similarly indicated similar degrees of implant inclination.

The current investigation used distal implant inclination because Walton, et al., [5] found that less experienced surgeons had a higher propensity to put implants that differed from each other in the frontal plane (with a distal inclination). Other investigations investigating the influence of implant angulation on peri-implant strain [8,26,32,33,36,38] and retention forces of various overdenture attachments employed this distal implant inclination.

The laboratory implants were secured to the epoxy model using resin cement placed in each prepared implant site. This was done to replicate the osseointegration of implants into the bone [26].

Silicone soft lining material with a thickness of 2mm was employed to replicate masticatory mucosa on all edentulous locations, as described in various invitro strain gauge experiments [30,31,17,37,39]. The nominal elastic modulus of the silicone material was on the order of 2 MPa, which is similar to the approximate elastic moduli observed in soft tissue uniaxial tensile testing. The thickness of the masticatory mucosa at the maxillary edentulous ridge varies from 1.92 to 2.38mm, whereas the thickness at the mandibular edentulous ridge ranges from 1.85 to 2mm [39]. As a result, 2-mm silicone soft lining material was used to guarantee that the silicone thickness matched the typical thickness of the masticatory mucosa in vivo [31].

One of the most important objectives in the biomechanical evaluation of load-bearing implants is to define and quantify in vivo peri-implant stress and strain in humans, as well as the relationship between peri-implant stress and strain and peri-implant bone loss [40]. There is currently no non-invasive method for determining real in vivo strain/stress in peri-implant tissues. The absence of adequate biosensors seems to be the key cause for this evaluation of load-carrying implants to qualify failure [41]. In vitro investigations are often used since in vivo studies cannot be reproduced under the same circumstances owing to the considerable variation in histological structures from case to case. In a clinical setting, parameters such as bone density of the individual mandible and, across sites, angulations of implants, direction and amplitude of stresses, superstructure fit, and ridge soft tissue resilience would be impossible to manage [28,40]. The biomechanics of dental implants are now assessed using photoelastic stress analysis, two-dimensional (2D) or three-dimensional (3D) finite element stress analysis (FEA), 2D or 3D mathematical (geometric) analysis, and strain gauge analysis (SGA) [40].

Electrical strain gauges have been utilized widely for quantitative measurement of the stresses surrounding implants supporting a mandibular overdenture in this work, and strain gauge analysis was employed to quantify the peri-implant strain [29,10,16,42,43]. This approach is one of the most often used techniques for dental strain analysis, and it may overcome many of the drawbacks of other methods [44]. Because of its compact size, linearity, and low interference during operation, Stafford and Glantz [45] recommended strain gauges for measuring strains and deformation. Photoelastic stress analysis, on the other hand, provides only qualitative information on the general position and concentration of stresses, with minimal quantitative data [8]. Furthermore, specimen preparation for this approach is time-consuming since the model must be homogeneous in thickness [27]. Furthermore, the procedure needs specialized equipment and knowledge to be effective [27]. The model's validity and accuracy are also limited by finite element analysis. Furthermore, the interfaces between various materials are considered to be in perfect adhesion in the finite element analysis, with elements made up of distinct materials being linked at common nodes. Another disadvantage is that the analytical computer package might be fairly expensive [27].

However, there are significant drawbacks to the strain gauge strain analysis approach, including susceptibility to electrical noise, high temperatures, and thermal and electromagnetic generated voltage interference, all of which might affect the analysis results [28]. Strain gauges may also be useful in determining the surface stresses in full dentures. However, alternative approaches, like as photoelastic models or FEA, are required to estimate the internal strain of the dentures [30].

According to the recommendations of earlier studies [31,46,47], central load was provided over a metal bar positioned between the right and left denture bases at the occlusal plane to offer an even and smooth surface to permit vertical load delivery without the loading pin slipping.

All measurements were taken with one point vertical static loading opposite the first molar to simplify the investigation and eliminate confounding factors. Because greatest occlusal stresses are often exerted in this location, which is also where the elevator muscles are most contracted, the first molar was selected for loading [48]. The central fossae of the 1st molars were subjected to a vertical (axial) static stress in this experiment. Tokuhisa et al., for example, agree on this [26] to mimic central occlusion in vivo, the load was delivered bilaterally.

The universal testing equipment was used to provide a 60 Newton static central load. Depending on the dentition of the opposing arch, this load quantity was chosen since it is within the range of normal occlusal mastication and near to maximum loads for implant overdenture patients [14].

The central loading of one side of the arch created strains in the supporting structure under the load and contralaterally for each implant position. These stresses were identical to those produced in similar areas with the same loads applied on both sides [36].

The strain gauge's grids were allowed to cool down for at least five minutes between readings in order to ensure that the results were as accurate as possible. As described by Dong et al., all measurements were carried out five times for each loading condition [15].

In the current investigation, all mesial peri-implant sites (right and left) encountered a compressive (negative) stresses, whereas distal implant sites revealed a tensile (positive) strains. This implant penetration was observed to be impeded by the resin resistance [49] owing to its hardness. Due to the implant's tendency to descend in an inclined manner when subjected to overdenture occlusal plane force, stress was concentrated on the implant's distal face when it was angled [33]. By using a finite element method.

According to these results, peri-implant stresses are higher with angled implants than with those that are vertically oriented, according to many biomechanical investigations. In comparison to stresses surrounding vertical implants, finite element studies show that tilting single implants increases peri-implant bone strains [34,50] Bevilacqua et al., [34] observed that stresses at the bone-implant contact increased with higher implant inclinations. Since the stress communicated to the bone-titanium contact rises with increasing implant inclination, they showed that vertical implants are still the best option for single implants. Watanabe, et al., [4] found that, with angled implants, the force was not directed towards the long axis of the implant, generating an unequal distribution of the load, which, in turn, resulted in the rise of the stresses magnitudes. Other studies have shown that stress distribution is less advantageous when an implant or abutment is tilted [35,36].

Hong, et al., [32] studied the amount and distribution of peri-implant bone stresses associated with mandibular two-implant overdentures held by ball attachment systems with varied implant angulations (17.5 degree of mesial, distal, buccal, and lingual inclinations) using finite element analysis (FEA). The strain on the peri implant bone was highest around distally inclined implants and lowest around buccally inclined implants when a load was applied. The authors found that inclined implants induced larger stresses in peri-implant bone than implants put parallel to the long axis, regardless of the direction of inclination. Pigozzo, et al., [33] found larger strain concentrations on the mesial and distal implant faces with distally inclined implants (17.5 degrees divergence from mid line) utilized to maintain mandibular overdentures to canine implants with bar and clip attachments in a recent photoelastic strain investigation. The researchers determined that as compared to angled implants, parallel implant placement displayed greater strain transfer because the pressures orientated along the axis were better absorbed by the bone.

When mandibular overdentures were held by two implants implanted with various implant angulations, long-term clinical study is still needed to assess the impact of reported strain levels on the peri-implant tissue, as well as possible problems and maintenance.

Finally, the impact of distal implant inclination on peri-implant stresses in 2-implant retained mandibular overdentures is simply one aspect of the entire strain analysis picture.

Conclusion:

1- As the angle of distal implant inclination rises, the peri-implant strain surrounding two implants put in the canine region to hold mandibular overdentures with TiSi attachments increases, compared to vertically oriented implants. To reduce stress transmission to the peri-implant area, it is recommended that the implants be placed parallel to each other and perpendicular to the crest of the ridge.

2- The effect of different retention sil used ,strain increased when retention sil with higher shore hardness values was used in all inclinations.

3- Although Retention sil 600 has higher shore A hardness of 65 SH and pull off 600 N higher than retention sil 400 (shore A) hardness of 50 SH both materials can be used with all implant abutment inclinations with nonsignificant effect on the periimplant strains.

Acknowledgments:

The authors would like to express their sincere thanks to Mr., Ahmed El-Shahawy for their statistical analysis and advice on manuscript preparation, respectively.

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تقييم تأثير زوايا مختلفة لوضع الغرسات على توزيع الجهد حول الغرسات تحت الأطقم السفلية المحمولة والمثبتة لمادة التيتانيوم سيليكون : دراسة معملية

يتمثل الهدف من كل عملية زرع عن طريق الفم، من الناحية الجراحية ومن ناحية الجراحة التقويمية، فى تحسين موضع الغرس عن طريق الفم لتحسين النتائج الميكانيكية الحيوية والوظيفية والجمالية والصوتية. حيث يعزز التقدم فى تصوير الزرع وتكنولوچيا الكمبيوتر القدرة على نقل الخطة قبل التدخل الجراحى إلى العملية الجراحية من خلال التوجيه الجراحى المحوسب.

لقد تم التحكم فى درجة الميل القاصى باستخدام برنامج حاسوب ذو تخطيط ثلاثى الأبعاد من أجل تخطيط الموضع والزاوية القاصية والتى كانت أكثر دقة لتخطيط التوجيه الجراحى (التصميم بمساعدة الكمبيوتر / التصنيع بمساعدة الكمبيوتر) الذى تم وضعه على السطح الإطباقى للحرف السنخى المتبقى الأمامى لكل نموذج والمثبت على السطح الشدقى.

لقد تم إجراء هذه الدراسة داخل الجسم الحى لتقييم الإجهاد حول الغرسات المائلة القاصية معمر تكزات التيتانيوم سليكون باستخدام أدلة جراحية موجهه بالكامل.