Research Article
ISSN 2077-5628

Effect of the Mucosal Thickness on the Stress Distribution of Implant Retained Mandibular Over-Denture with Resilient Telescopic Attachment (in Vitro Study)

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Received 16 January 2021/Accepted 15 March 2021

ABSTRACT

The aim of this study was to evaluate the effect of mucosal thickness on stress distribution around implant retained mandibular over-denture with resilient telescopic attachment. This in-vitro study was done on a three standard educational edentulous mandibular model. According to the mucosal thickness divided into three groups, each group had one standard model with two implants. Two implants were placed in the canine region. Tapered telescopic attachment with occlusal convergence of 0.03 mm was attached to each implant fixture. For each group three different mucosal thicknesses were used which are (one, two, three-mm respectively) layer of poly ethylene vacuumed sheet was placed on the models to acts as a spacer and replaced with polyvinyl siloxane impression material to simulate the resilient edentulous ridge mucosa. An experimental acrylic resin denture was conventionally fabricated on the model. Four strain gauges were attached to each implant to measure the strain on the implants. By using universal testing machine unilateral load applied to the occlusal surface of the right first molar region. The micro strain was measured at the four sides of the implant (mesial, distal, buccal and lingual) at loading and non-loading sides. The data was collected and statistically analyzed by two-way ANOVA.

The results of this study showed greatest strain with 1 mm mucosal thickness at different sites measurement (lingual= 63.12) in loading side and with 2 mm mucosal thickness (Lingual= -9.37) in the non-loading side and the greatest strain with 3 mm mucosal thickness at different sites measurement (mesial= 5.62) in the loading side. The stress was lowest with 3 mm mucosal thickness in the mesial and distal sides. For all sites for loading side was associated with greater strain then non loading side for all the groups.

The peri-implant stress reduced as the thickness of the mucosa covered the residual ridge increase, when resilient telescopic attachment is used with implant supported over-denture.

Keywords- *Mucosal Thickness: Retained Mandibular: Telescopic*

INTRODUCTION

It was agreed that the implant that supported over-denture is a reliable treatment option because of its relative simplicity, minimal invasiveness and economy.[1] It minimized risks on patients and tissues and becomes a true alternative to fixed prosthesis.[2] For the majority of patients, an over-denture on two implants is the first choice of treatment when complaining about the lack of stability of their mandibular denture.[3] Attachments used in conjunction with implants were found to enhance the retention, the stability and support of overdentures together with the implants, thus extending their longevity.[4] Many types of attachments have been used to augment the retention and stability of an implant over-denture. Among the different types used, stud, bar and magnetic attachments are the most commonly used. Furthermore, other attachment systems are used as the telescopic retainers.[5,6] All attachments are either rigid or resilient. Rigid attachments restrict rotational movement and provide only a limited path of off-angle insertion, while resilient attachments allow varying amounts of rotation and angulation correction. In situations where implants are even minimally nonparallel, a resilient attachment will consistently show less friction, wear, and breakage. Considering that patients frequently bite appliances into place, this resiliency also prevents premature wear and breakage.[7] Telescopic overdenture (double crown system as attachment for overdenture) is a treatment concept that has been widely and successfully used to support dentures since telescopic crowns introduced in the 1970s.[8] They avoid the disadvantages of screw-retained superstructures such as difficult access to the screw, access hole on the occlusal surface or esthetically unfavorable positions. They also allow easy access for oral hygiene procedures, relative independence of the individual attachment which often allows for sufficient support of the denture even after single abutments have failed as well as good handling of the overdenture.[9] The comparatively high retention, horizontal stabilization, supports and rigid connection to the abutments obtained by telescopic overdenture leads to

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good mastication and phonetics.[10] The mucosal thickness may affect the denture base displacement during denture function; therefore, the mucosal thickness probably influences the stress distribution. Some previous in vitro studies have indicated the effects of differences in the retentive system for supported implant with spuriously soft tissue.[11,12] Therefore, the purpose of this in vitro study was to compare the effect of different mucosal thickness on stress distribution around implant retained mandibular overdenture with a resilient telescopic attachment.

MATERIALS AND METHODS

Three standard educational edentulous mandibular models (Dentium dentist for dentist company) were used in this study. According to the mucosal thickness, the models were classified into three major equal groups: *Group I*: two implants (3.6 mm in the diameter, 14.0 mm in the length; Dentium company) were placed bilaterally in the canine region vertical to the residual ridge, with a mucosal thickness of 1 mm.

Group II: two implants (3.6 mm in the diameter, 14.0 mm in the length; Dentium company) were placed in the canine region, with 2 mm mucosal thickness.

Group III: two implants3.6 mm in the diameter, 14.0 mm in the length; Dentium company), placed in the canine region with 3 mm mucosal thickness. To simulate the different thickness of the mucosa covering the residual ridge, 1, 2 and 3-mm layer of poly ethylene vacuumed sheet, was placed on the models which acts as spacer, and replaced by polyvinyl siloxane impression material (Speedex, Coltene/Whaledent Inc. Cuyahoga Falls, OH, USA), the impression material was mixed during flasking and placed in the upper part of plaster index then closed with pressure until setting and the flask opened trimming for excess border to produce model with 1, 2 and 3 mm thickness respectively as (1 mm for group I, 2 mm for group II, and 3 mm for group III) polyvinyl siloxane impression material to simulate the resilient edentulous ridge mucosa.

Figure 1: Two implants inserted in the model, in the canine region.

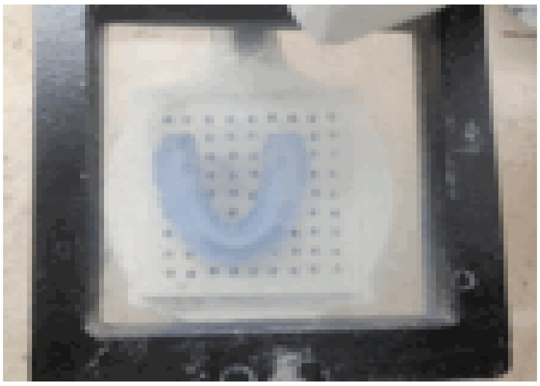

Figure 2: The mandibular cast seated in vaccum machine.

Figure 3: One mm thickness of vacuumed polyethylene sheet.

The internal hex abutment of gingival height for group I =1 mm, for group II = 1.5 mm and for group III = 2.5 mm. The abutments were prepared as primary copings to allow vertical play (resiliency) as follow: The occlusal surface was reduced for 0.3 mm, the occlusal third of the axial walls was reduced for 0.03 mm. The secondary copings were provided by manufacture as readymade plastic coping that fit the dimensions of the abutments. These copings were provided with two vertical slots to retain the acrylic resin denture base.

For telescopic over-denture construction: Holes were done related to number of telescopic attachments on the fitting surface of the mandibular denture. The mandibular denture was fitted again on the model, then auto polymerized acrylic resin was mixed and applied on the polished surface of the mandibular denture and closed all the holes around the telescopic attachment. After setting, finishing and polishing was done.

Four strain gauges (KFR-05-120-C-11; Kyowa Electronic Instruments, Japan) were attached to the mesial, distal, buccal and lingual sides of the neck part of each implant to measure the strain on the implants. By using universal testing machine unilateral load applied to the occlusal surface of the right first molar region to major the stress around each implant.

Load of 50 N was applied to the occlusal surface of the right first molar region (Figure 4). This study used a one-point concentrated load on the molar part that was considered to receive the load with the largest force during function, to simulate a moderate level of biting force on an implant-retained overdenture.

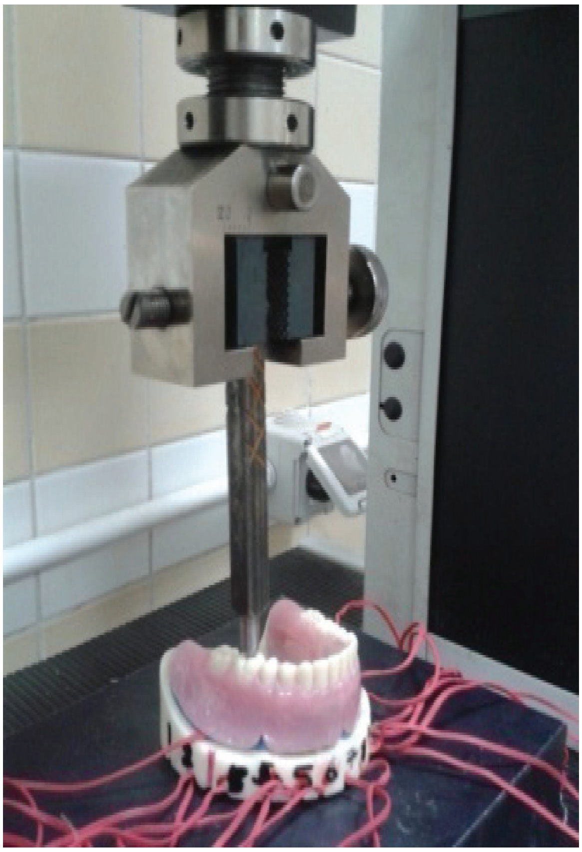

Figure 4: Unilateral loads on the right first molar region.

RESULTS

There was statistically significance different ($P \leq 0.001$) between different mucosal thickness for all the groups at the loading side (Figure 5).

Moreover, at the non-loading side, there was statistically significance different ($P \leq 0.001$) between different mucosal thickness for all the groups (Table 1).

In comparison of recorded micro strain values between loading and non-loading sides for the all groups. There was statistically significance different ($P \leq .00$) between loading and non-loading sides for all groups (Table 3).

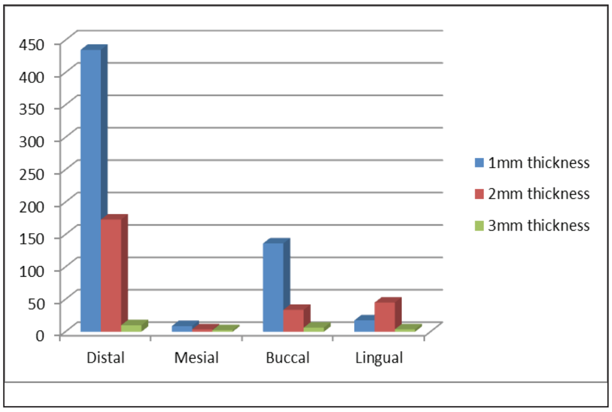

Figure 5: Comparison of recorded micro strain values between the three groups on the loading side at different implant sides.

Table 1: Comparison of recorded micro strain values between different mucosal thickness in all groups at non loading side.

	1mm thickness	2mm thickness	3mm thickness
	Group I (2-implants) X±SD		
Distal	-3.75±2.5	-7.5±2.8	-2.5±2.8
Mesial	-55±00	-7.5±2.8	-1.25±2.5
Buccal	-133.7±2.5	-8.7±2.5	-1.25±2.5
Lingual	-188.7± 4.7	-2.5±2.8	-1.25±2.5
ANOVA (p)	.00	.036	.87
LSD	51.25	5.0	-

Table 2: Comparison of recorded micro strain values between loading and non-loading sides for both groups

	1mm thickness	2mm thickness	3mm thickness
	Distal (X±SD)		
Loading side	435±00	173±2.5	10±00
Non-loading side	-3.75±2.5	-7.5±2.8	-2.5±2.8
t-test (p)	.00	.00	.00
	Mesial (X±SD)		
Loading side	8.7±2.5	7.5±2.5	6.25±2.5
Non-loading side	-55±00	-3.7±2.8	-1.25±2.5
t-test (p)	.00	.001	.005
	Buccal (X±SD)		
Loading side	136.25 ±8.53	33.7±6.29	2.5±2.8
Non-loading side	-133.7±2.5	-8.7±2.5	-1.25±2.5
t-test (p)	.00	.00	.049
	Lingual (X±SD)		
Loading side	17.5±2.8	45±00	3.7±2.5
Non-loading side	-188.7± 4.7	-2.5±2.8	-1.25±2.5
t-test (p)	.00	.001	.03

X; mean, SD; standard deviation

DISCUSSION

An implant-stabilized overdenture is a treatment possibility that improves function and comfort for edentulous patients and eliminates many of the problems that edentulous patients experience with conventional dentures.[13] In spite of the attractiveness of overdenture treatment, there are controversial opinions about design and indications for different attachment system for overdenture. As denture saddles tend to function like a fulcrum, implants may, depending on the attachments, receive a considerable bending moment transferred from the implant into the bone.[14] The long-term clinical use of resilient of telescopic attachment has been described. The implant abutment was used as the inner telescope due to the internal hex of the abutment prevents rotation.[15-17]

The conical telescopic attachment retention comes from friction between the inner and outer coping surface. Such retention depends on the number of copings, the taper angle of the inner crown and the dimensions of the surfaces contact.[10,18-21]

Modification of the abutment was made by creating an occlusal space (0.3mm) as well as (0.03mm) from the occlusal third of axial walls to create vertical play for the resiliency of the telescopic attachment.[21]

Unilateral loading of the overdenture was used to simulate the clinical situation as much of the chewing activities are carried out unilaterally. A force increasing from 0 to 50 N was applied by means of an electronic force donor.[18,22] In this *in vitro* study, the tests were performed under 50 N loads because these loads were within the average range of occlusal force observed in denture wearers with poor masticatory performance.[23,24]

The results of this study showed that at distal, mesial, buccal and lingual sites of loading side, greatest strain recorded with 1mm thickness, lowest with 3mm thickness. With exception of buccal sites, all sites at non-loading side recorded greater strain with 2mm thickness and lowest strain with 3mm thickness, this may be due to as the mucosal thickness is increasing, the elastic modulus decreased so does the stress, these findings are in agreement with the results of the study done by Tanino et al.[25], since the 3-mm mucosa (resilient) models lower stress values were observed when compared to the 1-mm mucosa (hard) models. Hence, as elastic modulus decreased (high resiliency) so did the stress.[26]

Also, Song et al. evaluated the relieving effect of different mucosa thickness beneath mandibular complete denture using a three-dimensional FEA. It was observed that as mucosa thickness increased so did the relieving energy which leads to lower bone tissue deformation. Therefore, thicker mucosa is beneficial to reduce bone loss.[27]

For all sites (mesial, distal, buccal and lingual), group I showed with greater strain than group II, III at loading site for 1- and 2-mm thickness. At non loading side, group III had greater strain than group II for (mesial, distal and lingual), and group II had greater strain than group I, III for (buccal side).

CONCLUSION

The peri-implant stress reduced as the thickness of the mucosa covered the residual ridge increase, when resilient telescopic attachment is used with implant supported over-denture.

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