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PERI-IMPLANT STRAIN WITH LOCATOR AND BAR ATTACHMENT DURING DISLODGING OF MAXILLARY IMPLANT OVERDENTURE. A COMPARATIVE INVITRO STUDY

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ABSTRACT

Purpose:_This study aimed to evaluate Peri-implant strain with locator and bar attachment during dislodging of maxillary implant overdenture

Materials and methods: Four implants were inserted in completely edentulous acrylic maxillary model in canine and premolar areas. Experimental maxillary overdentures with 4 metal hooks were constructed and connected the implants with bar attachments (group I) or locator attachment (group 2). Two strain gauges were bonded at buccal and palatal surface of each implant. Micro strains were measured at buccal and palatal surface of canine and premolar implants during the vertical dislodging of the overdenture. Dislodging was made by chains connected at one end to the metal hooks and to a universal testing machine at the other end.

Results: For canine and premolar implants, locator attachment showed significant higher microstrain values than bar attachments at buccal and palatal gauge positions. For bar group, no difference between buccal and palatal strain gauge positions was detected. However, for locator attachments, buccal strain gauges demonstrated significant higher strain than palatal gauges. For buccal and palatal strain gauges, canine implants showed higher strains than premolar implants for both groups

Conclusion: Within the limitation of this in vitro study, could be concluded that bar attachments may be recommended to retain maxillary implant overdentures than locator attachments in terms of reduced peri-implant stresses that occur during the denture dislodgment which may lead to increased bone resorption around the implants.

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INTRODUCTION

Although the survival rate of maxillary implant overdenture is lower than mandibular implant overdenture[1-3] due to compromised bone quantity and quality, such overdentures are widely used to provide retention and stability of maxillary denture, adequate lip support, enhance phonetics, and improve oral hygiene compared to fixed prosthesis in cases of atrophy of maxilla[4, 5]. There appears to be a consensus in the reviewed literature that a minimum of 4 implants is favorable[6-9]. The implants are positioned in premaxilla to avoid sinus floor elevation[10,11]

For maxillary implant overdentures, various attachment can be used including splinting (bar-clip constructions with various bar-shape designs) or not splinting the implants (Locators and attachments with telescopic copings)[12]. The used attachment should allow implant angulation due to inclination of the implants in pre-maxillary region. The bar attachments have several advantages such as splinting implants, wide load distribution, and can be used with divergent implants[13]. Locator attachments are widely used today due to simplicity. Moreover, it is self-aligning, provide several degrees of retention, have increased retention forces attributed to the internal and external friction flanges[14, 15]. Furthermore, it is resilient, can compensate for implant angulation, and it can be easily replaced if the retention decreased[14, 16]

With maxillary implant overdentures, implants are subject to high biomechanical forces due to reduced bone quality and quantity, divergent implant axes, and offset positioning of denture teeth, which increase bending moments on implants[17, 18]. The attachment design and retention mechanism may significantly influence stress/strain magnitude around implants[19]. Excessive loads applied to the implant may cause pathologic stresses and strains in the crestal bone stimulating resorption[20]. Enhanced overdenture retention and stability have been identified as the most important factors for producing more favorable overdenture treatment outcome and improved patient satisfaction and oral health related quality of life[21]. On the other hand, very high retention forces may induce load on implants during overdenture dislodgement or when removing the overdenture [22]. Therefore, a compromise should be made between high retention force vs. peri-implant stress [22, 23]

Reviewing the literature, many invitro reports[24-26] evaluated the retention forces of maxillary implant overdenture attachments. Other invitro studies[27, 28] investigated the effect of attachment type on peri-implant stresses. However, the evaluation of peri-implant stresses associated with different attachments during overdenture dislodging was scare and limited to mandibular overdentures only[29, 30]. The purpose of this invitro investigation was to study strain around implants with locator and bar attachment during dislodging of maxillary implant overdenture using strain gauge measurements. The null hypothesis is no difference in peri-implant strain between the attachments will be obtained.

MATERIALS AND METHODS

Fabrication of test model

A completely edentulous acrylic resin maxillary model that has no ridge undercuts and has adequate with bone quantity was constructed. Four implant fixtures (3.6×12mm, Dentium, Korea) were inserted in the maxillary anterior region canine and premolar areas using sequential drilling was acrylic bur[26]. Posterior implants were oriented vertically and anterior implants were oriented with slight labial inclination due to the anatomy of premaxillary region. The implants were fixed to the acrylic holes with self-cure acrylic resin to simulate osteointegration. The residual alveolar ridge and palatal areas of the model was covered with 2 millimeter with thickness resilient liner (Elite Super Soft, Zhermack, Badia Polesine, Italy) to mimic the palatal mucosa [31, 32]. The locator and bar and abutments were threaded to implant using torque wrench at 30 Ncm.

For bar group, 4 plastic bar abutments where connected to the abutments. The plastic resin of prefabricated Hader bar joint (Rhein, Italy) was luted to the plastic Caps. The resin bar was sectioned to 5 segments (one segment was fixed between canines, 2 segments were fixed between canines and the premolars and two segments were used as distal cantilevers (9mm length). All segments were oriented in the same vertical plane leaving 1.5mm space below the bar for oral hygiene.[33-35]. The plastic bar was cast in cobalt-chromium alloy. Four yellow plastic clips (medium retention) were positioned on the bar segments (2 in the anterior segment, 2 in the premolar segment and no clips were positioned on the cantilevers). For Locator group, blocking ring were snapped over locator abutments. Locator metal housings with processing inserts were positioned on the abutments (fig 1).

For each attachment, an experimental overdenture was fabricated (fig2). The overdenture is consisted of metal framework and acrylic resin occlusion rim. A duplicate impression was made for each attachment and poured with stone and investment to make master and refractory models. Over the investment model, cobalt-chromium metallic framework that cover the edentulous ridge was fabricated with four metal hooks attached to canine and second molar areas[35]. The metal framework was positioned over the master cast and acrylic resin denture base with occlusion rim was constructed using heat cure acrylic resin. Over the acrylic models, one experimental overdenture was connected to the bar clips and the other experimental overdenture was connected to the metal housing of the locators using self-cure acrylic resin. Locator medium retention, (pink inserts) were used.

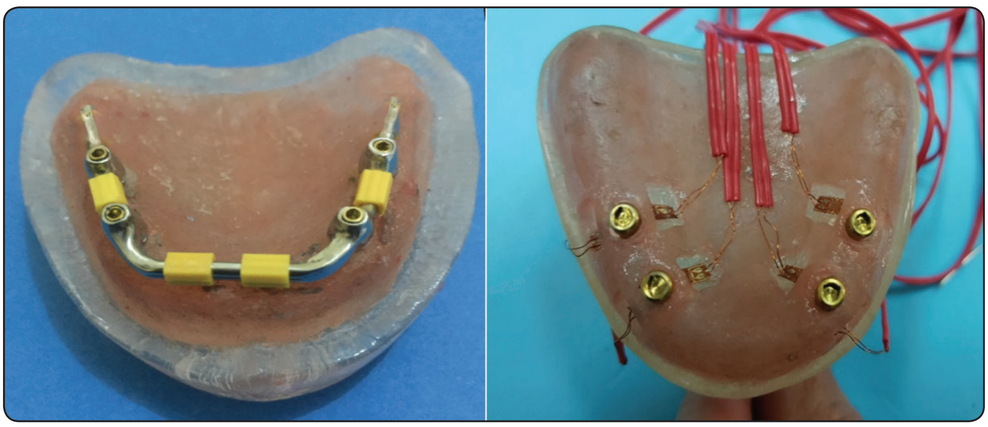

Fig. (1) (A) Hader bar group, (B) locator attachment group.

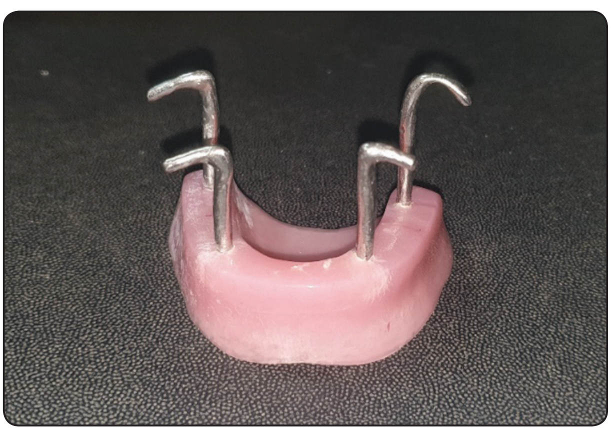

Fig. (2) Experimental overdentures with metal framework and acrylic resin rim

Strain gauge measurements

On the acrylic model, the resilient liner attachment was removed around each implant from buccal and palatal areas to provide room for strain gauge fixation. 4 strain gauges (KYOWA, Japan) were bonded to buccal and palatal areas of cast around implants [36] using a bonding agent provided by the manufacturer. The long axis of gauges was oriented with the axis of the implants (fig 1B). The wire ends of the gauge were connected to a ½ circuit Wheatstone bridge, and to a strain measuring device (Tinsley, London) that is guided by a software which convert the output voltage to microstrain data.

Four chains were attached to the to hooks at one end and to a metal plate at the other end[37]. The plate was connected to a testing device. Vertical dislodging force was exerted at 50 mm/min speed till complete dislodging of the overdenture from the model[37,38]. Measurement of periimplant strain (μmicrostrain) at buccal and palatal strain gauges was made during the vertical dislodgment (fig3). The measurements we repeated three times and mean was used for statistical analysis.

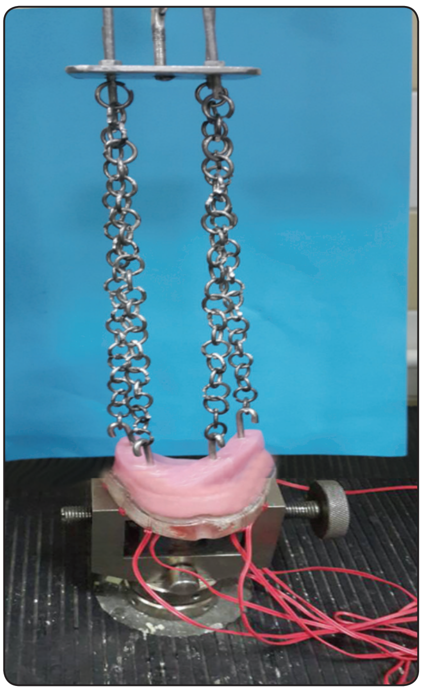

Fig. (3) Measurements of strain during overdenture dislodging

Statistical analysis

SPSS software version 22 (SPSS Inc.) was used to analyze the data. The normality of data distribution was tested by Shapiro wilk test. Independent sample t-test was used to compare recorded μmicrostrain values between groups, stating gauge positions and implant locations (canine and premolar implants). P <.05 was significant.

RESULTS

Before measurement, calibration of strain gauges was performed. The aim of the calibration was to ensure that all measurements are reliable and that all strain gauges read a repeatable measurement. To study the relation between applied force and resultant strain, a vertical load was applied to the overdenture from 0 to 60 Newton (10, 20, 30, 40, 50 and 60 N) and strain for each load was recorded. A verification of linear relationship between applied force and resultant strain was made.

At All microstrain data are normal distributed and are presented as mean and standard deviation. Extreme values were removed to avoid violation of normal distribution of the data. Comparison of microstrains between groups and strain gauge positions are presented in table 1. For canine implants, locator attachment showed significant higher microstrain values than bar attachments at buccal and palatal gauge positions. Comparison of buccal and palatal strain gauges is presented in the same table. There is no significant difference between buccal and palatal strain gauges for both groups. Regarding premolar implants, also locator attachments showed significant higher microstrain values than bar attachments for both palatal and the buccal strain gauge positions. For bar group, no difference between buccal and palatal stating gauge positions was detected. However, for locator attachments, buccal strain gauges demonstrated significant higher strain than palatal gauges.

Comparison of microstrain values between canine and premolar implants for buccal and palatal strain gauge positions is presented in figure 4 and 5 respectively. For buccal strain gauges, canine implants showed significant higher strain magnitude than premolar implants for bar (p=.009) and locator (p=.023) attachments. For palatal strain gauges, canine implants showed significant higher strain magnitude than premolar implants for bar (p=.012) and locator (p=.001) attachments.

TABLE (1) Comparison of microstrain between groups and strain gauge positions

	Bar		Locator		*P value*
	Canine implants				
	Mean	SD	Mean	SD	
Buccal	57.50	5.00	82.00	13.04	.007*
Palatal	52.40	15.21	81.00	15.84	.006*
p value	.56		.45		
	Premolar implants				
	Mean	SD	Mean	SD	
Buccal	30.00	3.54	64.00	14.75	.002*
Palatal	35.00	15.25	40.00	.11	.049*
p value	.47		.024*		

***** *p is significant at 5%.*

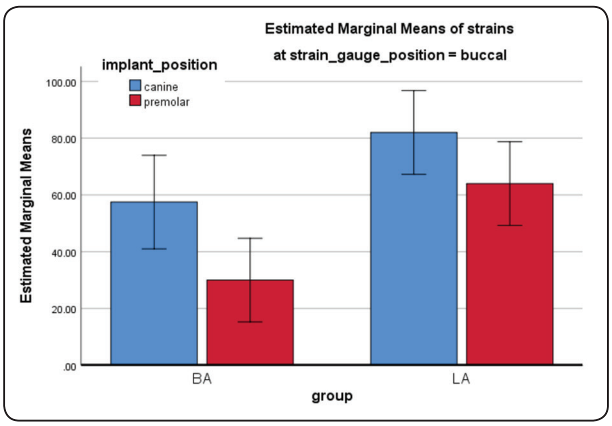

Fig. (4) Comparison of microstrain between implant positions at buccal strain gauges

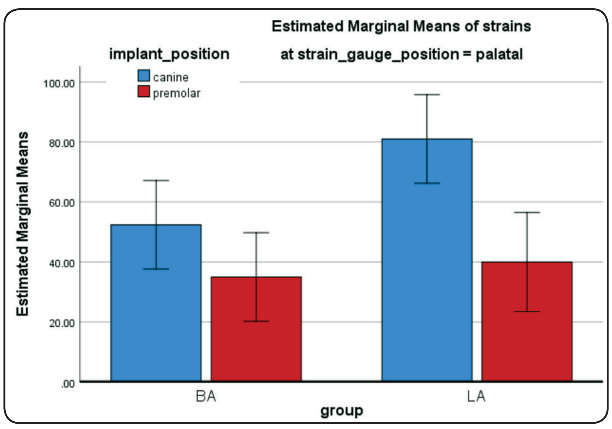

Fig. (5) Comparison of microstrain between implant positions at palatal strain gauges

DISCUSSION

In this study, 2 gauges were attached to the buccal and palatal surface of each implant and no mesial and the distal gauges were used. This is because not enough space at mesial surface of premolar implant and distal surface of canine implants to mount strain gauges due to close proximity of the implants to each other. Four metal chains connected at canine and second molar teeth and attached to the center of metal plate was used to apply vertical dislodging forces. Before dislodging, care was exercised to make sure is that all chains we are connected without slackness. This method ensures vertical dislodging of the overdenture as one unit without rotation. This method was designed and verified for accuracy in several previous in vitro studies for maxillary and mandibular overdentures[24-26,31,35,37-39]. Vertical dislodging force was exerted at 50mm/min speed to simulate the velocity of overdenture removal from the tissue during chewing as reported in previous studies [37, 40].

For canine and premolar implants, locator attachment showed significant higher microstrain values than bar attachments at buccal and palatal gauge positions during application of vertical dislodging forces. The decreased stresses with bar attachments may be due to the splinting effect of the bar to the implants and greater surface area provided by bar which reduces implant micromotion [41]. The plastic clips transmit the forces indirectly to the implants through bar segments. On the other hand, locator is individual attachments and the subject the implants to more load [42, 43]. Another explanation of increased strain was locator attachments is the increased retention forces provided by the double friction flanges of each locator attachments which provide internal and external retention behave like guiding planes and restrict lateral movement of the prosthesis. The increased retention of locator attachments comes from the large size of inserts and the small diameter of abutments [44]. This increased the retention may transmit more stresses to the implants during the dislodging[45-47]. Moreover, the abutment is parallel to the path of removal of the locator inserts, thus retention is driven from all the abutments undercut. Thus, the locators did not disconnect easily and transmit increased strains to the implants [29]. Considering that, the choice of ideal attachment should provide sufficient the retention but should apply reduced load to the implants during the denture removal by the patient[48], bar attachments for maxillary overdentures may be recommended then locator attachments in terms of reduced periimplant stresses that may lead to increased bone resorption around the implants. In line with the results of the study, rigid bars were reported to give good load distribution to the implants [42,49]. The peri-implant stress from splinting (bar) attachment, was found to be lower than that of unsplinted attachment, such as ball anchors [50, 51]. In agreement with our observation, Locators are associated with increased retention and peri-implant stress compared to the Hader bar-and-clip attachment when these attachments are used to retain auricular prosthesis as reported by another author [22]

For locator attachments of premolar implants only, buccal strain gauges demonstrated significant higher strain than palatal gauges. This may be due to the deformation of maxillary implant overdenture away from the midline when load is applied [52], indicating that implants were predominantly strained from palatal to buccal [28]. This pattern of denture deformation together with the increased retention of locator attachments may cause movement of the premolar implants to the buccal direction. Therefore, compression of acrylic resin on the buccal side of premolar implants may occur and could be responsible for increased stresses in the buccal side of premolar implants than palatal side.

For both groups and strain gauge positions canine implant recorded significant higher strain than premolar implants during the dislodging. This may be due to canine implants in the model are slightly inclined labially due to the inclination of premaxillary bone. The dislodging the forces are applied toward the center of maxillary overdenture. Therefore, the dislodging forces are applied at an angle to canine implants which may increase stresses around these implants. On the other hand, premolar implants are located near the center of the denture. Therefore, the dislodging forces are applied to the long axis of premolar implants with rapid disconnection of the attachments from premolar implants. The locator at canine implants are inclined to slightly labially and he may create labial undercuts with nylon inserts during dislodging. Similarly, in bar group, 2 clips are attachment to the bar segment between canine implants and one clip attachment between canine and the premolar implant. This cause increased retention in the area of canines compared to premolars during dislodging which may increase the stresses on canine implants compared to premolar implants.

The limitation of this study includes the absence of simulation of nonaxial dislodging forces which may occur during the denture was working removal by the patient. Also, the absence of saliva may influence the friction between the attachment of components, which may influence the retentive force and consequently the resultant strain [53]

CONCLUSION

Within the limitation of this study, it could be concluded that bar attachments may be recommended to retain maxillary implant overdentures than locators regarding reduced peri-implant stresses that occur during the denture dislodgment which may lead to increased bone resorption around the implants.

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