Stern snap angle versus locator attachment: In vitro strain analysis study around two inclined implants used To retain mandibular overdenture

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Abstract:

Aim: the aim of this study was to compare two different concepts of attachment in case of two implant retained mandibular overdenture.

Materials and Methods Four experimental acrylic mandibular edentulous model were constructed. In the canine regions of each model, two recesses were prepared in different inclination at 20^0 to the residual ridge (Group I, buccally inclined) (Group II, lingually inclined), (Group III, mesially inclined), and (Group IV, distally inclined) degree of lingual implant inclination. Two laboratory implants (3.3mm x 11mm) were inserted in each model and covered with 2mm simulated mucosa. Four duplicate mandibular dentures were constructed and connected to the implants using Locator attachments and Stern snap angle attachments. Four linear strain gauges were bonded to the acrylic resin at mesial, distal, buccal and lingual surface of each implant to monitor the strain around the implants on loading and non-loading sided during unilateral and bilateral load application

Results: At different sites of inclination (mesial, distal , buccal and lingual) during unilateral and bilateral load application : distally and lingually inclination recorded the highest strain values, and mesially and buccally inclination recorded the lowest values. And at different groups (regardless of inclination, loading side and loading application) the locator attachment recorded the highest strain values, and stern snap angle attachment recorded the lowest values.

Conclusion: During unilateral and bilateral loading regarding inclination the stern snap angle recorded lowest strain than locator attachment. This means that the stern snap angle attachment seems to be more favorable in the stress distribution around inclined implant than a Locator attachment.

Keywords: *implant overdenture, Locator attachment, stern snap angle attachment, inclined implants, strain gauge*

Introduction

Tooth loss is a multifactorial and often a complex interaction of multiple morbidities that, left unresolved, may progress to complete edentulism.[1] The traditional treatment modality of edentulism has been the fabrication of removable complete dentures.[2] three main factors are involved in optimal denture treatment: retention, support, and stability. it is critical to evaluate and properly estimate their contribution to optimal denture. [3]

The treatment for edentulous patients with implant-preserved implants has proven to be a predictable and successful result which overcomes conventional dentures and provides a reliable and straightforward solution to support for retention of dents as well as stability problems(4).

A well accepted treatment option is Mandible with a2-implant retained overdenture.(5) Jemt et al(6) have found 94,5% cumulative success rates in implants and 100% in overdentures in a study of this treatment..

Human cephalometric radiographs characteristically show an angle of 90 to 95 degrees between the mandibular plane and the dental axis of the mandibular incisors .as a result of ongoing mandibular atrophy, the remaining bone does not reveal its maximum diameter in the direction of the axial position of the natural tooth; instead, it appears to be retroinclined. This atrophy is associated with a modified morphology for the placement of anterior implants in the interforaminal region, which frequently causes a lingual inclination of implants[(7)].

Various attachment types can be employed to retain mandibular overdenture to implants, basically splinting (bar-clip constructions with various bar shape designs) or not splinting attachments (various ball type attachments, magnet attachment and attachments whit telescopic coping). [(8)]

Depending on retention levels, arch morphology, patient expectations, costs, soft tissue pain, and load distribution to implants and surrounding tissue, the choice of attachment system depends. The Angulation of implants also plays a major role in the choice of attachments. (9)

In this situation, implants may be inserted into angulations with each other. SO, the use of tilting allows for the placement of longer implants, which increases the degree of implant to bone contact area and also the implant primary stability[(10)]. The compromised bone of the sinus antrum can be circumvented, thereby, reducing the cantilever length with an equivalent number of masticatory units, giving rise to reduction in the moments of force and thus improving the load distribution.[(11)]

Because of limited inter-ridge space, low-profile systems must be used that can cause denture base thinning with at least 2 mm.. The Locator is a new resilient connector whose abutment and attachment system height is only 3.17 mm and has been available since 2001. The system can be applied in a limited inter-ridge space[12], And is a convenient alternative to staples It consists of a metal matrix and a resilient plastic component that is placed on a latch embedded directly in the prothesis The system offers four different colored lining that affords various attachment forces.. In this way, The patient is satisfied with the esthetic effect and the system also achieves greater retention and stability for the prothesis. There are other low-profile attachment systems that can be used with mandibular overdentures besides the Locator system (13) .

A new attachment system including stern snap and snap angled, congruent with all common implant systems, The innovatives two-piece design enables to correct True Angle with divergent implants up to 20 degrees without needing to rely on a hinging attachment. The system has a new maximum durability cap that requires no housing, requires only 2.5 mm of low profile and requires less space in the denture.

Therefore, the aim of this work will be to compare two different concept of attachment design used to manage the tilted implant placement.

Materials and Methods:

Experimental models and overdentures

This study was conducted on four duplicate, completely edentulous mandibular acrylic models. Two 11 × 3.3-mm implants (IHDE implants.ALLFI sso,swiss) were inserted in the canine areas of each model. Artificial acrylic resin teeth were arranged on a wax trial denture base. The trial denture was flasked and packed with clear acrylic resin to obtain a guide template, which was used to mark the implant placement sites for each model (29).

Using a parallometer milling machine (BF 2, Bredent, GmbH&Co, KG, Senden, Germany), two recesses were prepared in the marked sites in the canine areas [15]. The models were classified into the following four groups on the basis of the site of implant inclination: mesial, distal, buccal, and lingual at 20^0 (Fig. 1). Drill inclination was controlled by moving the table of the milling machine in a mesio-distal and buccl-lingual directions. The implants were inserted in the prepared recesses with platforms leveled at the crest of the acrylic ridge. The implants were fixed to the acrylic models using a resin cement to simulate osseointegration [16]. For each model, an approximately 1.5-mm layer of silicone soft liner (Softliner®, Promedica, GmbH, Neumünster, Germany) was used to simulate the alveolar mucosa [15,17,18,19,20]

eight duplicate experimental overdentures (two experimental overdentures/group) were constructed over the models.

Tested attachment

1.locator attachment:

The Locator attachments (localicer, IHDE, SWISIS) comprised black processing inserts that were attached to Locator matrices, and the assembly was plugged on to Locator abutments. Sufficient relief spaces were provided on the fitting surface of the overdentures, which corresponded to the implants to accommodate the metal housings of the Locator attachments. The Locator matrices were attached to the fitting surface of the overdentures using autopolymerized acrylic resin (Fig. 2). The black processing inserts were replaced with blue nylon inserts for all inclination's sites.

2.stern snap angle attachment:

First, the stern snap abutment (STERN GOLD, USA) base were screwed on implants by Flat Blade Square Drive tools kit supplied by manufacture , The abutments are tightened to 30 Ncm ,Then the modified ball were screwed in to abutment base by .050 Hex Tool (Fig.3).The area of denture base directly over the stern snap attachment were relieved by round bur to receive the retentive cap, which were placed on the stern snap attachment. The denture was then positioned on the model to insure enough space for the direct pick up of the retentive cap.

two lingual holes were prepared on the denture base opposite to the stern snap attachment to allow for the escape the excess resin martial during the pickup procedure. Separating medium was applied on the acrylic resin model and self-cured acrylic resin was mixed and added on the top of retentive cap (green) and in the cross-ponding areas prepared in the fitting surface of the denture base. The denture was then seated and kept in place until polymerization of the acrylic resin ,after which it was removed with the retentive cap picked up in its fitting surface .

Strain gage fixation

At least 5 mm of the silicone mucosal simulation was removed from the mesial, distal, buccal, and lingual areas around the implants to permit bonding of strain gages to the acrylic resin. The acrylic resin surfaces were flattened with a fissure bur, as recommended by the manufacturer. The surfaces were then smoothened using a fine grit sandpaper to obtain a surface texture suitable for strain gage bonding and to avoid incremental apparent strain. Four linear strain gages (Type KFG-1-120-C1-11L1M2R; gage length, 1 mm; gage resistance,119.6 ± 0.4 Ω; adaptable thermal expansion, 11.7 PPM/C; temperature coefficient of gage factor, + 10118%/C; gage factor, 2.08 ± 1.0%) were bonded to the acrylic resin at the mesial (M), distal (D), buccal (B), and lingual (L) surfaces of each implant [15,19]. A strain gage adhesive (Kyowa Electronic Instrument Co., LTD., Tokyo, Japan) was used to monitor the strain around the implants during load application. The gages were oriented mesiodistally perpendicular and bucco-lingually parallel to the implant axes (Fig. 4). Acrylic dummies were constructed to control thermal changes that resulted from loading [15]. Active and dummy gages were wired to a half-circuit Wheatstone bridge (four-way armored cable, AF4 × 1 × 28; AWG, Pirelli, Sao Paulo, Brazil). The other half of the bridge was internally located using in a digital strain meter (Cio- Exp-Bridge 16; Measurement Computing, Middleboro,MA, USA).A static load, ranging from 10 to 60 N, was applied 5 times (in 10 N steps) to the occlusal surface of the denture using a loading device to calibrate the gages The calibration process aimed to verify the linear association between the applied load and resultant strain and assess the repeatability of the measurements [15,17,19,20].

. **Strain measurement**

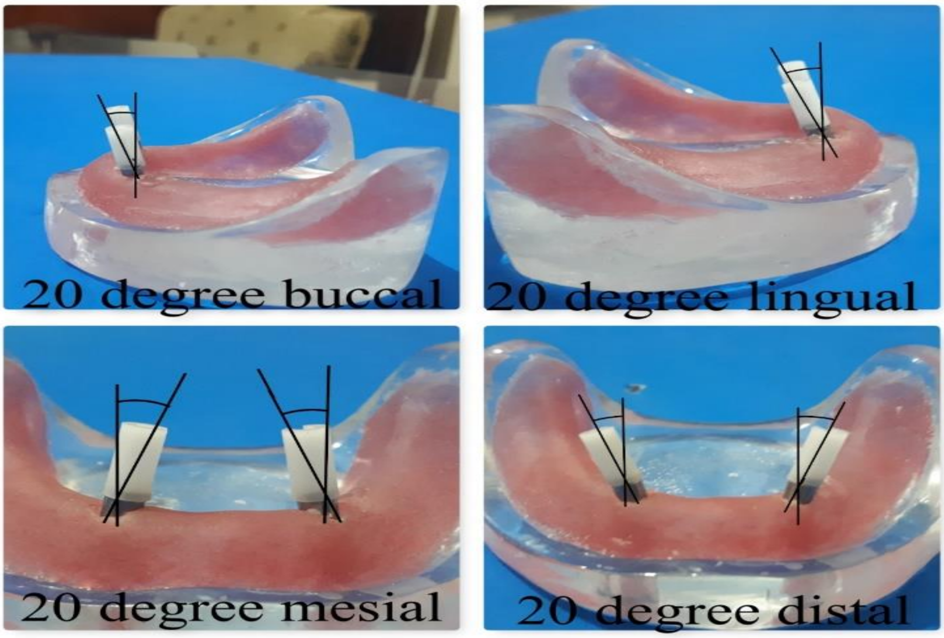
A universal testing machine (Model-2006, Instron Corp, Canton, MA, USA) was used to deliver vertical static loads of 100 N [21] bilaterally (to simulate clenching in centric occlusion) and unilaterally (to simulate chewing on preferred side). This amount of force represents a moderate level of biting force on implant-retained overdentures [21,22]. The load was applied in a compression mode at a constant rate (cross head speed) of 0.5 mm/ min (5).

For bilateral loading, a metal bar was placed on the occlusal plane of the occlusion denture between the right and left denture bases in the mesial cusp of the first molar. The forces were delivered to the center of the metal bar using the loading pin of the loading device [15,17,19,20]. For unilateral loading, strains were measured at the M, D, B, and L peri-implant sites on the loading (right) and nonloading (left) sides. The point of load application was selected at the central occlusal fossa of the first molar and notched with a diamond bur. This was performed to accommodate the loading pin at the same location (for reproducibility) and to prevent the slipping of the pin during loading [15,17,19,20].

Electric signals from the four strain gages were collected at a rate of 2 Hz (two readings/s) and were amplified, transmitted, and recorded using a software package (KYOWA PCD, Kyowa Electronic Instruments Co.). All experiments were repeated 5 times for each denture, and the mean recorded microstrain was subjected to statistical analysis.

Statistical analysis

Mixed ANOVA was used to compare strains between groups and load applications (bilateral and unilateral), followed by Bonferroni post hoc test. A P value of <0.05 was considered to be significant



Group I (20^0) buccal implant inclination; Group II (20^0) lingual implant inclination, Group III (20^0) mesial implant inclination, Group IV (20^0) distal implant inclination

Fig. 2 Locator pink inserts attached to the fitting surface of the overdentures.

Fig.3 stern snap screwed in to implants

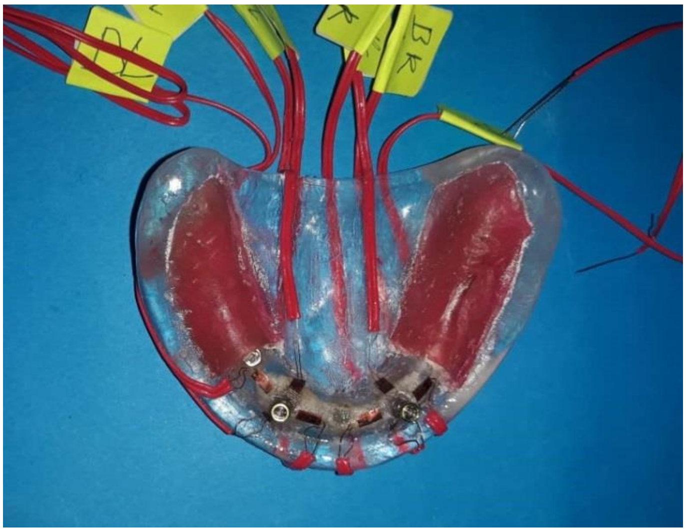


Fig.4 Orientation of strain gauges in relation to long axis of the implant

3- Results

A. ***Descriptive statistics***

- *The absolute values of strain were analyzed.*
- *The data were parametric as explored by Shapiro-wilk test*
- *Descriptive statistics are performed using mean, standard deviation, median, minimum, and maximum*

I. ***Bilateral loading***

- *Microstrain of the of all implant inclinations for Locator and stern snap attachments during bilateral loading.*

II. ***Unilateral loading on the loading side***

Microstrain of the of all implant inclinations for Locator and stern snap attachments during unilateral loading on the loading side

III. ***Unilateral loading on the non-loading side***

Microstrain of the of all implant inclinations for Locator and stern snap attachments during unilateral loading on the non-loading side

B. Comparison of strains between implant inclinations and attachment types during bilateral loading

Comparison of strains between implant inclination and attachment types during bilateral loading is presented in table 1

Table1. Comparison of strains between implant inclinations and attachment types during bilateral loading

	Locator Attachment		Stern snap attachment		Two-way ANOVA (p value)
	X	SD	X	SD	
Mesial inclination	67.00 A	5.70	23.00 A	4.47	<.001*
Distal inclination	122.00 B	5.70	74.00 B	2.24	<.001*
Buccal inclination	19.00 C	2.24	11.00 C	4.18	.049*
Lingual inclination	89.00 D	6.52	41.00 D	12.45	<.001*
Two-way ANOVA (p value)	<.001*		<.001*		

*X; mean, SD; standard deviation, *P is significant at 5%.*

C. comparison of strains between groups and implant positions during unilateral loading on the loading side:

Comparison of strains between implant inclination and attachment types during unilateral loading on loading side is presented in table 2.

1.Comparison of strains between implant inclinations:

For locator attachment, there was a significant difference in strains between implant inclinations. Multiple comparison of strains between each 2 implant inclinations is presented in the same table. The highest strain was noted with distal inclination followed by buccal inclination, then lingual inclination and the lowest strain was noted with mesial inclination.

For stern snap attachments, there was a significant difference in strains between implant inclinations. Multiple comparison of strains between each 2 implant inclinations is presented in the same table. The highest strain was noted with distal inclination followed by buccal inclination, then lingual inclination and the lowest strain was noted with mesial inclination.

2.Comparison of strains between attachment types:

For mesial inclination, Locator attachment recorded significant higher strain than stern snap attachment

For distal inclination, Locator attachment recorded significant higher strain than stern snap attachment

For buccal inclination, Locator attachment recorded significant higher strain than stern snap attachment

For lingual inclination, Locator attachment recorded significant higher strain than stern snap attachment.

Table2. Comparison of strains between implant inclination and attachment type during unilateral loading on the loading side

	Locator Attachment		Stern snap attachment		Two-way ANOVA (p value)
	X	SD	X	SD	
Mesial inclination	33.00 A	2.74	17.50 A	2.89	.048*
Distal inclination	241.00 B	8.94	85.83 B	32.47	<.001*
Buccal inclination	126.00 C	7.42	37.00 C	2.74	<.049*
Lingual inclination	63.00 D	5.70	27.00 D	2.74	<.001*
Two-way ANOVA (p value)	<.001*		<.001*		

D.Comparison of strains between implant inclinations and attachment types during unilateral loading on the non-loading side:

Comparison of strains between implant inclination and attachment types during unilateral loading on the non-loading side is presented in table3.

1.Comparison of strains between implant inclinations:

For locator attachment, there was a significant difference in strains between implant inclinations. Multiple comparison of strains between each 2 implant inclinations is presented in the same table. The highest strain was noted with distal inclination followed by buccal inclination, then lingual inclination and the lowest strain was noted with mesial inclination. No significant *difference was noted between mesial and lingual inclination*

For stern snap attachments, there was a significant difference in strains between implant inclinations. Multiple comparison of strains between each 2 implant inclinations is presented in the same table. The highest strain was noted with distal inclination followed by buccal inclination, then lingual inclination and the lowest strain was noted with mesial inclination. No significant difference was noted between mesial and lingual inclination nor between buccal and distal inclination.

2.Comparison of strains between attachment types:

For mesial inclination, no significant difference between the attachment types was noted.

For distal inclination, Locator attachment recorded significant higher strain than stern snap attachment.

For buccal inclination, no significant difference between the attachment types was noted.

For lingual inclination, no significant difference between the attachment types was noted

Table3. Comparison of strains between implant inclination and attachment type during unilateral loading on the non- loading side

	Locator Attachment		Stern snap attachment		Two-way ANOVA (p value)
	X	SD	X	SD	
Mesial inclination	13.00 A	2.74	3.75 A	2.50	.25
Distal inclination	441.00 B	27.70	30.00 B	7.75	<.001*
Buccal inclination	22.00 C	2.74	29.00 B	10.84	.35
Lingual inclination	19.00 A	11.94	8.00 A	2.74	.15
Two-way ANOVA (p value)	<.001*		.011*		

4- Discussion of results:

The in-vitro test of an implant usually showed that peri implant bone has more stress than implants parallel to the long axis Implants. [14].

As for the inclination of implants in the bilateral loading and unilateral loading of 200 distally inclined implants with a statistically significant high strains, this can be due to high stress on the mesial side, the vertical movement of the proths base at vertical loading compresses the acrylic resin distally towards implants, and the generation of compresses [14].

In the present study the inclination of 200 grades implants in any direction the attachment in the locator showed that the strain is significantly higher than the stern snap angle attachment, because of the reduced cushion effect of the locator resulting from a slightly larger size of the male nylon insert and the smaller diameter of the inner ring of the female abutment. This finding confirmed by study of Alsabeeha et al [15]. Furthermore the increased angulation of the implant may increase the magnitude of the micromotions around two un-split implants in clinical situations. When these micromotions exceed 100 μm, they can trigger bone loss by bone induction [16] [17].

Despite low-profile design of both attachments the reduced recorded microstrains with stern snap my be related to more cushion effect of stern snap, as there is no metal housing and the true angle correction provided [18] .

In comparison with the locator attachment, the 200 stern snap angle recorded low stress at all directions, this can be due to the ability of a stern snap to perform a better distribution of stress around inclined implants.. This finding can be explained by Hirata et al [19], who discovered that the stress on a tilted implant could be reduced by changing its angle to be perpendicular to the occlusal plane.

This study revealed statistically significant value between the attachments at 20^0 distally inclined implants on the non-loading side. The highest strain on the nonload side of the locator f record was surprising. However, that can happen because the locator attachment is not completely unplugged on the non-loading side when dentures rotate on the loading side with swiveling implant. The absence of de-engagement on the un-loading side of the locator may be due to the existence of the double friction flange and an increase in under-cutting distal to the locator connector. [16].

The enhanced stress on the non-loading side distal site was consistent with several in vitro research [20,21], that simulated load transfer of resilient attachments with 2 implant divergently inclined 15^0-17^0 [21]. In contrast, in another study that investigate the effect of different degrees of distal implant inclination on peri-implant strain of locator retained mandibular overdentures, the distal site of non-loading side was associated with the lowest strain [22].

The major shortcoming of methods for analyzing biomechanical stress in vitro is the need to drive certain assumptions or to use materials that often do not simulate the complex nature of living tissues[23], Therefore the results of this study are only descriptive because the physical properties of acrylic resins do not simulate the complex nature of living bone regarding mechano-biology and osseointegration.

The simulated loads have been carried in vertical, but mastication forces are known to occur in many different directions [24,25]. A limitation of this study is the absence of the nonaxial load application. hence stress patterns can change as a load direction. Further studies would therefore be beneficial for the assessment of stress transmission with axial and offset load applications [26]

Long - term clinical research is still necessary to determine the influence of observed stress levels of stern snap angle attachment on peri implant hard and soft tissues as well as possible complications and maintenance.

5- Conclusions:

According to the results of this study, the following conclusion can be done:

Regardless the attachment system, The 20^0degree distally inclined implants inserted in canine area to retain mandibular overdentures showed higher preimplant strains.

It is advisable to place the implants as parallel as possible to each other and perpendicular to the crest of the ridge to minimize stress transfer to the peri-implant region.

The stern snap angle attachment seems to be more favorable in the concern of biomechanical stresses distribution around 20^0 degree distally inclined implants than locator attachment in anterior mandible.

Retention characteristics of the newly introduced attachment is an important issue for investigation. Clinical assessment and long-term trials seem to be most beneficial for success of overdenture treatment.

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