

## Comparison Between Splinted and Un-splinted Medi-Implants Retaining Mandibular Overdenture (In-vitro study)

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### ABSTRACT

An in-vitro study was done to compare between splinted and un-splinted Medi-implants and their effect on the implants and supporting structure. Two mandibular acrylic models were made with the placement of two implants in each one on the canine region. The locator and bar were used as attachments. After the attachment was fitted to its abutment four channels were done in each model mesial and distal to the implants to receive the strain gauge. Universal-testing machine was used to apply standardized static load with a special load applicator. Loading was performed unilaterally in the vertical direction at the right 1st molar on both models. Then a bilateral loading was applied in the vertical direction on both models at the 1st molar. Comparing the results of the two types of attachment revealed that there was a significant difference between them (p value<0.001). So, it can be concluded that un-splinted implant retained mandibular overdenture transmits less stress to supporting structures than splinted implants. In both splinted and un-splinted retained mandibular overdenture, the distal aspect shows greater stress than the mesial one.

*Keywords: Implant, Bar, Locator, Overdenture*

## 1-Introduction

Edentulism is not an eventual, healthy occurrence in an adult population. Rather it is most often the result of repeated tooth extractions from the combined pathological processes of dental caries, periodontal disease, or a method to reduce the costs associated with dental treatment. <sup>(1-2)</sup>

The rate of edentulism increases at 4% per 10 years in elderly adults and increases to more than 10% per decade after age 70. The average total rate of edentulism around the world is 20% at age 60, although there is a wide disparity between the countries. <sup>(1-2)</sup>

Sharp residual alveolar ridge crest can be the result of pre-extraction bone destruction, trauma during extractions, or post-extraction resorption. Crestal bone irregularities and radiolucency toward the ridge crest suggest this in radiographs showing the ridge in profile. Palpation usually will reveal the sensitivity of the mucoperiosteum over the crest. Because of the sensitivity, sharp ridge crests cannot contribute much to the support of a denture. <sup>(2)</sup>

Surgical reduction is tempting and sometimes indicated, but the reduction in ridge height adversely affects the stability of a denture. The ridges are sometimes kept for their contribution to stability if they are relieved of direct pressure by using a selective pressure impression technique that gains support for the denture from other areas. <sup>(3)</sup>

Severe resorption will expose the mental foramina on the crest of the mandibular residual alveolar ridge. This may be seen radiographically. The exposed mental nerve is sensitive to pressure. The patient wearing dentures may report sporadic shooting pain in the distribution area of the nerve. <sup>(3)</sup>

Then, as shrinkage continues, the anterior part of the basal seat for the mandibular denture moves forward. These changes must be noted at the time of the examination for the resultant problems of leverage, occlusion, and tooth position for esthetics. <sup>(3)</sup> The reduction of alveolar ridge size is frequently accompanied by an apparent encroachment of muscle on the crest of the ridge (high muscle attachment) serves to reduce denture bearing area and undermine stability. <sup>(3)</sup>

Oral implants have revolutionized the practice of dentistry. Many experimental and clinical studies have focused on the mechanisms of tissue integration and the possibilities to secure long-term success. The concept of osseointegration was developed by BRANEMARK in the middle of the 1960s and led to the predictable long-term success of oral implants. <sup>(4)</sup>

The highest target in the dental profession is the fulfillment of patient wishes. The greatest wish of the patient is always the fast, painless replacement of their missing teeth or stabilization of the prosthesis. A fast, stable, and esthetic reconstruction of the patient's dentofacial system is the main goal of every dentist.<sup>(5)</sup> The FDA cleared the conventional-diameter root-form implants for clinical use in 1976. Millions of conventional-diameter implants have been placed for more than 4 decades, and their cumulative success rate of around 95% is impressive.

In many situations, it has been our experience that the conventional prosthodontic portion of implant treatment fails faster than the properly integrated root-form implants.

In the early 1990s, some innovative practitioners started using Mini-implants for long-term use in situations with insufficient bone. Mini implants are a relatively new modality in implant therapy. They were originally developed by several implant manufacturers as "transitional" implants. These screw-type implants were to be placed between endosseous implants to support a fixed, provisional prosthesis while the permanent implants healed, and Osseointegrated.

These transitional implants would then be removed before final prosthodontic procedure completion. Some clinicians found that these "temporary" implants had Osseointegrated when they attempted to remove them. They found that these implants were much simpler to place than conventional implants, and due to their small dimensions, could be placed in areas of very limited bone.<sup>(6)</sup>

Some implant companies have recognized the challenge of minimal bone presence with the risk of fracture of Mini implants and made implants of a smaller diameter than the conventional implants which are commercially known as 'Medi-implants' (ranging from 2.4 to 3 mm). Although this change is only a slight reduction in diameter, it has allowed easier placement of root-form implants in the maxillary lateral incisor area, mandibular anterior sites, and in any area with severe bone resorption.<sup>(7-8)</sup>

It has been also suggested that Medi-implants are more advantageous than Mini-implants in withstanding stress structurally and increasing fracture resistance so fewer implants can be used. Also, the use of Medi-implants decreases the stress transmitted to the bone and results in less bone resorption. Small-diameter implants have been advocated for specific clinical situations including reduced inter-radicular bone, a thin alveolar crest, or the replacement of teeth with small cervical diameters.<sup>(9)</sup> Such designs may also obviate the need for bone augmentation and preliminary orthodontic treatment.<sup>(9-10)</sup> Different attachment systems have been used to retain

mandibular overdenture: Bars with clips, Studs, and Magnets are among the most attachments used.<sup>(11)</sup> Attachments were defined as a mechanical devices for the fixation, retention, and stabilization of a prosthesis or a retainer consisting of a metal receptacle and a closely fitting part; the former, the female (matrix) component was usually contained within the normal or expanded contours of the crown of the abutment tooth and the latter, the male (patrix) component was attached to a pontic or the denture framework. Bar attachment provides a direct mechanical attachment between the overdenture and the supporting structures. It acts as a splint between the abutments. Bar attachment provides either rotational movement between the bar and the overlying sleeve (bar joint) or rigid fixation (bar unit).<sup>(12)</sup> Splinting distributes the functional and nonfunctional forces over a broader area and protects the weak abutments. In cases of separate abutments, independent movement occurs, and if one abutment is especially weak, the strong abutment can serve as the fulcrum point for the movement of the weaker abutment.

## 2. Experimental

### **Mandibular test model construction:**

Fabrication of the edentulous mandibular denture base A silicon mold (fig1) was created from a standard edentulous mandibular die (dental study model 402U, GC, Japan), and two corresponding plaster casts were poured in type IV dental stone (Die-Keen, Heraeus-Kulzer, Germany).

The silicon Mold was poured by epoxy resin<sup>1</sup> (fig2) and a mucosa simulation was applied to the casts as the following, approximately 2.0mm thickness was reduced from every model this was controlled by a round bur of 2mm depth for pitting the edentulous area, followed by uniform reduction to the denture-bearing area and the limiting borders.

Three grooves were made on the cast to represent the 2 mm thickness of the tissue simulator material then a vacuum sheet was processed over the duplicate cast to construct a stent with 3 tissue stops to ensure uniform thickness for the tissue simulating material. An adhesive for bonding of the mucosa simulation was painted over the model. A mucosa gingival mask<sup>2</sup> was injected and then pressed over the model to simulate mucosa.

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<sup>1</sup> bredent exakto form epoxy Germany

<sup>2</sup>Addition svernetzends Zahnfleischmasken-Silicon(bredent)



**Figure 1. Silicone rubber mold**



**Figure 2. Mandibular epoxy test model**

**Experimental complete denture construction:**

Two mandibular stone models were used to construct two complete dentures (fig 3). On each stone model, one sheet of wax base plate was adapted. Two identical sheets of acrylic teeth were used for setting up teeth, according to the anatomical and mechanical considerations. Waxing up, flasking, wax elimination, packing, and curing of heat-cured acrylic resin followed by finishing and polishing of the two dentures were done. Each denture was tried to fit into the two acrylic models.



**Figure 3. Mandibular complete denture**

### **Implant insertion:**

The areas below the denture canines on the epoxy model(fig5) were marked by indelible pencil, and these marks were extended to the crest of the mandibular edentulous model to determine the planned implant sites.

Two implants (3 mm in diameter and 10 mm in length) were inserted bilaterally in the canine region previously marked.<sup>3</sup>

Drilling was made in the canine regions; a milling machine(Fig) was used to be sure that the implants were placed parallel to each other in place and perpendicular to the occlusal plane<sup>3</sup>.



**Figure 4. Milling machine**



**Figure 5. Model with locator attachment.**

### **Attachment designs and fitting of overdenture:**

**1-Locator attachment (group 1):** The female metal housings were fitted over the locator and the first overdenture was seated, areas to be relieved in the fitting surface of the overdenture, opposite to the metallic housing were marked. Relief was made and the overdenture was resealed and tried in place by using pressure-indicating paste to clarify the amount of relief. A mix of self-cure acrylic resin was used to pick up the metal housings. (Fig 6)

**2-Bar joint attachment (group 2):** Wax coping was made on the square head abutments and a straight plastic bar was connected between them, the plastic bar, was placed with its flat surface facing the ridge, and its rounded surface facing occlusally. (Fig 7)

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<sup>3</sup>Implant Direct Sybron Manufacturing 27030 Mallbu Hills road.



Figure 6.: Metal housing in the denture



Figure 7. Bar attachment with clip

**Strain Gauges Installation:** The strain gauges used in this study were supplied with a fully encapsulated grid and attached wires. Four strain gauges (KFG-1-120-C1-11L1M2R, with gauge factor  $2.08 \pm 1.0\%$ , gauge length 1 mm, gauge resistance  $120.4 \pm 0.4$ -ohm, adoptable thermal expansion  $11.7 \text{ PPM}/^\circ\text{C}$ , and temperature coefficient of gauge factor  $+0.008/^\circ\text{C}$ ) were installed at the mesial and distal aspects of both implants. (fig 8,9)

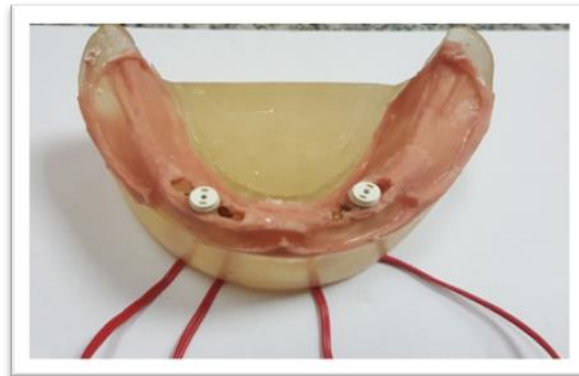


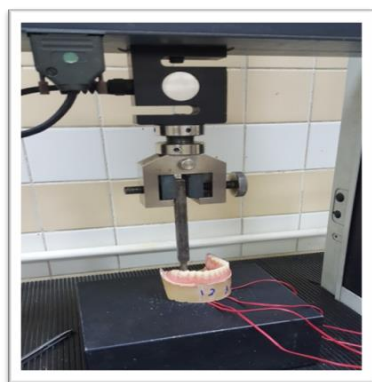
Figure 8. Strain gauge orientation on the mandibular cast with locator attachment



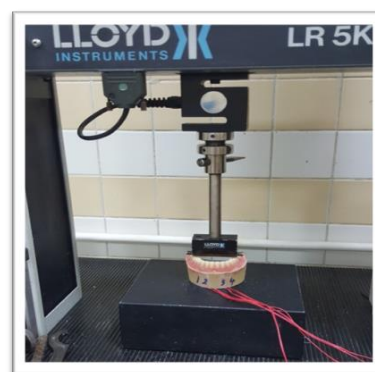
Figure 9. Strain gauge orientation on the mandibular cast with bar attachment

## **Loading tests**

Each attachment was fitted to its overdenture and was fitted to its abutments. The acrylic model was placed on the lower flat metal plate of the testing machine. A loading device (universal-testing machine)<sup>4</sup> was used to apply standardized static load. Loads were applied with a magnitude of 100N. A special load applicator was used to apply standardized static load. Loading was performed unilaterally in the vertical direction at the right 1st molar on both models (Fig 10). Then a bilateral loading was applied in the vertical direction on both models at the 1st molar (Fig 11). A four-channel strain meter was used to assess the strains induced by each applied load. The applied load started from zero up to 100N. The micro strains of the four strain gauges were recorded to measure the strains developed at the distal and mesial aspects of each implant for each load application. Once the load was completely applied, the macro strain readings were transferred to micro strain units from the four-channel strain meter.



**Figure 10. Unilateral loading**



**Figure 11. Bilateral loading**

## **3-Results**

Numerical data were presented as mean and standard deviation (SD) values. They were explored for normality by checking the data distribution and using Shapiro-Wilk test. Data showed parametric distribution, so they were analyzed using paired t-test for intergroup comparisons and repeated measures ANOVA followed by Bonferroni post hoc test for intragroup comparisons. The significance level was set at  $p \leq 0.05$ . Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows<sup>5</sup>.

<sup>4</sup> LLOYD instruments, Universal Testing Machine

<sup>5</sup>R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.



**Effect Of Unilateral load (on the right side) on the right and left side of the splinted (bar attachment) and un-splinted (locator attachment) Medi-implants:**

Mean of unilateral micro strain on the implants supporting bar attachment and implants supporting Locator attachment: Table (1) Shows the mean and standard error of unilateral micro strain on the Bar group and Locator group. It was found that the mean of unilateral micro strain on the Bar group in the right implant was 37000 and on the left implant was 23500. It was found that the micro strain on the locator group for the right implant was 110000 and for the left implant, it was 28000. This difference between the right implant and left implant of the bar group and the right implant and left implant of the locator group was statistically significant at a P-Value <0.001 as shown in table (1).

**Table (1): Right side loading:**

		Mean	Std. Error	95% Confidence Interval		P value
				Lower Bound	Upper Bound	
Bar group	Right	37.000	2.264	31.780	42.220	<0.001
	Left	23.500	1.854	19.225	27.775	
Locator group	Right	110.000	2.264	104.780	115.220	<0.001
	Left	28.000	2.016	23.352	32.648	

**The mean of bilateral micro strain Mesial and distal to the implants supporting the bar and locator attachment:**

Table (2) shows the mean and standard error of bilateral micro strain Mesial and Distal to the implant supporting Bar and locator attachment. It was found that the mean of bilateral micro strain mesial to the implants in the Bar group was 75000 and, in the Locator, group was 23500. It was found that the mean of bilateral micro strain distal to the implants in the Bar group was 34000 and, in the Locator, group was 19500. This difference between the mesial and distal aspects of the implant supporting by the bar attachment and the mesial and distal aspect of the

implant supporting locator attachment was statistically significant at a P value <0.001 as shown in table (2).

**Table (2):**

		Mean	Std. Error	95% Confidence Interval		P value
				Lower Bound	Upper Bound	
Distal	Bar	75.500	1.581	71.854	79.146	<0.001
	Locator	23.500	1.696	19.590	27.410	
Mesial	Bar	34.000	1.871	29.686	38.314	<0.001
	Locator	19.500	1.936	15.034	23.966	

**Effect of bilateral loading on each group: the implant supported by Locator attachment versus the implant supported by Bar attachment:**

Table (3) shows the mean and standard error of bilateral micro strain on each group the splinted implants (Bar attachment) and un-splinted implants (Locator attachment). It was found that the mean of the bilateral micro strain of the un-splinted group (Locator) was 21.5 and it was found that the mean of the bilateral micro strain of the splinted group (Bar) was 54.5. The difference between splinted Medi-implants (Bar attachment) and un-splinted Medi-implants (Locator attachment) was statistically significant at P Value <0.001 as shown in table (3).

**Table (3):**

	Mean	Std. Error	95% Confidence Interval		P value
			Lower Bound	Upper Bound	
Bar	54.5	1.96	50.1	58.9	<0.001
Locator	21.5	1.57	18.65	24.36	

#### 4- Discussion:

This study showed that there was a significant difference between loaded and non-loaded implant sides when unilateral load was applied. This came in accordance with other stress-strain analysis studies.<sup>(13)</sup> Where the stresses tend to become alleviated at the contra-lateral side of load application, creating significant differences between both sides.

Also, the comparison between splinted (Bar attachment) and un-splinted (Locator attachment) groups upon the application of bilateral load resulted in a significant difference in the stress-induced around the implants, it showed that the locator group has the lowest stress value on implants and this may be attributed to the higher resiliency of the locator attachment and that it allowed movement in all directions on contrary of the bar which allowed rotatory movement in an anteroposterior direction.

This finding agreed with the study carried out by **Kanazawa**, who pointed out that using ball attachment as un-splinted attachment transfers the lowest stresses and loading movements on implants compared to splinted attachment (Bar attachment), and this may prolong the longevity of the health of the surrounding bone.<sup>(14)</sup>

On the other hand, the locator attachment system has the lowest profile in comparison with the other studs and bar attachments as it permits up to 40° of divergence between two implants. The advantages of locator attachment are related to its design which allows a space of 0.2 mm of vertical resiliency and 8° of hinging in any direction, thus allowing the attachment to move in both the vertical plane and hinge axis. Therefore, this locator can favorably distribute forces along the long axis of the implant.<sup>(15)</sup>

This study also agreed with the results of **Tokuhisa et al** study<sup>(16)</sup>, which showed that, the use of the un-splinted attachment could be more advantageous than the splinted one in implant-

supported and retained overdenture, regarding minimizing stress and minimizing overdenture movements.

This study also showed that there was a significant difference between the mesial and distal aspects of the implants in the splinted (Bar attachment) and the un-splinted (Locator attachment) groups. The distal aspect of both groups showed a higher value than the mesial aspect on the application of bilateral load in the first molar areas. This may be attributed to the torque action on the implant when a bilateral load was applied, as this case may be considered a free-end saddle case. When a functional load is induced on this kind of distal extension, a rotary movement usually occurs around the fulcrum of the terminal abutments, this phenomenon causes torque action on the abutment and the resorption of the residual ridge<sup>(17)</sup>.

## **5. Conclusion**

1-Unsplinted Medi-implant retained mandibular overdenture transmits less stress to supporting structures than splinted implants.

2-In both splinted and un-splinted retained mandibular overdenture the distal aspect shows greater stress than the mesial one.

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- **Conflict of Interest**

There is no conflict of interest.

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