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BIOMECHANICAL BEHAVIOR OF THREE SOLITARY IMPLANTS SUPPORTING MANDIBULAR OVERDENTURE: A RADIOGRAPHIC EVALUATION

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ABSTRACT

Objective: Bone assessment around three implants supporting mandibular overdenture

Methodology: Ten completely edentulous patient were meticulously selected to receive a mandibular overdenture retained by three un-splinted implants placed in the anterior region with ball and socket attachments. Mesial and distal bone for the three implants levels were monitored at the time of denture delivery, 6 and 12months.

Results: The results of this study revealed insignificant difference between the bone level and percentage of bone loss for the three implants along the whole study period.

Conclusion: The three-implant overdenture treatment can achieve favorable results from a biomechanical point of view as well as peri-implant bone response

INTRODUCTION

Complete edentulism is now considered to be one of the most common debilitating oral conditions, often resulting in poor quality of life for the patients both functionally and psychologically [1-4]. Following total tooth loss, the lack of stimulation to the residual ridge causes a marked decrease in the width and height of the alveolar bone. The average first year bone loss was reported to be more than 4 mm in height and 30% in width [5-6].

Edentulism had been conventionally managed by the provision of complete dentures, a treatment modality that is associated with its own set of complications and problems; additionally Bone loss is further accelerated when the patient is wearing a poorly fitting denture [7-8]. Lower denture movement during function often causes trauma to the underlying mucosa [9-11]. Over and above complete denture wearers begin to avoid certain types of food which often results in an impaired nutritional status [12]. Finally, treatment outcomes with complete dentures often do not meet the esthetic, psychological or social needs of the individual [7].

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The use of dental implants with complete edentulism has become an integral treatment modality in prosthetic dentistry. The implant-supported prostheses have been found to substantially reduce bone loss in the edentulous jaw as well as improving masticatory performance, esthetics, and patient satisfaction [13-14].

The implant overdenture retained by stud attachments has been increasingly accepted as a successful treatment modality for the completely edentulous mandible. Stud attachments have served as overdenture abutments for several decades. Studs are among the simplest of all attachments, as they require less chair-side time and are easier to handle technically. In addition, they can provide stability, retention and support with less space requirements due to their minimum bulk [15-18].

Many studies have been conducted on the number of implants to be used in implant-supported prostheses. It was reported that two or four implants were preferred in implant-supported removable prostheses and increasing the number of implants shifted the support from mucosal surfaces to the implants with respect to anatomic-morphologic conditions [19]. Additionally, the size, curvature and shape of the ridge determined the distribution of implants over the arch [20].

The success of the two-implant overdenture has led to two international consensuses on the management of edentulism, namely the McGill and York Consensuses. Both have resulted in statements recommending these as the minimal standard of care for edentulous patients [21-23]. However, one limitation of two-implant overdentures, is the potential for anterior/ posterior rotation of the denture base around the attachments was correlated with decreased chewing ability that could compromise a patient's satisfaction as well as unfavorable stress distribution around the implants [24].

The concept of three implants to support a mandibular denture with separate stud attachments or splinted implants has been introduced since 1980s, and this modality of treatment has been widely used [25-26].

Although adding an additional implant increases the cost of treatment, this increased cost is still less than the cost of more expensive treatment alternatives, such as fixed implant restorations or removable prostheses supported by four or more implants. The addition of a third implant in the symphyseal region could provide extra support for the denture and preclude rotational movement without resulting in higher strain on the denture bearing mucosa, abutments, implants, or ridge which might lead to some sort of overload of the middle third implant or its failure in some[27].

In this radiographic study we will try to shed a light on the biomechanical behavior of the bone surrounding three implants supporting mandibular overdentures will be monitored.

MATERIALS &METHODS

10 completely edentulous male patients were selected from the outpatient clinic of the Department of Prosthodontics, Faculty of oral and Dental Medicine, Cairo University. Criteria for patient selection were set to excluded smokers and Patients with systemic diseases and conditions that might affect the process of healing and osseointegration, as well as patients with abnormal maxillomandibular relations. Patients were carefully screened by obtaining their medical and dental histories. Next, clinical examination, radiographic assessment and diagnostic mounting were done to further refine and complete the process of patient selection.

Conventional acrylic resin upper and lower complete dentures were constructed for all patients starting by primary alginate impressions, then final zinc oxide and eugenol impressions to obtain master cast. Occlusion blocks were constructed followed by maxillomandibular relation record to mount the casts on an articulator. Artificial teeth were set according to the lingualized concept of occlusion and the trial dentures were tried in the patient's

mouth. Then, the dentures were processed in high impact acrylic resin and delivered to the patients after necessary adjustments were done.

Alginate impression material was used to duplicate the lower denture for the fabrication of a clear acrylic resin stent to facilitate and guide surgical drilling. At the day of surgery a full thickness muco-periosteal flap was reflected followed by sequential drilling to prepare osteotomies to receive three tapered, self-tapping, internally hexed implants*, 3.7 mm in diameter and 13 mm in length in the interforaminal area with proper alignment and parallelism between the three implants. Using the surgical guide the implants were planned to be placed one in the midline and the other two equidistant between the lateral incisor and the canine. Finally healing collars were secured to the implants and flap was repositioned and sutured to avoid second stage surgery. Afterwards, the lower denture was relieved and relined with tissue conditioning material** and adjusted intraorally for occlusal interferences before it was delivered.

Prosthetic phase was scheduled after a period of three months, during which patients were frequently recalled for inspection of the dentures and adjustments or replacement of the tissue conditioning material. The healing collars were replaced by ball abutment with proper cuff height and the clear nylon caps were then inserted into the attachment metal housing and placed over the ball attachments Fig (1). Dentures were properly relived in order to be seated in place without interfering with the attachments, thereby creating sufficient space for acrylic resin pick-up which will pick up the housing of the attachment in the denture Fig (2). Finally, the denture was finished, polished and delivered to the patient.

Digital Radiographic evaluations were performed using the Digora system for all the parents at the time of delivery, after 6 months and after 12 months Fig (3). Custom made radiographic stent in combination with long cone paralleling technique were used to standardize the position of the imaging plate in relation to the implants at each imaging session. A line tangent to the apex of the implant was drawn using the software, then two lines were drawn on the mesial and distal aspects of the implant, perpendicular to the first line and extending to the alveolar crest. The mean value of bone height measurements of the two sides was calculated for each implant and the results were tabulated for statistical analysis.

Fig. (1) Three ball and socket attachments screwed to the implants

Fig. (2) Ball and sockets matrices picked up in the denture

* Legacy II Implants, Implant Direct TM LLC Spectra-System Dental Implants, 27030 Malibu Hills, USA
** Alpha-dent® tissue conditioner, Dental Technologies Inc., Lincoln Wood, Illinois, USA.

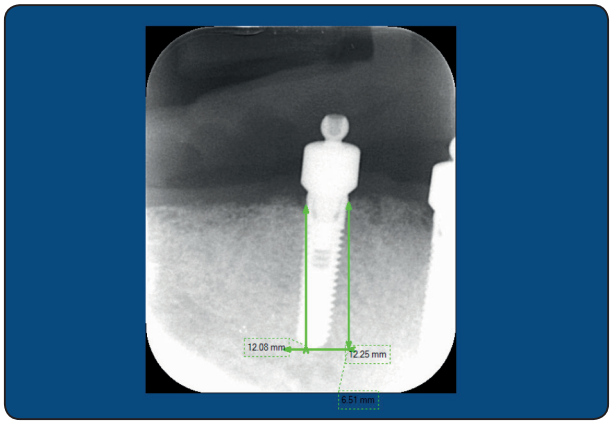

Fig (3): Bone height measurement using Digora software

RESULTS

This study was classified as a case control study aimed to observe the peri-implant bone response around three implants retaining an overdenture using stud attachments.

Measurements were taken mesially and distally to each implant and mean and standard deviation were calculated for further statistical study. There was no statistically significant difference between bone height measurements at the mesial and distal sides, so the mean of the two sides will be used for further comparisons. For more accurate significance, mean change percentage was calculated for both groups for each follow up interval using the following equation

$$\frac{\text{Bone height (Base line)} - \text{Bone height (Post-operative)}}{\text{Bone height (Base line)}} \times 100$$

Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests and showed parametric (normal) distribution. One-way ANOVA was used to compare between more than two groups in non-related samples followed by tukey post hoc test. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

The results revealed that there was no statistically significant difference in mean of bone height between the three implants at the zero month, 6 and 12 months, Where the highest mean of bone height was found in {Left implant} followed by {Right implant while the least mean of bone height was found in {Mid implant}

TABLE (1) Comparison between bone heights measurements of the three implants during 12 months follow up period:

Variables	0 months	6 months	12 months
	Mean ± SD	Mean ± SD	Mean ± SD
Left implant	11.85 ± 0.54[a]	11.89 ± 0.31[a]	11.57 ± 0.30[a]
Mid implant	11.18 ± 0.38[a]	11.15 ± 0.46[a]	11.22 ± 0.28[a]
Right implant	11.77 ± 0.80[a]	11.64 ± 0.64[a]	11.28 ± 0.66[a]
P-value	0.066ns	0.055ns	0.057ns

Mean with different letters in the same column indicate statistically significance difference *; significant (p<0.05) ns; non-significant (p>0.05)

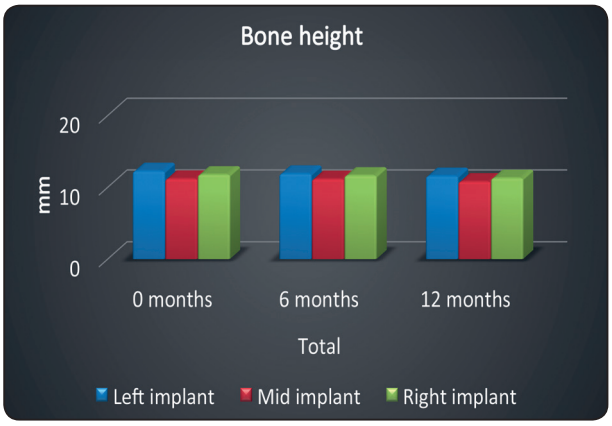

Fig (4): Bar chart representing comparison between bone height measurements around the three implants through the study period

Additionally, there was no statistically significant difference in mean percentage of change in bone height between the three implants between zero month and 12, zero month and 6 and finally 6 month and 12 month.

TABLE (2) Mean percentage of change for the three implants for each interval:

Variables	0-6 months	0-12 months	6-12 months
	Mean ± SD	Mean ± SD	Mean ± SD
Left implant	0.88 ± 0.86 [a]	5.47 ± 0.81 [a]	2.66 ± 0.32 [a]
Mid implant	0.29 ± 0.05 [a]	3.36 ± 0.99 [a]	3.07 ± 0.82 [a]
Right implant	0.83 ± 0.04 [a]	3.93 ± 0.35 [a]	3.14 ± 0.62 [a]
P-value	0.586ns	0.719ns	0.380ns

Mean with different letters in the same column indicate statistically significance difference *; significant (p<0.05) ns; non-significant (p>0.05)

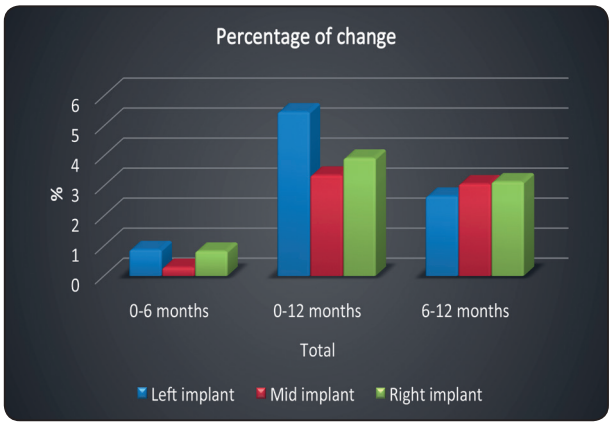

Fig (5): Bar chart representing comparison between percentages of bone change for the three implants for each interval

DISCUSSION

Researchers reported in literature that increasing implant number decreases stress values on implant, yet to date, there is no consensus on the influence of implant number on stress distribution [27-28].

It has been suggested to overcome the problem of rocking and rotation of the overdenture retained by two implants is to add a third implant in the symphyseal region which could prevent rotation by avoiding tissue intrusion in the anterior part of the denture would work similarly to the indirect retainer of a distal-extension removable partial denture [27,29]. This Rotational movements are more pronounced when the horizontal overlap between the incisors and the labial flange is wide. Another factor directly associated with rotation is the anterior/posterior dimension of denture bases [24].

The present study findings revealed insignificant difference between the mean bone heights between the three implants along the whole study period as well as insignificant percentage of bone loss throughout the study period. In addition, the marginal bone loss around the middle implant was insignificantly lower than that around the lateral implants.

All this results showed that the three-implant overdenture treatment can achieve favorable results from a biomechanical point of view as well as peri-implant bone response. This results might be attributed to the marked decrease in denture rotation around the implants as well as providing good posterior support from the edentulous ridge by maximum tissue coverage. Over and above using resilient stud attachments which allowed some degree of movement of the denture in six directions which will dissipate some of the stresses away from the implants. Finally it should be noticed that the opposing restoration was upper complete denture that exerts less load on opposite arch compared to natural dentition or fixed restorations [30].

In spite of the fact that crestal bone resorption around the implants is a well-known phenomenon occurring mostly as an immediate bone response after implant insertion as well as after functional implant loading however in this study the annual bone loss remain within the clinically permissible range. These results are in accordance with many studies which reported also encouraging outcomes regarding the implant survival, success rate, patient satisfaction and crestal bone resorption for the three implant retained overdenture [31-33].

CONCLUSION

Within the limitation of this study the three-implant overdenture treatment can achieve favorable results from a biomechanical point of view as well as peri-implant bone response

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