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Locator versus Equator attachments used with short implants for retaining mandibular complete overdenture: peri-implant marginal bone height changes

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Abstract
purpose: *This study was conducted to compare between Locator and Equator attachments used with short implants to retain mandibular complete overdentures, regarding the peri-implant marginal bone height changes.*
Materials and Methods:*Ten healthy complete edentulous patients were selected and constructed conventional complete denture for each patient. Then mandibular denture was duplicated by clear acrylic resin to be used as radiographic stent. Each patient received two short implants in the canine areas by flapless technique using cone beam computer tomography surgical template. Then, divided into two equal groups; group A received locator attachments and group B received equator attachments. After one month direct picking up were made. Standardized periapical radiography evaluations of periimplant bone height changes were performed immediately, 3 months, 6 months, and 12 months following picking up of attachments, The bone loss was calculated during each interval and statistically analyzed.*
Results:*When comparing vertical bone loss between groups at different observation, there was significant difference between groups except at T0-T3 (p=1.00) and was no significant difference in horizontal bone loss between groups at T3-T6 and T6-T12.*
Conclusions:*Within the limitations in this study, it can be concluded that the low-profile Locator and OT-Equator attachments can be used for retaining mandibular implant overdentures, regarding the accepted range of periimplant marginal bone height changes. The using of Locator attachment may be more beneficial in preserving the periimplant marginal bone than OT-Equator for retaining the mandibular implant overdenture.*
KEY WORDS: *Short implants; Locator; Equator; Overdenture attachments; Implants overdentures.*

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I. Introduction

Edentulism causes bone resorption, which is ten times greater during the first year than in subsequent years, with the mandible absorbing four times more than the maxilla. The conventional treatment for edentulism was a complete denture (CD). However, a common complaint is the lack of stability and retention, as well as diminished chewing capacity. As a result, CD are no longer the preferred prosthodontic treatment for edentulous mandibles.

To resolve these drawbacks, a mandibular two-implant overdenture (IODs) is recommended as the primary treatment choice for the edentulous mandible, as it improves quality of life, improves masticatory function, and provides patient comfort with little invasiveness[1].

The height, amount, and location of loaded implants have an effect on the peri-implant supporting alveolar bone. Although the use of two implants to assist the mandibular complete overdentures (ODs) is discussed, the difficulties of poor implant support and stability, mandibular ridge resorption lateral to the implant as a consequence of the load transmission to the bone as a result of the prosthesis rotating around the anterior implants, and greater attachment wearing during function are all discussed[2].

The prosthodontics management of mandibular resorbed residual ridge (RRR), including the use of short dental implants cause have a number of clinical benefits, including less surgical skill needs, less morbidity by avoiding more expensive bone augmentation therapies, speedier removal in the event of failure and most crucially a larger number of implant sites available. Clinicians, on the other hand, might be concerned about drawbacks including a high crown/implant ratio (C/I) and a high risk of biological and technological issues due to potential overload. None of these potential limitations are therapeutically meaningful, according to preclinical and clinical investigations, aswell as current systematic reviews. Short implants have similar implant survival rates and biological consequences to long implants, according to longer-term research[3–5].

IODs come with a variety of attachments, including ball, bar, magnetic, telescopic, equator, and locator attachments[6].

Zest anchors developed the locator attachment, a non-splinted technique that has since become commonly used for IODs. Repairing and replacing the attachment is simplistic and quick according to its self-alignment and dual retention (inner and outer) characteristics. Furthermore, because of its reduced vertical height, the locator attachment can be used with limited occlusal distance and a minimal risk of CD base fracturing when compared to other options attachment systems. The typical inserts for the locator system contain three color-coded inserts (blue, pink, and red) with different retention values. The retention rate of the red implant is medium (22.2 Newton). The pink insert contains mild retention (13.3 Newton), whilst the blue insert contains extra-light retention (6.67 Newton)[7].

Equator profiles have the smallest total displacement of any attachment system on the market, allowing dentists and technicians more case design options for aesthetics and function, as well as simplicity of use. They can also be utilized to treat low vertical dimension and improved retention force. When compared to the different attachment systems available, the equator attachment offers several advantages, making it a superior choice. This attachment's biological benefit is that it maintains fibromucosal adhesion while emphasizing the formation of a gingival barrier, which prevents inflammation and peri-implantitis[8].

Hence, when two short canine implants are indicated for assisting mandibular complete ODs, which attachment will beneficial regarding the effect on peri-implant alveolar bone height changes, Locators or Equators?

II. Materials and Methods

Ten healthy complete edentulous patients, ranging in age from 60 to 70 years, were selected for this study. According to the ethical committee at Mansoura University's faculty of dentistry, all patients accepted an informed permission form for their participation in this study.

Patient Selection:

All patients were free of any systemic disorders, that determined by a physician's medical history and clinical examination, for at minimum one year, they had an edentulous maxilla and mandible, all patients had atrophied edentulous mandible with healthy firm mucosa evaluated by panorama x-ray and normal maxillofacial relationship “Angle’s class I ".

A traditional complete denture is constructed as according **Devlin**[9]maxillary and mandibular conventional CD were created for each patient In an appropriate stock tray, after primary and secondary maxillomandibular impression making and jaw relation transfer to semi-adjustable articulator by face-bow record, the artificial teeth were set according to lingualized occlusionscheme, after clinical try in, the denture was flasked, finished, and polished in conventional manner. Patients received denture and were followed-up for one month toverify denture occlusion and adaptation.

The mandibular complete denture was duplicated[10]. the duplicated denture was used during double scanning by CBCT with modification of the intaglio by adding gutta-percha opposing to two canine areas. Images were loaded into 3D image planning software (i- CAT Vision®) to design position and angulation of implants virtually. A mucosal supported stereolithographic surgical guide with two metal sleeves and anchor pins was printed according to implant planned sites. A dose of antibiotic (Megamox, Al-Jazeera Pharmaceutical, Saudi Arabia) prophylaxis was administered 1 hour preoperatively. Under local anesthesia (Mepecaine-L, Alex Co., Egypt), Universal Surgical Kit was used to perform full sequence drilling through the anchored guide. Each patient received two implants (6mm × 4.2mm; Mode, Turkey). The intaglio of the denture opposite to implants was recessed and filled with soft liner (Promedica, Germany). the patient was instructed for soft diet and home care with frequent recall and follow-up. After three months, healing abutments were screwed for two weeks with required modification of the intaglio of mandibular denture the Locator® attachments (mode System, Turkey) were screwed to internal hex of the group A and the OT Equator® (Neocluss, Turkey) were screwed to internal hex of the group B. Rubber dam sheets in a circle around on the head of each attachment (Fig.1). Metal house with black nylon inserts for Equator® and Locator® were placed on attachments and the denture was modified to include attachments with caps without rocking. the pick-up was done by adding auto-polymerized acrylic resin (Acrostone, Egypt) in modified intaglio of the denture and under patient’s occlusion. After complete polymerization, excess released from preprepared lingual vents and the fitting surface was trimmed. Laboratory black insertsin female housings were replaced by medium plastic retention inserts (Fig.2). then panorama radiograph was taken to assessed the attachment. The patient was instructed for home care and regular follow-up.

According to **sewerin**[11], standardized intraoral digital periapical radiography evaluations were performed immediately ,3 months, 6 months and 12 months following IODs implantation. The paralleling approach was employed with an occlusal bite index made of silicone material and fixed to a sensor holder* to obtain repeatable periapical images. Radiographic measurements were traced on the radiograph by using software (Corel Draw v12, Corel Co., Canada). **Walter et al**.[12] and **Heckmann et al**.[13] showed how to measure peri-implant marginal bone height changes, The difference between the shoulder of the implant (spot A) and the first bone to implant touch (spot B) was measured and termed to as the vertical bone level in mm (AB line)(Fig.3). The AB line at the time of insertion (0 month) was deducted from the AB lines at 3months, 6 months and 12 months to calculate the Vertical Bone Loss (VBL) during each interval. Furthermore, the distance between the peri-implant bone level (C spot), which is the crossing point of the tangent to the horizontal bone crest (CD line) and tangent to the crater shaped defect (CB line) and the implant at right angle, was evaluated and termed to as the horizontal bone level for measuring horizontal alveolar bone height changes[14,15].CBCT using to assessed the implants after 12 months after picking up.

Statistical analysis

The SPSS statistical package for social science version 22 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Shapiro-Wilk test was used to test the normality of the bone loss values. The data was parametric and normally distributed. Descriptive statistics were performed in terms of mean, median, standard deviation, range, minimum, maximum. Repeated measures ANOVA was used to test significant difference in VBL and HBL between time intervals followed by Bonferroni post hoc test for multiple comparison between each 2-time intervals. Independent samples t-test was used to compare VBL and HBL between groups. P is significant if < 0.05 at confidence interval 95%.

III. Results

1. Descriptive statistics

The descriptive statistics of BL in group A and B at different observation times [the first 3 months after overdenture insertion (T0-T3), the second 3 months after overdenture insertion (T3-T6), the first 6 months after insertion (T0-T6), the second 6 months after insertion (T6-T12) and 12 months after insertion (T0-T12)] as shown in table 1.

Table 1. Descriptive statistics of BL in two groups at different observation times.

	T0-T3		T3-T6		T0-T6		T6-T12		T0-T12	
	VBL	HBL	VBL	HBL	VBL	HBL	VBL	HBL	VBL	HBL
Group A (X±SD)	.29±.06	.09±.03	.21±.08	.09±.02	.52±.13	.18±.03	.22±.06	.11±.02	.73±.18	.30±.03
Group B (X±SD)	.34±.06	.14±.03	.32±.03	.13±.05	.65±.05	.28±.06	.44±.09	.12±.02	1.11±.09	.40±.07

2. Analytical statistics

Comparison between time intervals:

- When comparison of VBL between different time intervals for group A there was a significant difference betweeneach 2-time intervals except between T3-T6 and T6-T12 and the VBL at T0-T6 was significantly higher than all other observation times. And the VBL decreased significantly from T0-T3 to T3-T6 (p=.042), and from T0-T6 to T6-T12 (p<.001). And the VBL increased significantly from T0-T3 to T0-T6 (p<.008). While no significant difference was found between T3-T6 and T6-T12. While when comparison of VBL between different time intervals for group B there was significant difference between each 2-time intervals except between T0-T3 and T3-T6 and the VBL at T0-T6 was significantly higher than all other observation times. And no significant difference was found between T0-T3 and T3-T6. The VBL increased significantly from T0-T3 to T0-T6 (p<.001), from T0-T3 to T6-T12 (p=.026) as shown in table 2
- When comparison of HBL between different time intervals for group A there wasa significant difference between each 2-time intervals and the highest HBL was reported at T0-T6 and no significant difference between T0-T3 and T3-T6. And the HBL increased significantly from T0-T3 to T0-T6 (p<.001), from T3-T6 to T0-T6(p=.004). While when comparison of HBL between different time intervals for group B there wassignificant difference between each 2-time intervals and the highest HBL was reported at T0-T6. And no significant difference was found between T0-T3 and T3-T6, T0-T3 and T6-T12 and between T3-T6 and T6-T12. And the HBL increased significantly from T0-T3 to T0-T6 (p<.001), from T3-T6 to T0-T6(p<.001) as shown in table 2

Comparison between groups:

As shown in table 2, when comparison of VBL between groups at different observation times. At T0-T3, there was no significant difference in VBL between groups. At all other time intervals and for the total bone loss, there was a significant difference in VBL between groups (independent samples t-test, p<.002). Group B recorded significant higher VBL than group A at T3-T6 (p=.001), at T6-T12 (p<.001), and at T0-T12 (p<.001). While, when comparison of HBL between groups at different observation times. At T3-T6 and T6-T12, there was no significant difference in HBL between groups (independent samples t-test, p>.05). At all other time intervals and for the total bone loss, there was a significant difference in VBL between groups (independent samples t-test, p=.002). Group B recorded significant higher HBL than group A at T0-T3 (p=.002), and at T0-T12 (p=.002).

Table 2. Analytical statistics of BL in two groups between different times intervals.

	T0-T3		T3-T6		T0-T6		T6-T12	
	VBL	HBL	VBL	HBL	VBL	HBL	VBL	HBL
Group A (X±SD)	.29±.06	.09±.03	.21±.08	.09±.02	.51±.13	.18±.03	.22±.06	.11±.02
Group B (X±SD)	.34±.06	.14±.03	.32±.03	.13±.05	.65±.05	.28±.06	.44±.09	.12±.02
(p value)	.105	.002*	.001*	.051	<.001*	.614	<.001*	.002*

IV. Discussion

When comparing between all observation times in each group, the periimplant alveolar bone loss (VBL and HBL) showing statistically significant difference where the mean of the MBL decreased significantly from the 1st 3 months to the end of 2nd 6 months.

According to the success criteria established by **Albrektsson et al**.[16] these results within the accepted ranges of peri-implant VBL, which state that marginal bone level changes in the first year following implant insertion should be less than 1.5 mm and the annually bone loss should be less than 0.2 mm. Also, Lekholm et al.[17] noted that over the first year following loading, there was an average MBL of 1.2 mm from the first thread. Additionally, according to Rasouli Ghahroudi et al.[18] the amount of bone loss after one year of implantation should not be greater than 1.5 mm, with a mean yearly rate of 0.1 mm in the succeeding years.

Although short implants were used in this study, the periimplant MBL through the study period is within the accepted limits. This can be explained by the increased diameter of these short implants.

Several clinical studies[19–21] reported the wide-diameter of implants were found to have better survival rates and less crestal bone loss.

This concluded with **Petri et al**.[21] they noticed that decreasing the implant's diameter can decrease its osseointegration surface and affect the mechanical conditions of the implant body. Also, Degidi et al.[22] they finding the wider implants had more mechanically resistant and more torque forces required for removal of osseointegrated. Furthermore, several studies indicated that implants with a diameter of 4mm or greater had a higher success rate compared to implants with a diameter of 3.75mm or less[20].

This result is concurred with the results of Hartman and Cochran[23] who discovered that it looks impossible to prevent MBL surrounding dental implants, especially after abutment connection; hence, limited MBL following the implant-abutment connection is thought to be a sign of the long-term success of implant restorations.

There are a number of causes for the decreased VBL. The limited disturbance to the periosteum produced by the flapless placement approach protects the periosteal and endosteal blood supply, maintaining the height of the bone surrounding the implants after surgery[24,25].

In group A, the VBL in the 1st 3 months was significantly higher than in the 2nd 3 months, while in group B, the decrease of the VBL in the 2nd 3 months was insignificant.

The radiographic evaluation of periimplant alveolar bone height in the two groups revealed more loss during the 1st 3 months, which could be due to initial loading stresses with the high bone remodeling rate during the stage of osseointegration, and future changes after the implant conjunction with the OD. This is in agreement with the findings of **Habeeb**[26] who suggested that the impaired remodeling during the healing phase can be causative factors for initial bone loss around implants during the first year of function loading.

The stress areas were more evident around the neck of the implants. These might be explained as result of the stress-transferring mechanism that occurs in the implant-bone complex[27]. Stresses induced by occlusal loads are initially transferred from implant to cervical bone, while a small amount of remaining stress is spread to trabecular bone at the apical region. It is also possible that higher strain values are observed in cortical bone as it presents a higher elastic modulus compared with trabecular bone and thus a greater ability to transfer stress[27]. Meijer et al.[28] evaluated the stress distribution in implant-retained OD. They observed that in OD retained by unsplinted implants the stress concentrated at both mesial and distal sides of implants.

In addition to the previous studies, another explanation for the significantly higher bone loss in the 1st 6 months may be the using of short implants for assisting the OD.

Clinical investigations have shown better survival rates for implants with greater length than shorter ones, may be due to MBL affects long-term survival of short implants with less bone contact surface to maintain osseointegration[19,29] .

According to **Hasan et al**.[30] that found the reduced of implant length might complicate the biomechanical effects of loads transferred to the surrounding bone.

When used short implant, the clinical crown height may be greater than the implant length. That mean the C/I ratio will lead to excessive occlusal loading and influence on the MBL[31].

The comparison between the 1st and 2nd 6 months in the two groups showing statistically significant decreased in VBL which may be due to the natural biological process of bone remodeling which occurs after implant placement and immediate bone response to healing and reorganization combined with initial functional loading.

This explanation is concurred with **Akca et al**.[32] who reported that early mechanical environment in bone around implants might impair the initial healing when two unsplinted implants are planned to support mandibular OD. In addition, the dual retention property of attachments which comes from friction between the inner and outer surface together with limited lateral and hinge movement may be responsible for transferring more moment loads to the implant, thus contributing to increased bone loss.

Cochran et al.[33]reported that peri-implant bone remodeling after implant placement is more accentuated in the first 6 months after surgery. These authors found 86% of the bone loss to take place in the first 6 months between the initial implant insertion control and the control at final placement of the prosthesis.

The decreased bone loss in the 2nd 6 months may be due to increased strength of the bone from the beginning of loading after surgical exposure and up to 1 year after loading, the bone become denser because of an increase in mineral content. Partially mineralized bone is weaker than fully mineralized bone. The increased bone loss in the first 6 months may be attributed to an organization of the surrounding bone after implant insertion. Because of the trauma from placement of the implant the surrounding bone becomes necrotic and is replaced by woven bone[34].

There was insignificant MBL after using OT Equator with mandibular IODs **John et al**.[35] concluded that the small diameter attachment plays a role to minimize the stresses to marginal bone. On the other hand, the insignificant difference of the MBL may be due to the low-profile design. This was in line with **Abdelhamid et al**.[36] who illustrated that low-profile design has a role in dissipating occlusal loads through the abutment to the marginal bone around implant. Although both attachment caps shared similar occlusal load, it seemed that the available thickness of the acrylic OD overlying the low-profile design attachments acted as a mechanical absorber for the applied load decreasing the induced stresses on the marginal bone[37].

Although the results of this study showing insignificant difference between the 1st and 2nd 3 months regarding the HBL in each group, the HBL in 1st 6 months was significantly higher than in the 2nd 6 months.

This may be due to the less lateral stress on implants by the low-profile attachments, the attachment features a combination of dual retention, it is also characterized by low profile design, and a resilient connection for the OD without any loss of retention during mastication can explain this finding. In addition, movement is provided in both the vertical plane and the hinge axis through a space of 0.2mm created to allow for vertical resiliency and hinging in any direction can[38]explain this finding.

According to previous study,[39] the abutment height is the main cofactor in MBL. The cantilever action of the low-profile abutment assists the suppression of MBL. This also combined by Vervaeke et al.[40] after monitoring 39 cases. The vertical and rotational resiliency provided by nylon insert for both attachments minimizes the stress transfer to the supporting tissues. However, this was found to conflict with the findings by El-Anwar et al.[41] and Celik and Uludag[42] who noticed greater stress values at using Locator attachments. The double matrix-patrix relationship in the Locator attachment has been mentioned as a reason for such stresses. This could explain the significant decreased in HBL by the result of this study during the 2nd 6 months.

Finally, when comparing between the two groups, the VBL showing statistically significant difference in all intervals except 1st 3 months, where the VBL in group B was statistically significantly higher than group A. The HBL showing statistically significant difference in all intervals except 2nd 3 months and 2nd 6 months, where the HBL in group B was statistically significantly higher than group A.

Thus, one year after OD insertion, the mean of MBL in group B was significantly higher than in group A, this may be due to the big share of stresses carried by the high-density resin cap of Locator attachment.

The locator has high-density resin cap that is originally designed to be incorporated into the denture base to help managing stresses. It acted as if it helped by carrying a big share of stresses to protect the simulated supporting structures; cortical and cancellous bone as well as the implant body from being stressed.[43]

The locator attachment is advantageous biologically and mechanically as it reduced the stress on the implant body and supporting structures under oblique and vertical loading compared to other attachments according to**Sading**.[38]

This result concurred with Damghmani et al.[44] who observed the decreased of stresses on the implants when was utilized locator attachment, the value of stresses on the bone slightly declined.

V. Conclusion

Within the limitations in this study, it can be concluded that the low-profile Locator and OT-Equator attachments can be used for retaining mandibular implant overdentures, regarding the accepted range of periimplant marginal bone height changes. The using of Locator attachment may be more beneficial in preserving the periimplant marginal bone than OT-Equator for retaining the mandibular implant overdenture. This study recommendation to use of Locator attachment for retaining mandibular implant overdenture for preserve the periimplant marginal bone height. Other studies with more patients and longer time of observation with other evaluation methods are recommended.

Fig.1: Female metal houses are positioned over their patrices

Fig.2: Black inserts replaced by mediuminserts

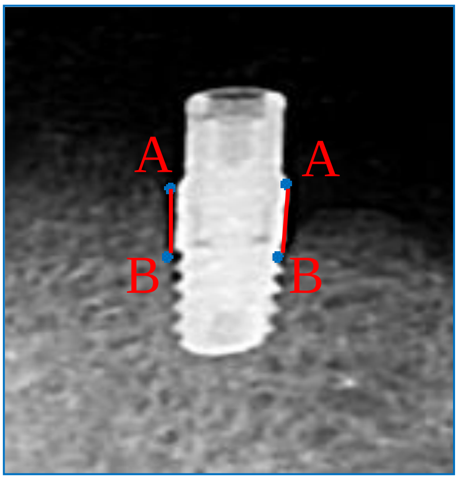

Fig.3: Evaluated Peri-implant vertical bone height changes

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