Effect of Different Bar Designs to Retain Implant Mandibular Overdentures on Alveolar Ridge Resorption

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ABSTRACT

Objective: To evaluate and compare both anterior and posterior area indices of two different bar attachments bar-locator & bar-clip that are used to retain implant mandibular overdentures. Materials and methods: sixteen completely edentulous participants were eligible (mean age is 50 years old). Every participant received new maxillary and mandibular conventional dentures. After 3 months of adaptation, 2- dental implants were inserted in mandibular canine regions. All participants were randomly divided into 2- equal groups; eight patients received bar-locator attachment (group I) and eight patients received bar-clip attachment (group II). Anterior area index (AAI) and posterior area index (PAI) was performed using a panoramic radiograph (AutoCAD® software) at the time of insertion (T0) and after 5 years of insertion (T5). The data were collected and analyzed by independent t-test and paired t-test. Results: For both groups at both times (T0 & T5); there was a significant difference in anterior maxillary bone resorption for group I (p=0.012) while in group II (p≤0.001). Furthermore, Posterior mandibular bone resorption showed a significant difference in both groups (p=0.002) with an increased amount of bone loss in group II than in group I. Conclusion: it was shown that 2-implant mandibular overdentures retained by bar-clip attachment expressed higher values of mandibular posterior and maxillary anterior bone resorption compared to 2-implant mandibular overdentures retained by bar-locator attachment.

KEYWORDS: Implant overdenture, Bar-clip, Bar-locator, Anterior area index, Posterior area index.
INTRODUCTION

Complete edentulism hinders oral function with psychological and aesthetic impairment. These functional changes related to completely edentulous participants are diminished dentures retention in addition to decreased chewing and masticatory efficiency.¹

Mandibular overdenture supported by 2-implants inserted in the inter-foraminal area have been considered a unique treatment for complete edentate patients.² Such overdenture prosthesis is considered an attractive treatment option due to many advantages including simplicity, minimally invasive, economic, and high success rate.³⁻⁷

When designing mandibular 2-implants supported overdentures, 2-implants are inserted mostly in the anterior canine area. The denture base was secured to dental implants by transmucosal abutments that transmits the stress of functional loading to the implants.⁸⁻⁹ In the anterior mandibular region, the ridge-mucosa is spared from functional loading generated by the denture base. The denture base may rotate along the axis of a rotation expressed by the implants and exert pressure against the edentulous mandibular posterior area.¹⁰⁻¹²

Bone loss can increase because of exaggerated functional masticatory forces generated from the overdenture base. The higher force, the greater bone loss occurred. Complete edentate participants may generate approximately 25% of the occlusal forces when compared to complete dentate individuals.¹¹ On the other hand, participants wearing 2-implants supported overdentures generate significantly higher occlusal forces than others wearing complete dentures.¹²

There are numerous advantages of bar attachment such as splinting, distribution of stresses between dental implants, horizontal stability in cases of an atrophied ridge, a perfect choice when implants are angulated, and according to its specific cross-sectional shape, it provides different degrees of rotational movement in addition to tissues-ward vertical movement.¹³⁻¹⁶

Bar attachments can be divided into 2-basic groups as follows: bar joint and bar unit.¹⁷ During mastication, the bar joint permits some degree of movement that occurred around the bar. Both vertical and rotational movements can be obtained
by spaced oval or round bars. Firstly, the Dolder bar joint is an egg-shaped bar, that has a spacer inserted between the bar and its sleeve, this will permit the sleeve to have vertical in addition to rotational movement around the bar, so, it is considered a resilient attachment. On the other hand, during rest position, the denture rests on the alveolar ridges and it is considered completely tissue-support, the sleeve is about 1 mm above the bar crest, on the other hand, during function Dolder bar joint permits vertical translation, frontal, and sagittal rotation. 18,19

Secondly, the Hader bar has a round superior aspect and an apron toward the tissue below. Its height is only 3 mm. It consists of a keyhole-shaped male bar resin pattern, a Teflon fabricating rider, and a female nylon rider clip.20

For restoring completely edentate participants, the bar-locator attachment is considered the best choice. Bar-overdentures give the advantage of implant splinting within the arch for removable appliances and, the incorporation of locator attachments to the bar offers more stability and retention compared to isolated attachments.21

The bar-locator attachment has many advantages compared to other attachment systems. Locator attachments offer dual retention by external and internal mating surfaces, a self-aligning property that is necessary for patients' guidance when placing their dentures and can be combined with guide planes on a milled bar for a common path of insertion.22

The extent of load transmission to the posterior residual alveolar ridge is depending on how the connecting bar allows vertical as well as rotational movements of the denture.23,24 Bar-supported overdenture on 2-implants has been related to worse posterior residual ridge resorption when compared with implant-supported fixed prostheses and showed annual posterior residual ridge resorption 2 to 3 times that of conventional complete denture wearers.25 Controversially, Kordatzis et al.26 reported that there was a lower resorption rate of the posterior mandible in patients having overdentures supported by 2-implants compared with conventional denture wearers for 5 years.

Combination syndrome (anterior hyperfunction syndrome) development noted in participants with completely edentulous maxillary arch opposing to short dental arch in combination with a mandibular prosthetic device, increases in participants
wearing mandibular implant-retained overdentures. The five symptoms that are commonly related to anterior hyperfunction syndrome are anterior maxillary ridge resorption, tuberosities enlargement (fibrous or bony), palatal papillary hyperplasia, mandibular anterior teeth extrusion, and decreased mandibular bone under distal extension areas related to a removable partial denture.\textsuperscript{27,28}

Saunders et al.\textsuperscript{29} demonstrated that anterior hyperfunction syndrome starts with mandibular posterior residual ridge resorption (RRR). This resorption results in gradual loss of posterior occlusal load and increases the anterior occlusal load. Increasing the load anteriorly led to maxillary anterior residual ridge resorption. similar oral changes may be found in participants treated with implant-retained mandibular overdenture. Kordatzis et al.\textsuperscript{26} demonstrated that less resorption was noted with overdenture than with conventional dentures. furthermore, Wright et al.\textsuperscript{30} found lower mandibular posterior RRR rates in participants treated with implant-retained overdenture and bone apposition in the same area for participants with fixed cantilever implant restoration.

Närhi et al.\textsuperscript{31} reported that the maxillary residual ridge width was decreased and not related to mandibular denture type, being an implant overdenture that retained by 5-bars, an implant-mucosa-supported overdenture on a single bar retained by 2-implants or conventional complete denture. on the other side, more maxillary RRR by year in participants having conventional complete dentures compared to participants treated with implant-retained mandibular overdenture.\textsuperscript{31,32} There was higher vertical anterior maxilla bone loss in mandibular implant-retained overdenture participants.\textsuperscript{27,34} Finally, in a systematic review, there was no exact evidence that maxillary RRR was accelerated with the mandibular implant-retained overdenture on 2-dental implants.\textsuperscript{35} Wright and Watson\textsuperscript{24} compare the posterior RRR in mandibular overdenture participants supported by parallel-sided and ovoid Dolder bars. They concluded that; the posterior RRR was insignificantly influenced using prefabricated bar design after 8 years after denture delivery.

Therefore, this current study aimed to assess and evaluate the effect of mandibular implant-retained overdenture with different bar designs (bar-locator versus bar-clip) on RRR for both anterior maxillary and posterior mandibular areas for 5 years. The null hypothesis was that there will be no difference in bone changes between mandibular overdentures with different bar attachments.
MATERIALS AND METHODS

PATIENT SELECTION AND STUDY DESIGN

Sixteen complete edentate participants aged range from 40 to 60 years (mean 50 years) were selected from the outpatient clinic of the department of removable prosthodontics, Faculty of Dentistry, Mansoura University. An 80% power was used to calculate the patient sample according to the results of a previous study. The power analysis was performed using the G*Power program (version 3.1.5, Kiel, Germany). The present study has been approved by the Ethical Committee (No: M21011122), Faculty of Dentistry, Mansoura University. All the selected participants have been notified in detail about all treatment plans and procedures, in addition to the required follow-up recalls, then, they all signed written consents.

All participants had sufficient maxillary and mandibular residual alveolar ridge verified by cone beam computed tomography (CBCT), covered with healthy firm mucosa. No previous denture experience, class I maxilla-mandibular relationship, and sufficient inter-arch space.

Participants with parafunctional habits, smoking, alcoholism, uncontrolled diabetes, radiation therapy in the head and neck region, and TMJ disorders were excluded from the current clinical study.

Pre-surgical procedure:

For each participant, a conventional complete denture was constructed and delivered. After one month of denture use, the mandibular complete denture was duplicated in clear acrylic resin, gutta-percha markers were inserted in the mandibular duplicate denture at different buccal and lingual areas, then the patient was subjected to CBCT scan (VGI, QR, Verona, Italy) while wearing clear denture with radio-opaque markers and biting in centric occlusion, then a second scan was performed to denture alone.

On the software (OnDemand3D software, Cybermed, Seoul, Korea) mucosal supported stereolithographic surgical template was performed. This template was necessary for the exact implant location and angulation, Figure 1.
**Surgical procedure:**

After injection of local anesthesia, 2-implants (Laserlok tapered internal self-tapping) (13 mm length and 3.7 mm width) were surgically inserted in mandibular canine areas using 2-stage surgical protocols.

Participants were asked to bite on a surgical guide using a maxillary denture and fixation pins were placed in their positions, drilling bone with the first drill was done then the guide was removed to assure drilling sites then placed again and successive drilling was done according to instructions supplied with a surgical guide, surgical guide removed and implants were fastened with torque 45 nm.\(^{37}\), covered with a cover screw then panoramic radiograph was performed to evaluate implant positions post-surgically.

Corresponding to the implant, the mandibular denture has been relieved and relined by applying a tissue conditioning material (Viscogel, Dentsply).

**Prosthetic procedures:**

After the osseo integration periods (3 months in the mandible), exposure of the dental implants was done, and screwing of healing abutments in its place for 2 weeks was performed until the formation of the gingival collar occurred.

For all participants, a functional impression (open tray) was made using 2-long transfer copings, and 2-analogs were attached to the transfer coping before impression pouring. A mandibular master cast was obtained.

In the current clinical study, random classification of the participants was done into 2-equal groups as follows: Group I: Eight patients received mandibular overdentures with BL attachment. A custom-made milled bar was constructed, and its walls are parallel. In the waxed bar, the threaded site was drilled (1.7 mm bar-drill), then, on the milling machine, a bar tap (2 mm) was mounted, and 2 holes were performed in the bar top surface. Finally, a special rider was used to attach the locator female part, Figure 2. Group II: Eight patients received mandibular overdentures with BC attachment. A plastic ready-made bar was cast in cobalt chrome alloy.
Both BL and BC (I&II) were tried intra-orally and new mandibular overdentures were constructed. For BL group, locator male portions were picked-up, a metal ring was performed, then a medium retention male portion was used, and two yellow plastic clips were used for BC group, Figure 3.

Both BL and BC, anterior maxillary, and posterior mandibular ridge resorption were evaluated at the time of overdenture delivery (T0) and 5 years after overdenture delivery (T5).

**Assessment of maxillary anterior area index (AAI):**

Maxillary anterior bone loss was evaluated using a previous technique that depend on proportional area measurements.\(^{38}\) Scanning x-rays were done. The sizes of the anatomical and reference regions were determined by outlining reference points and lines with a cursor.

The following reference points were used for the investigation. The anterior nasal spine S and the 2-lower most bony margins of the orbit O right and O left form the ‘central triangle’. The line O joins O right and O left. The intersection between O and P, a line perpendicular to O through S, is point P. Point R divides the distance (PO) into two-thirds and one-third. This value was determined experimentally to divide the maxilla in the anterior and posterior regions. R is a line perpendicular to O through R. U is a line parallel to O through S. U and R meet at the point U. P’ was marked by measuring the distance (UR) starting from S. R’ was marked by measuring the distance (UR) starting from U. The line I connects R’right, and R’left. I is the intersection of the alveolar crest with P, and 2 is the intersection of the alveolar crest with R. In the anterior area, the experimental area is outlined by the area S12U and the reference area by the area SP’R’U.

On the right & left sides, anatomical and reference areas were averaged, and a ratio (R) for the anterior maxillary bone area was calculated by dividing the anatomical bone area by the reference area.

The change in anterior maxillary RRR was calculated by subtracting the ratio at the baseline from the ratio at the time of overdenture insertion and 5 years after insertion, and it was indicated as AMaxRR Figure 4a.
Evaluation of mandibular posterior area index (PAI):

The method of evaluating mandibular posterior bone resorption consisted of proportional area measurements following Wright et al.\textsuperscript{30} Using proportions minimizes magnification faults.

For every radiograph, a tracing was made on the mandible. The anatomical landmarks M (lower border of mental foramen), S (sigmoid notch), and G (gonion) were used to construct the triangles on the right (M-S-G) and left (M’-S’-G’) side of the mandible with center N.

Boundaries were constructed by the following lines: the line M-G; the line A-L; a line from the crest of the residual ridge (point A) to the lower border (point L) through M, perpendicular to M-G, the boundary line M-N and boundary line G-P; and the line G-N extended to the crest of the residual ridge through point P. The experimental bone area was eventually outlined by the area PAMG and the reference area by the triangle MGN.

A ratio was calculated by dividing the bone area by the reference area. The ratios for the right and left parts in one patient were averaged. The change in posterior mandibular residual ridge resorption was calculated by subtracting the ratio at the time of insertion from the ratio at 5 years, and it was indicated as PMandRR Figure 4b.

For all participants, panoramic radiographs were performed immediately after mandibular overdenture insertion (T0) and 5 years after mandibular overdenture insertion (T5).

Statistical analysis:

The collected data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 26). Firstly, the normality of data was tested with a one-sample Kolmogorov-Smirnov test. Continuous variables were presented as mean±SD (standard deviation) for normally distributed data. The two groups were compared with an independent t-test while paired groups were compared by paired t-test. The threshold of
significance is fixed at a 5% level. The results were considered significant when \( p \leq 0.05 \).

RESULT

Radiographic evaluation was performed between two current study groups for both evaluation periods as follows: T0: immediately after mandibular overdenture insertion. T5: 5-year after mandibular overdenture insertion.

For anterior maxillary bone resorption; when comparing both studied groups at both evaluation periods (T0&T5); there was a significant difference between studied groups with a level of significance as for group I (p=0.012) and (p<0.001) for group II with increased anterior maxillary bone loss in group II than in group I (Table 1& Figure 5).

For posterior mandibular bone resorption; when comparing both studied groups at both measurement times (T0&T5); there was a significant difference between studied groups with a level of significance as for group I (p=0.002) for group I and (p=0.002) for group II with an increased amount of bone loss in the posterior mandibular area in group II than in group I (Table 2& Figure 6).

Table (1): show radiographic comparison of anterior area index between group I and group II at different evaluation times after overdentures insertion (T0&T5).

<table>
<thead>
<tr>
<th>Group</th>
<th>T0</th>
<th>T5</th>
<th>Paired t test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>0.548</td>
<td>0.500</td>
<td>4.33</td>
<td>0.012*</td>
</tr>
<tr>
<td></td>
<td>0.499</td>
<td>0.056</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td>0.552</td>
<td>0.038</td>
<td>17.45</td>
<td>≤0.001*</td>
</tr>
<tr>
<td></td>
<td>0.401</td>
<td>0.022</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X: mean, SD: standard deviation, *Indicates significant difference at 5% level.
Table (2): show radiographic comparison of posterior area index between group I and group II at different measurement times after overdentures insertion (T0&T5).

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Paired t test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T0</td>
<td>1.725</td>
<td>0.036</td>
<td>1.684</td>
<td>1.775</td>
<td>6.81</td>
<td>0.002*</td>
</tr>
<tr>
<td>T5</td>
<td>1.693</td>
<td>0.028</td>
<td>1.665</td>
<td>1.733</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group II</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T0</td>
<td>1.748</td>
<td>0.031</td>
<td>1.716</td>
<td>1.784</td>
<td></td>
<td>7.65</td>
</tr>
<tr>
<td>T5</td>
<td>1.625</td>
<td>0.018</td>
<td>1.603</td>
<td>1.648</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X: mean, SD: standard deviation, *Indicates significant difference at 5% level.

**DISCUSSION**

In implant-supported overdentures, the implant is considered a retainer and prosthetic holder. They present a rigid anchorage system between the implant and the overdenture, and it’s not necessary to be held on soft tissues. The removable overdenture is firmly and rigidly adjusted to the implants, decreasing its lateral in addition to rotary movements. Different forces and stresses released along dental implants evenly distribute by a rigid anchorage system. For example, of rigid anchorage system is an implant-supported milled bar overdenture, limiting its lateral and rotational movements and distributing stresses on the dental implants. Milled bar overdenture movement is affected only by the path of removal that is favorable for preventing prosthetic maintenance and bone resorption.39-41

On the other side, implant-tissue retained overdentures, are simple and necessary for participants with prosthetic instability, the only function of the implant in this prosthetic type is prosthesis retention. It is a resilient anchorage system that allows vertical and rotary movement of the overdenture. A Dolder bar or any other kind of round bar supported by 2-implants allows both rotary and vertical movements so when utilizing this kind of attachment; we increase the prosthesis tissue support during function. Also, it offers percent load relief to the supporting implants as in this prosthetic design, the alveolar ridge acts as the
primary holding area. Continuous occlusal forces would generate progressive resorption of the alveolar bone, excluding the areas where dental implants are placed.\textsuperscript{42-44}

Measurements on panoramic radiographs are subject to enlargement and distortion complications, and reliable data can be obtained from comparisons of ratios instead of absolute values.\textsuperscript{45,46} The applied methods can compensate for positioning any errors in an OPT machine within a defined scale. Potential variability in head position and only minimal annual bone loss might even result in a putative bone gain in a single individual. This problem should be overcome, when investigating a large number of participant groups with great panoramic radiographs numbers, with clear trends observable, as in the current study.

Earlier studies on maxillary anterior bone resorption under conventional complete dentures used cephalometric radiographs. This technique has many advantages as, both magnification factors (vertical & horizontal) are known, and the images of both jaws (maxilla & mandible) are reproduced. However, the superimposition of the alveolar ridges occurred, and this makes it impossible to distinguish the differences in resorption between the two sides. Furthermore, lateral cephalometric radiographs are not usually obtained for adults. On the other side, in clinical cases, OPTs are widely used. Therefore, the residual ridge resorption investigation in large numbers of participants is feasible.\textsuperscript{47}

The phenomenon occurred in participants wearing conventional maxillary complete dentures against mandibular removable partial dentures only rested on anterior teeth described as combination syndrome (anterior hyperfunction syndrome). This phenomenon is pronounced due to anterior maxillary alveolar atrophy.\textsuperscript{47} The rigid anchorage of the implant-supported bar had a similar effect. Tilting of the mandibular overdenture on the ovoid bar may result in a loss of occlusal contacts on the premolars and molars and increased bite forces in the mandibular anterior region. This promotes and accelerates the resorption of the edentulous antagonistic alveolar bone. Mandibular overdentures retained by movable joints can accelerate posterior mandibular bone resorption on a larger scale than by complete dentures.\textsuperscript{30}
Implants-supporting mandibular overdentures allow the same bio-mechanical situation of natural anterior teeth complicated with anterior hyperfunction syndrome. Therefore, when a complete denture is opposed by mandibular anterior teeth, maxillary bone resorption occurred. This could be compared with bone resorption caused by conventional dentures opposing implants-supported either fixed or removable prostheses. Many research demonstrated significant maxillary anterior bone resorption compared with implant-assisted mandibular overdentures.

Increasing maxillary anterior bone resorption could be related to excessive tilting and settling of the mandibular free-end saddle removable partial denture when subjected to masticatory functional forces, these results are due to transmit forces to the mandibular residual ridge by the posterior aspect of the tissue-supported removable partial denture. The forces transmit undesirable loading to the maxillary anterior area that accelerates bone resorption.

From another point of view, these results could be related to transmitting the excessive occlusal forces to the maxillary anterior areas with maxillary RRR in addition to inflammation of the mucosa. Furthermore, the increased bone resorption in the anterior maxillary area could be related to a decreased initial bone width, evaluated by pre-operative CBCT radiographs. This is in agreement with Khuder et al. who investigated the maxillary residual ridge resorption both anteriorly and posteriorly, in participants wearing mandibular implant overdentures and complete dentures. They found there was higher relation between ridge resorption and occlusal load in the maxillary anterior area. Furthermore, the posterior ridge resorption was diminished, and this may be associated with favorable load distribution and decreased higher occlusal load on the posterior ridge by the mandibular anterior teeth or dental implants.

Overall, the null hypothesis was rejected in the current study.

**CONCLUSIONS:**

Within the limitations of this study, it was shown that 2-implant mandibular overdentures retained by bar-clip attachment expressed higher values of posterior mandibular RRR and anterior maxillary RRR compared to 2-implant mandibular overdentures retained by bar-locator attachment.
CONFLICT OF INTEREST

Authors have no conflicts of interest in connection with this article.

FUNDING

None

REFERENCES


**Figure Legends**

Fig (1): pre-operative CBCT scan for implant placement planning.

Fig (2): a: intra-oral bar-locator attachment. b: pick up of locator attachment to mandibular overdenture.
Fig (3): a: intra-oral casted metal bar attachment. b: plastic clips inserted over casted metal bar. c: pick up of plastic clip attachment to mandibular overdenture.

Fig (4): a: radiographic reference points and lines to evaluate maxillary anterior bone resorption. b: radiographic mandibular tracing for evaluation of mandibular posterior bone resorption.
Figure (5): Comparison of anterior area index for both studied groups (I&II) at different measurement times (T0 &T5).

Figure (6): Comparison of posterior area index for both studied groups.