ORIGINAL RESEARCH

Radiographic Assessment of Three-implant-retained Mandibular Overdentures: A Clinical Study of Alveolar Bone Height Changes (Randomized Clinical Trial)

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Abstract

Aim: To evaluate the residual alveolar ridge bone height changes regarding the impact of the block-out spacer used during the pick-up procedures of implant-assisted mandibular complete overdentures.

Materials and methods: This study was a randomized clinical trial conducted on 18 patients. All patients received three mandibular dental implants with definitive locator attachments which were directly picked up with two different techniques. Patients were classified randomly without any bias into two equal groups (Group I block-out spacer) and (Group II without block-out spacer). Over a year, the digital radiographic technique with new technique of reference points was employed to evaluate the changes in the residual alveolar ridge bone heights. The data were statistically analyzed to test the significance difference between groups.

Results: Concerning the residual alveolar ridge resorption RRR, group I exhibited a significantly higher RRR than group II.

Conclusion: In terms of residual alveolar ridge preservation, not using the block-out spacer was more beneficial than using it.

Clinical significance: Alveolar bone heights can be affected by the use of block-out spacer during pick-up procedure within accepted physiologic values. The removal of the block-out spacer could be more beneficial with respect to the preservation of the residual alveolar ridge.

Keywords: Block-out spacer, Digital radiograph, Locator attachment, Pick-up.

The Journal of Contemporary Dental Practice (2023): 10.5005/jp-journals-10024-3588

Introduction

When teeth are lost, many patients have difficulties tolerating their conventional complete dentures, particularly the lower one. This is due to the mobile floor of the mouth, the atrophic oral mucosa that covers the mandibular residual alveolar ridge, reduced alveolar bone support, and muscular factors.[1] Implant-assisted mandibular complete overdentures are an efficacious treatment option for edentulous mandible rehabilitation.[2]

The number and distribution of dental implants used to support overdentures are debatable. Adding a midline dental implant to the mandibular two-implant overdenture has been regarded as a valuable treatment option as it enhances the retention, support, stability and reduces the rotational movement of the prostheses without causing strain on the denture-bearing mucosa, abutment, or implant. With the three-implant overdenture design, the presence of the posterior implants could reduce excessive stresses and reduce posterior residual ridge resorption. It also reduces the cost to the patients compared to fixed options.[3]

Attachments used for implant-retained overdentures have numerous advantages, including increased retention, improved stability, and support, as well as playing an essential role in achieving patient comfort, function, besides, psychological acceptance.[4] In general, the attachment systems are classified as splinted or solitary, like locator attachment.[5] Locator attachments with varied retention insert values preserve crestal bone superior to ball and socket stud attachments.[6]

The low-profile configuration of locator attachment has the advantage of reducing the load transfer to the dental implant. Also, the use of a block-out spacer ring to pick-up a locator attachment allows the vertical movements of the overdenture according to the resilient property of nylon inserts. On the other hand, direct pick-up of metal housing over its corresponding locator attachment abutment limits these vertical movements according to the resilient property of nylon inserts.[7]

Regarding the patients who are completely edentulous, residual alveolar ridge resorption may progress without apparent clinical symptoms until the patient's complete dentures become loose, thus shortening the life of the prosthesis. Panoramic radiograph is a routine dental imaging method that offers a valuable screening opportunity with low radiation dose than others like cone beam computed tomography. Panoramic view X-ray was the best-chosen method in the assessment of loss of bone. But it is subjected to varying degrees of magnification in addition to distortion. Notwithstanding, these obstacles were reduced once we recognized the amount of magnification of the panoramic view, taking X-ray with the same technician and twice panoramic

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How to cite this article: Mohammed REL, Askar OM, El-Waseef FAE, *et al*. Radiographic Assessment of Three-implant-retained Mandibular Overdentures: A Clinical Study of Alveolar Bone Height Changes (Randomized Clinical Trial). J Contemp Dent Pract 2023;24(11):847–852.

Source of support: Nil

Conflict of interest: None

view taking to confirm its validity.[8] Additionally, its standardized projection in the vertical plane is also one of its advantages, making it well suited for vertical measurements.[9]

Throughout reviewing the current relevant literatures, numerous studies concerning three-implant-assisted overdentures were available. Nonetheless, little is known spotlighting the impact of using a block-out spacer or not during the picking up of the attachments used to retain the three-implant-assisted mandibular overdentures. Thence, the current investigation was conducted to clinically evaluate the changes in residual alveolar ridge bone when using or removing a block-out spacer during the picking up of the locator attachments retaining the three-implant-assisted mandibular complete overdentures.

The null hypothesis proclaimed that no difference would be revealed in residual alveolar ridge bone throughout the evaluation intervals in the presence and absence of the block-out spacer while picking up the locator attachments used to retain the three-implant-assisted mandibular complete overdentures.

Materials and Methods

Study Design

This study was randomized clinical trial conducted on 18 patients.

Sample Size Calculation

Based on an earlier study conducted by Elmowafy et al.[10] that compared the mean retention force and peri-implant tissue health between two and three-implant groups after 6 months of insertion. An effect size of 2 was gained considering deviations of (10.97 ± 2.32) in two implants group and (16.65 ± 3.26) in the three-implants group. Using this effect size with a given type I error = 0.05 and a power 80%, a sample size of 9 per group was calculated with a software program (G*power 3.1.9.6).[11]

Ethics

This study was conducted after obtaining the approval of the Ethics Committee, Faculty of Dentistry, Mansoura University, and registered with number M11071020. The study included a radiographic assessment of three-implant-retained mandibular overdentures. The study's proposal, treatment plan, and necessity for periodic and frequent recalls were clarified to the patients. Their agreement to be participants in this study was officially ensured by signing the consent forms.

Study Model

The protocol followed the recommendations of the consort statement. The study was registered at ClinicalTrials.gov by registration ID: NCT05843825.

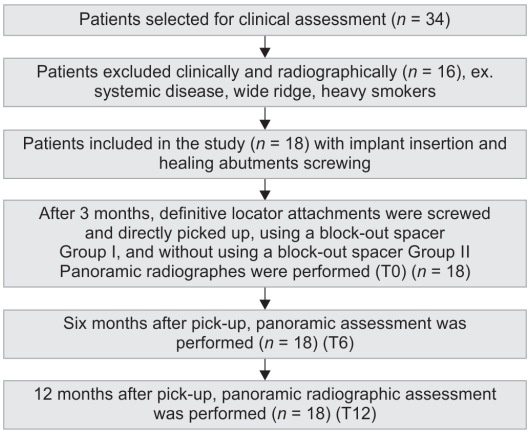
Patient Selection

Eighteen completely edentulous male subjects were chosen from the Outpatient Clinic, Faculty of Dentistry, Mansoura University; their ages ranged from 50 to 60 years old. All the patients were completely edentulous and complained about the loss of retention of their mandibular complete dentures. They were looking for implant placement along with a prosthesis that was more retentive. Medical histories were obtained from all individuals.

Inclusion Criteria

Patients were completely edentulous with sufficient restorative space vertically not less than (8.5 mm) and horizontally not less than (9 mm) which were verified by a tentative jaw relation record and mounting on the articulator, to accommodate implant placement which was determined by CBCT, additionally, they were having class I maxillomandibular relation. All patients had healthy and firmly attached residual alveolar ridge mucosa.

Flowchart 1: Flowchart



Exclusion Criteria

Uncontrolled diabetic patients, history of head and neck radiotherapy, autoimmune disease, patients with cancer, patients with parafunctional habits, heavy smokers, and those had localized bone defects were excluded from the study.

Randomization

Eighteen completely edentulous male patients were divided randomly into two groups (9 patients for each group). Group I (9 patients); the locator attachments were picked up using a block-out spacer. Group II (9 patients); the locator attachments were picked up without using a block-out spacer as explained in the flowchart (Flowchart 1). The study was conducted by evaluation of inter-group variation.

Clinical Procedures

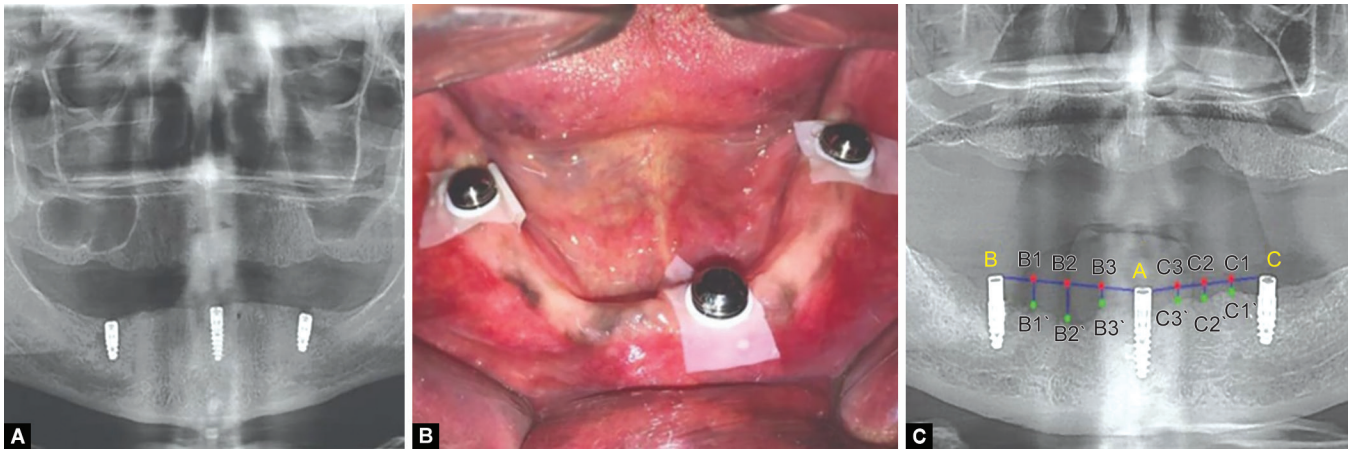
Construction of Conventional Complete Denture

Preliminary maxillary and mandibular alginate impressions, study casts over which customized trays were fabricated using autopolymerized acrylic resin, final zinc oxide impressions, jaw relation records and try-in of complete trial dentures were done for all patients. All participants were delivered maxillary and mandibular conventional complete dentures with lingualized occlusal schemes.

Construction of Radiographic Stent

Mandibular complete denture was duplicated using a modified flask method and silicone impression material to produce an autopolymerized clear acrylic resin mandibular denture.[12] The duplicate denture was modified by drilling 1 mm deep pits in the lingual, labial, and buccal surfaces of the intaglio surface and filling them with radio-opaque gutta percha markers to act as reference points during CBCT imaging. This was carried out to be used during the radiographic assessment of residual alveolar bone quantity and quality.

A dual scan technique was followed with an I-CAT dental machine to the radiographic stent. One of them was performed inside the patient's mouth during wearing it, while the other scan was performed outside the patient's mouth to have a 3D model.



Figs 1A to C: (A) Postoperative panoramic radiographs; (B) Block-out spacer pick-up technique; (C) Measurements of bone height changes

Superimposition of the two scans was done guided by radio-opaque markers using the computer software to relate the digitized model over the bone for the prospective implant locations and angulations planning. The width, height, and density of residual alveolar bone were measured. If the mentioned measures were accepted, the virtual positions of the three dental implants were planned using the software considering the implants to be at least 2 mm away from the inferior alveolar nerves posteriorly and inter-foraminal sublingual artery that enters the mandibular midline lingual foramen anteriorly.

Fabrication of Stereolithographic Surgical Guide Template

Rapid prototyping machine was used for the construction of the stereolithographic stent according to the planning STL file with the horizontal location for fixation pins. After finishing and polishing, the stereolithographic guide template and surgical kit were supplied.

Surgical Technique

The placement of implants was planned based on the CBCT imaging results; one anterior midline straight implant (3.7 × 12 mm; Tio Logic Dentaurum, Co.) and two posterior straight implants at 1st molar areas (4.2 × 9 mm). Antibiotic prophylaxis (2 gm/day of clavulanic acid with amoxicillin) was started 1 hour before surgery and continued for 5–7 days after surgery. The surgical guide was kept in place under local anesthesia (Mepecaline L, Alexandria-co) and instructing the patient to occlude on it with keeping the maxillary denture in place. The anchor pins were inserted into the bone subsequent to bone drilling in order to stabilize the surgical guide.

Tissue punch with the same diameter as the implant was used to cut the soft tissue to the crest of the ridge with continuous copious irrigation. Removal of the soft tissue cut to expose the alveolar ridge was performed. Through the metal sleeves and drill keys, initial drilling was done to locate the direction and depth of implant osteotomy sites, then successive numbers of drills (supplied with dental implants surgical kit) were used until reaching the predetermined depth and width by the final drill. Thoroughly rinsing the newly created alveolus with a sterile cooled saline solution was done. Finally, three endosseous dental implants of selected sizes were placed into their positions by holding them with the placement tool and manually inserted in the prepared implant site using a hand ratchet till they became slightly beneath the crest of the ridge.

Post surgical

Postoperative panoramic radiographs were taken for confirming the position and orientation of the dental implants (Fig. 1A). The healing abutments were secured into place using the delayed loading protocol, and the denture's intaglio surface was relieved to avoid contact with the healing abutments. Three months later, the healing abutments were removed, and the definitive locator attachments were screwed into their implants. The locator attachments were directly picked up intraorally utilizing autopolymerizing acrylic resin, according to Taddei et al.[1] The eligible participants as mentioned were randomly divided into two equal groups as follows: Group I (Block-out spacer group/9 patients) ; the locator attachments were picked up using block-out spacer, and Group II (Without block-out spacer/9 patients); the locator attachments were picked up without using block-out spacer.

During pick-up procedures, a clean sheet of rubber dam was pinched corresponding to the implant site and applied intraorally to prevent the escapement of resin to the undercut areas around the locator attachments. In Group I, the block-out spacer was applied over the rubber dam sheet but no block-out spacer was used for Group II. Then the metal housing (with a pink plastic insert of 3 lbs retention force) was placed over its abutment part (Fig. 1B). Autopolymerizing acrylic resin was applied in the cavities of the denture related to each locator and the denture was completely seated while the patient was biting in centric occlusion. All patients were recalled monthly for inspection.

Patient's Evaluation

Evaluation of residual alveolar ridge bone height changes: Over a year after picking up of the locator attachments, radiographic evaluations were carried out immediately (T0), 6 months (T6), and 12 months (T12). A digital panoramic radiograph was used to assess the changes in mandibular bone height following implant placement. The same technician took all of the images according to the standardized protocol for patient positioning as well as exposure parameter setting. Some images were taken twice to confirm their validity.

Evaluation Technique

The measurements were made digitally according to the magnification ratio on an analyses program. Midline implant named A, right dental implant named B and left one is C. The new technique of taking the implants locators as fixed landmarks during bone

Table 1: Comparison of RRR between groups at different observation times

RRR	*Group with spacer (n = 9)*	*Group without spacer (n = 9)*	*Independent t-test*	*p-value*
(T0–T6)	0.14 ± 0.008	0.08 ± 0.009	*T* = 11.61	≤0.001*
(T6–T12)	0.12 ± 0.009	0.06 ± 0.00	*T* = 16.43	≤0.001*
(T0–T12)	0.26 ± 0.015	0.14 ± 0.008	*T* = 16.43	≤0.001*

p-value is significant at 5% level

height measuring which is more simple than the posterior area index technique. The locator's abutments were used to construct aiding lines. Two lines were drawn; the first line from the most superior right side of locator implant A (fixed point) to the most superior medial side of locator implant B (fixed point). The second line is from the most superior left side of locator implant A (fixed point) to the most superior medial side of locator implant C (fixed point).

Both lines were divided into four segments with three points on each side of the mandible. B1, B2, and B3 points on the right side and C1, C2, and C3 on the left side. Then, perpendicular lines were drawn from both lines (connecting locators) at the predetermined points (B1, B2, B3, C1, C2, C3) to the crest of the residual alveolar ridge points (B1`, B2`, B3`, C1`, C2`, C3`).

At T0, the length of the lines (B1-B1` and B2-B2` and B3-B3`) and (C1-C1` and C2-C2` and C3-C3`) were measured. Also, at T6, the predetermined lengths were measured. Finally, at T12, the previous lengths were measured.[13] To calculate the residual alveolar ridge bone height changes in the first 6 months; the lengths at T0 were subtracted from the same lengths at T6. In the second 6 months; the lengths at T6 were subtracted from the same lengths at T12 (Fig. 1C).

Statistical Analysis

For inter-group data analysis, SPSS (the statistical package for social science version 22, SPSS Inc., Chicago, IL, USA) was utilized. To test the normality of the values of bone loss, Shapiro–Wilk test was employed. The data were parametric and normally distributed. Descriptive statistics were presented in terms of mean, median, standard deviation, range, minimum and maximum. Repeated measures ANOVA was used to test the significant difference in bone loss between time intervals followed by Tukey *post hoc* test for multiple comparisons between each 2-time intervals. To compare bone loss between groups, the independent samples *t*-test was used. *p* is significant if <0.05 at a confidence interval 95%.

Results

Comparison of RRR between the two groups (inter-group variation). Comparison of RRR between the two studied groups at different observation times is given in Table 1.

There was a significant difference in RRR among groups in the first 6 months following overdenture insertion (independent samples *t*-test, $p < 0.001$). Group I exhibited significant higher RRR than Group II.

Additionally, respecting the second 6 months after overdenture insertion, a significant difference in RRR between groups was found (independent samples *t*-test, $p < 0.001$). Group I displayed a significantly higher RRR than group II.

Moreover, a significant difference in RRR among groups was observed pertaining to the total bone loss from the time of insertion to 12 months after insertion (independent samples *t*-test, $p < 0.001$).

Discussion

It is generally assumed that loading the residual alveolar ridge above a certain level may lead to its atrophy. So, residual alveolar ridge resorption is a common clinical symptom of completely edentulous patients. Nevertheless, to avoid residual alveolar ridge bone resorption, it is essential to get an adequate denture-bearing surface, a proper fit and occlusion of the implant-assisted mandibular complete overdenture. Implant-assisted overdenture is one of the valuable treatment options. So, the aim of this study was to evaluate the residual alveolar ridge bone height changes regarding the impact of block-out spacer used during the pick-up procedures of 3-implant-assisted mandibular complete overdentures.

Several measuring methods of panoramic radiographs have been used to assist residual alveolar ridge bone resorption. One of them considered the lower edge of the mental foramen a useful reference mark in panoramic radiographs for estimating the amount of mandibular alveolar bone lost. The authors rationalized that the bone below the foramen constitutes a predictable proportion of the total bone height in most normal patients and is not significantly affected by resorption until extreme atrophy occurs.[14]

Another useful method for measuring mandibular residual alveolar bone resorption was drawing a line tangential to the most inferior points at the mandibular angle and the lower border of the mandible. The measurements were done from the tangent to the fixed points determined on the crest of the residual alveolar ridge. Each radiograph was viewed digitally, and one investigator was responsible for the selection of the panoramic radiographs and performing the measurements. The measurements were made digitally according to magnification ratio on an analyses program.[15]

According to the present study, lines were drawn between implant locators to act like the previously mentioned tangent, and the measurements were done from the lines to the fixed points determined on the crest of the residual alveolar ridge. In this study, the locator attachments are considered as fixed points in the X-ray.

From the findings of the present study concerning both the first and second 6 months after overdenture pick-up, group I reported a higher RRR than group II. Also, there was a significant difference in RRR between groups in total bone loss from pick-up to 12 months following pick-up. It was reported that RRR for implant-assisted mandibular complete overdenture could be affected by using block-out spacer during the step of pick-up.[7]

With respect to the results of the present study, the use of a block-out spacer during the pick-up procedure allows vertical movement of the overdenture according to the resilient properties of nylon inserts. This vertical movement allows sharing of the loads between the dental implants and the residual alveolar ridge, as shown in Group I.

In Group II, overdenture pick-up without using of block-out spacer limits and decreases the vertical movement of the overdenture as a consequence to the resilient properties of nylon inserts. So, sharing of the loads between the dental implants and the residual alveolar ridge is limited. The main load is directed toward the dental implants and less load is directed toward the residual alveolar ridge. So, Group I demonstrated a significantly instead of significant higher RRR than Group II.

These observations might be coping with previous research.[7] The authors proclaimed that the presence of an axial gap that can be obtained by setting a spacer disc between male and female parts during overdenture polymerization allowed for vertical movements of the overdenture. This gap caused an increase in the mastication

load transiting through the denture-bearing surface and caused a wider contact area between the mucosa of the denture-bearing area and the prosthesis. So, the implants supported only a weak part of the contact force.[7]

Respecting the group I configuration, the load applied to the denture-bearing area was greater than in the Group II configuration. This can be explained by the fact that the vertical gap can cause the axial contact between the female and male components to be delayed. In consequence, attributable to the axial gap, the wider contact area noticed in such cases would involve much greater denture-bearing areas as in Group I.[16]

This result concurred with a previous *in vitro* study.[17] This previous study compared the stresses on the dental implants in two groups of patients who received complete overdentures which were picked up with two different techniques. Group I dentures were picked up by using a block-out spacer and Group II dentures were picked up without using a block-out. The authors declared that Group II patients implants recorded significant higher stresses than Group I. So, the implants in Group II supported a great part of the contact force and the minimum force directed toward the RRR.[17]

The presence of a blocking ring spacer during the pick-up procedure of a complete overdenture enabled overdenture vertical movement according to the resilient property of nylon inserts. This movement allow functional fitting of the overdenture base to be much better. Eventually, a superior distribution of load occurs between dental implants and RRR. In the present study, this explains the greater bone resorption that occurred in Group I. In group II, this form of load sharing and functional fitting is not present.

The investigators of a former study announced that incorporating a blocking ring around the ball attachment during female housing pick-up enables functional fitting of the denture in addition to better distribution of load between the mucosa and implants, offering primary soft tissue support and a resilient situation.[18]

According to previous research,[19] authors reported higher stresses on implants in the case of ball attachment picked up without using of block-out spacer. High stresses of occlusion directed toward the dental implants so, it decreased the stresses directed toward the RRR. The net result was a reduction in RRR resorption.[19] That concurred with our result as in Group II.

Our result is in agreement with the authors who noted that low-profile attachments having a direct contact with their keepers without intervening space, may be responsible for transmission of the stress to the implants.[20]

Also, our outcome was in parallel with a previous study which demonstrated that, when the ball and socket contact each other without intervening space, it does not permit vertical movement of the prostheses due to the absence of vertical resiliency and results in more stress around the dental implants.[21]

Nonetheless, it was postulated that the overdenture motion caused by the vertical gap when using a block-out spacer during pick-up procedures generated a bending moment. As a result, even if the load transmitted through implants is reduced in vertical gap cases, great stresses around implants along with ball abutments may be produced. The stresses were distributed in the bone, which may account for the significant levels of bone resorption documented in the peri-implant bone as compared with earlier studies.[22]

From the results of this study, the null hypothesis, that using or removing a block-out spacer during picking up of the locator attachments retaining the three-implant-assisted mandibular complete overdentures would have no effect on residual alveolar ridge bone all over the time intervals, was rejected. The message given to clinicians based on the outcome of this study is that the elimination of the block-out spacer during the pick-up procedure of locator attachment is more beneficial regarding the residual alveolar ridge.

Conclusion

In terms of residual alveolar ridge preservation, not using the block-out spacer was found to be more beneficial than using it during the pick-up procedure of locator attachments. These locator attachments were used as the main abutments for 3-implant assisted mandibular complete overdentures.

Study Limitations

This study is limited by the small sample size and short follow-up. Hence, future randomized clinical trials with a sizable sample size and extended follow-up are necessary.

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