International Dental & Medical Journal of Advanced Research (2017), 3, 1–6

ORIGINAL ARTICLE

Radiographic evaluation of posterior alveolar ridge resorption in implant-retained mandibular overdentures using three different bar modalities

Amr Mohamed Ismail Badr, Ahmed Gamal Ahmed Hassan

Department of Prosthodontic, Faculty of Dentistry, Minia University, Minya, Egypt

Keywords
Bar and clip connection, bone implant interaction, clinical research, immediate loading, overdenture bar, prosthodontics

Correspondence
Amr Mohamed Ismail Badr,
Department of Prosthodontic, Faculty of Dentistry, Minia University, Minya, Egypt.
Email: dr.amrbadr1972@gmail.com

Received June 01, 2017;
Accepted June 23, 2017

doi: 10.15713/ins.idmjar.69

Abstract

Background: There are many types of attachments used for retaining overdentures. The attachments are either solitary or bar attachments. The type and shape of bar and clip attachments are very important regarding the load distribution between implants and posterior residual ridge.

Aim: The aim of this study was to evaluate the posterior residual ridge resorption in overdenture retained by 3 different types of bar and clip connections (resilient, semi-resilient, and rigid).

Materials and Methods: A total of 18 completely edentulous male patients (age between 50 and 60 years) were selected to have two mandibular implants at the canine region connected with bar then immediate loading was done. The patients divided randomly into 3 equal groups to receive 3 different types of bar and clip connections. Orthopantography was used to measure the resorbed posterior mandibular ridge. The collected data were tabulated and statistically analyzed.

Results: There was no significant difference between all the groups at the 1st and 2nd intervals regarding the posterior alveolar ridge reduction. While there was a significant difference within each group between the mean values of the 1st and 2nd intervals as *P* value was >0.05.

Conclusion: Under the limitation of this study, it was concluded that: (1) Two mandibular implants connected with bar is considered a viable treatment option in mandibular edentulism, (2) the type and shape of the bar and clip connection do not significantly affect the posterior residual ridge resorption within the 1-year follow-up period.

Clinical Significance: The clinical significance of this study was evaluating the best type of bar and clip connection which is recommended in overdenture cases regarding the preservation of posterior alveolar ridge.

Introduction

Edentulism is considered the most common debilitating oral condition that faces geriatric patients resulting in decreased masticatory function, loss of vertical dimension, defective speech, psychological problems, and change in dietary selection leading to impaired nutritional status.

Recent advances in implant designs, manufacturing, and techniques have led to high success rate in solving the problems of retention and stability of conventional dentures, especially the mandibular ones.[1]

Overdentures supported by two implants have become increasingly popular within the past 20 years and considered the standard of care for edentulous mandible and the least costly implant prosthetic option.[2-5]

However, there are concerns that overdentures supported by only a few anterior implants might lead to progressive resorption of the posterior alveolar ridges.[6]

Many retentive means between the implants and the denture can be incorporated using different forms of attachment designs, such as the ball attachment, the magnetic attachment, the telescopic attachment, and the bar and clip ones. The

ultimate choice of attachment type should be based on clinical performance of the attachments regarding the functional loads on the implants and surrounding tissues, patient's satisfaction, technical problems, maintenance service, and attachment costs.[7]

Bar attachment has the advantage of splinting implants together and consequently, the stresses and loads are distributed more uniformly.[8] However, the use of bar attachments includes some drawbacks, such as fracture of the prosthesis, require more space, over bulging of mandibular dentures lingually, frequent maintenance requirements, and increase the cost of overdentures.[9]

Many authors accepted that traced panoramic radiographs are suitable for making reliable measurements of bone resorption in both the maxilla and the mandible. They presented a method of demarcating two areas in the jaws, one determined by the extent of the alveolar ridge and the other from anatomical landmarks not susceptible to resorption. The proportional value between the two areas was referred to as the area index.[10-12]

So the question is, do the different bar designs, shapes, and movements permitted between the bar and denture will affect the posterior residual ridge resorption.

The aim of this study was to evaluate the posterior residual ridge resorption in overdenture retained by 3 different types of bar and clip connections (resilient, semi-resilient, and rigid).

Materials and Methods

A total of 18 completely edentulous male patients (age between 50 and 60 years) and complaining from inadequate retention of their mandibular dentures were selected from the outpatient clinic of Faculty of Dentistry, Minia University.

The patients were selected with the following inclusion criteria: Sufficient bone volume in the inter-foraminal region of the mandible, absence of mucosal lesions, and sufficient inter-arch space, co-operative patients, U-shaped lower ridge to avoid the lingual placement of the bar that occurs with V-shaped ridges, Class 1 Angle's classification with sufficient inter-arch distance (not <15 mm. at rest), normal horizontal relationship of the upper and lower arches, no tempro-mandibular joint disorders and normal tongue shape and size.

Exclusion criteria includes patients with any systemic diseases that may affect osseointegration (uncontrolled patients with diabetes and osteoporosis), cardiac diseases, and blood diseases as proved by the medical examination and laboratory investigations, any medical conditions that would seriously affect the surgical procedure and patients with bad habits such as smoking, alcohol consumption, or history of bruxism. All the patients were informed about their line of treatment, procedures and the necessity for their frequent attendance. A printed approval document was signed by each patient.

Each patient was examined carefully and a new complete denture was constructed. All steps for conventional complete denture construction were carried out according to the standard technique of denture construction. A panoramic radiograph and periapical radiographs at the selected implant sites were performed for each patient.

The lower complete denture was duplicated into transparent acrylic stent that was modified by reduction at the pre-estimated implant positions to be used as surgical stent. This stent was cold sterilized by glutaraldehyde solution.

Each patient received two implants inserted at the canine region bilaterally. A total of 36 screw indirect implants were inserted. The implants were connected by bars and immediately loaded within 2 weeks. All patients were randomly assigned and divided into 3 equal groups (6 patients each). Group 1: Received a rigid bar and clip connection (rounded top, flat sides in cross section, and transparent in color). Group 2: Received a semi-resilient bar and clip connection (teardrop shaped bar in cross section and yellow in color). Group 3: Received a resilient bar and clip connection (rounded bar in cross section and blue in color) [Figure 1a].

The implants used were screw indirect one-piece implant system (Spectra system, implant direct LLC, 27030 Malibu Hills Road, Calabasas Hills, CA 913101, US); 13 mm length, 3.7 mm width, and 5 mm platform. The standard technique of implant insertion was followed under strict rules of sterilization. Pre-operative medications: The patients were given a pre-operative antibiotic injection dose that was continued for 48 h then followed by an oral form for another 72 h. Great care was taken to maintain parallelism between the implants in buccolingual as well as mesiodistal directions. The occlusal level of the implants was also adjusted to be the same at both sides. The fitting surface of the denture was prepared opposite to the implant sites to accommodate the implant heads. A tissue conditioning material (Alpha Dental Products Co., subsidiary of Wallace A. Erickson & Co. 1920N. Clybourn Ave., Chicago, IL 60614, USA) was used to reline the mandibular denture to avoid tissue irritation or implant overloading.

According to the design of bar attachments (Oraltronics, steg-clip-system, Dental Implant Technology Gmbh, Postfach 102747. 28027 Bremen, Germany), the same procedures were made for each group except changing the type of the bar and sleeve. After 1 week of implant insertion, 2 plastic copings were attached to the implant heads with fixation screws. A plastic bar (according to the selected bar design for each group of patients) was placed between the 2 copings and its required length was marked and cut. 2 slots were made in the mesial aspect of each plastic coping using a round bur. These prepared sites guided the occlusogingival positioning of the bar pattern and facilitated its fixation into the copings (retaining slots) [Figure 1b].

The bar was fixed in place with the 2 copings using burnout self-cured acrylic resin (Duralay, Reliance Dental Manufacturing Co., Chicago, USA). After setting of the burnout self-cured acrylic resin; the 2 fixation screws were removed and the whole assembly was removed as 1 piece. The 2 copings and bar assembly were cast as 1 piece into nickel-chromium alloy according to the commonly used casting technique. The construction was then finished, tried in the patient mouth, and then polished. The passive fitness of the bar copings complex over the implants was checked by the tactile sense when seating the tightening screws in place without any resistance. If there was any misfitness; the

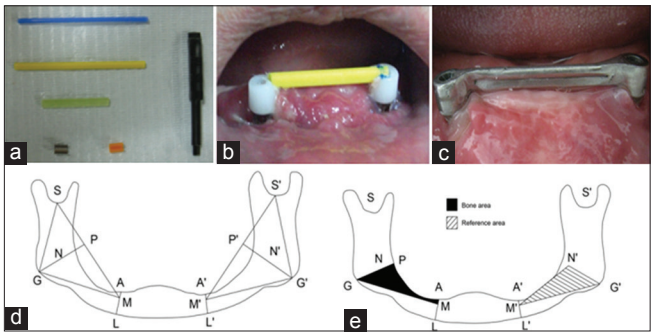

Figure 1: (a) Different types of bars and metal sleeve, (b) the plastic bar is placed in between the retaining slots made in the plastic copings, (c) the finished bar and copings assembly screwed in place intraorally, (d) tracing the anatomical landmarks, (e) measuring points and measuring lines: resulting reference area (area M"G"N") left and measuring bone area (area PAMG) on the right

construction was split and rejoined with Duralay for soldering. Only one bar needed splitting and soldering as this bar was fixed to the copings without the formation of the retaining slots at the mesial aspect of each plastic coping. Afterward, the preparation of these retaining slots was a standard procedure in all the cases.

The cast copings and bar were fixed in place onto the implant heads using fixation screws that were easily and passively tightened [Figure 1c]. The clinical pick-up procedure was the same for each group. The aim was to attach the metallic sleeve to the fitting surface of the mandibular denture under maximum biting force. The metal sleeve with the nylon clip was fixed in place on top of the metallic bar. The undercuts beneath the bar and copings were blocked out using smooth casting wax. The denture's fitting surface opposite the bar coping complex and metallic sleeve was prepared to allow for complete seating without interference. A small window was created at the lingual flange opposite to the bar and sleeve attachment to allow for escape of excess pick-up material. Methyl methacrylate free self-curing rebase material (Tokuyama Rebase II Fast, Tokuyama Dental Corporation, Japan) was mixed and applied in the fitting surface of the mandibular denture. The denture was seated in the patient mouth and the patient was asked to close in centric relation and maintain maximum biting for the period of setting of the rebase material. After setting of the rebase material; the denture was removed slowly then finished and polished. The implants in the three groups were engaged in active loading within 2 weeks of their insertion. After denture loading, the following measurements were carried out for each patient to evaluate the posterior residual ridge resorption at 2 follow-up intervals (from the loading time till 6 months and from the loading time till 12 months).

Proportional area measurement

This method is similar to that used by Wright *et al.* 2002[13] using proportions that minimize errors related to magnification and distortion. The radiographs were digitized by scanning and tracing using AutoCAD (AutoCAD, AutoDesk 20.5, 2015) computer program. The anatomical landmarks: M (lower border of mental foramen), S (sigmoid notch), and G (gonion). These 3 landmarks were used to construct the triangles on the right side (M-S-G) and left side (M"-S"-G") of the mandible. Point (N) is the center of the triangle if line was drawn from each corner (or vertex) of a triangle to the midpoint of the opposite sides, then those 3 lines meet at a center of the triangle [Figure 1d].

Boundaries were constructed by the following lines: The boundary line M-G, the boundary line A-L: A line from the crest of residual ridge (point A) to the lower border of the mandible (point L) through M perpendicular on M-G, the boundary line M-N, and the boundary line G-P: 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 [Figure 1e].

The posterior ridge ratio was calculated by dividing the bone area over the reference area. Moreover, the ratios for the right and left part in each patient were averaged to get the mean. The change in posterior mandibular ridge ratio was calculated in the 1st interval by subtracting (the ridge ratio at 6 months - the ratio at the loading time) and the 2nd interval by subtracting (the ridge ratio at 12 months - the ratio at the loading time).

Statistical analysis

Statistical analysis was performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). For description of data, the mean values and standard deviation were calculated for the change in residual ridge resorption. An analysis of variance with repeated measures was carried out to compare between the groups under all interrelated factors. The data were subjected to three-way ANOVA followed by one-way ANOVA.

Results

During the different follow-up intervals, the posterior alveolar ridge reduction was recorded at the right and left sides of each patient in all groups.

When comparing the mean values of alveolar bone loss in the right and left sides for each patient in all groups, no statistically significant difference was observed during the follow-up intervals. Therefore, the mean values of the right and left sides were added and subtracted by 2 to get the mean bone height loss in each patient.

The mean bone loss or reduction at the 1st interval (from the loading time to 6 months) was 0.29 ± 0.11 for resilient bar group,

Table 1: The mean bone height reduction of the posterior edentulous residual ridges in the three groups at different follow-up intervals

Group follow-up interval	Resilient bar	Semi-resilient bar	Rigid bar	*P* value
(1st interval) from the base line to 6 months	0.29±0.11	0.23±0.08	0.21±0.09	0.49
(2nd interval) from the base line to 12 months	0.49±0.12	0.39±0.13	0.36±0.16	0.45
P value	0.032*	0.045*	0.046*	

*$P \leq 0.05$ considered significant

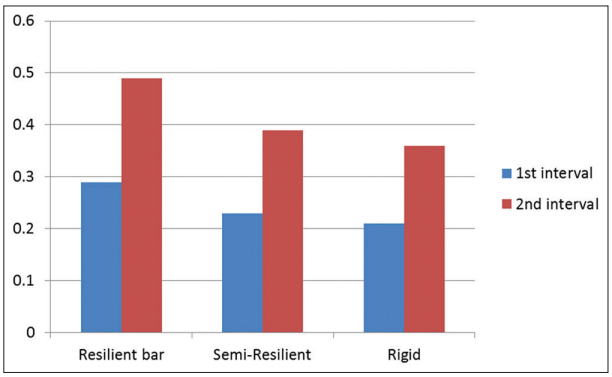

Figure 2: A bar graph showing the mean bone height reduction of the posterior edentulous residual ridges in the three groups at different follow-up intervals

0.23 ± 0.08 for semi-resilient bar group, and 0.21 ± 0.09 for rigid bar group.

The mean bone loss or reduction at the 2nd interval (from the loading time to 12 months) was 0.49 ± 0.12 for resilient bar group, 0.39 ± 0.13 for semi-resilient bar group, and 0.36 ± 0.16 for rigid bar group [Table 1 and Figure 2].

There was no significant difference between all the groups at the 1st and 2nd intervals regarding the posterior alveolar ridge reduction. While there was a significant difference within each group between the mean values of the 1st and 2nd intervals as *P* value was >0.05.

Discussion

This study was to evaluate immediately loaded implants; connected together with a bar. 3 different types of bar and clip connection were used in this study.

All factors that may contribute to implant failure and that may enhance the process of osseointegration were taken into consideration.

Only male patients were selected to avoid any possible hormonal changes accompanied with menopausal conditions which could affect bone condition. The sex and age group were unified to minimize variability in the rate of bone resorption.[14,15]

Patient's selection criteria were directed to avoid any condition that may interfere with normal bone metabolism or complicates surgical treatment. This was done using comprehensive medical history, clinical examination, and laboratory investigation.

All patients participating in this study exhibited Angle's Class I ridge relationship to avoid subjecting the implants to abnormal forces. Furthermore, patients with inadequate interarch space were excluded to facilitate insertion of the implant abutments, bar, and overdentures.[16,17]

Smokers were excluded due to the bad effect of nicotine on healing capability, impairment of blood circulation, and consequently affect the process of osseointegration.[18,19]

Patients with a history of abnormal or para-functional habits as clenching and bruxism were excluded to avoid excessive load and undue concentrated forces on the implants.[20,21]

Radiographic examinations were performed to detect any abnormalities or pathosis at the implanted site or denture foundation area. The amount of the available bone was measured to assess the capability for the treatment.[19,22]

Threaded form one piece implant (screwed) was used with the same length and width in all groups to make the comparison valid. As it needs less surgical procedure, minimizes operating time, and enhances the primary stability of the implant during the initial healing period as the screw geometry design provide the largest mechanical retention.[23]

Recent survey reveals high success rates for implants retained mandibular overdenture most of which were retained by only 2 implants opposing mucosa supported maxillary denture.[24]

The choice of the anterior mandibular region (the interforamina region) for implant insertion was due to the greatest available height of bone is located in the anterior mandible between the mental foramina. In addition, this region usually presents the optimal density of bone for implant support; it entirely features thick dense cortical plates, as well as dense trabecular bone, unlike the anatomy found in the posterior mandible which reported higher failure rates.[25]

The importance of passively fitting superstructures to the implant and surrounding bone has been emphasized.[26] However, one of its disadvantages that appeared in one case in the current study was misfit of the metal framework to the implants. Distortion of the framework during the casting procedure has been cited as the main cause of misfit that complicates the treatment.[27]

Infection control was strictly considered during surgical insertion of the implant which was done under aseptic conditions to enhance proper osseointegration.

The immediate loading approach presents several advantages. Only one surgical step is necessary and decreasing treatment time. Furthermore, soft and hard tissues are preserved as much as possible and the edentulous patient has definitive immediate prosthesis.[28]

Splinting the implants may help to distribute the load widely between the 2 implants. It looks as if stress concentration around the implants in the bar was relatively less than that in the free standing implants.[29]

The direct pick-up technique was preferred over the indirect technique in incorporating the metal clip to avoid the possible discrepancies that may occur if indirect technique was used.[30]

The measurements within this study were performed on panoramic radiographs. Although minor differences in positioning patients are possible, the use of panoramic radiographs is generally accepted as a standardized procedure and has been used for equal purposes in previous studies.

Panoramic radiographs are widely used in clinical practice and are part of many recall programs. Therefore, the investigation of ridge resorption in large numbers of patients with these radiographs are feasible.[31] The proportional measurements are suitable and reliable for the assessment of residual resorption in the mandible than absolute measurements as it reduces the problems associated with magnification and distortion inherent in rotational tomograms and compensates for head positioning errors.[32]

All the patients participated in this study used their dentures successfully. The patients were instructed to maintain proper oral hygiene, especially in the area below the bar. This area is very critical as it is liable to inflammation and hyperplasia if left without sufficient home care.

The insertion of 2 implants in the lower edentulous jaw had changed the mode of support from totally mucosa support; the case in complete denture to implant mucosa support. Changing the mode of support may help to relieve the anterior part from excessive pressure, decreasing the susceptibility of trauma, and sore spots which are common complaints in conventional complete dentures wearers. While the posterior residual ridge shares some of the load transmitted to some extent, this may lead after a short period to ridge resorption.[33]

With resilient bar and clip connection retained restorations, the connection between the bar and the clip permits hinge motion (full rotational movements) as the bar is rounded in cross section, and this joint act as stress breaker. This full rotational movements allow the posterior residual ridge to share most of the load, and this can explain the more bone resorption in these cases with this type of bar and clip connection.[34]

The clip being in the central part of the bar may act as stress breaker helping denture retention and at the same time allowing some movements without jeopardizing the supporting implants. This may be translated that the forces transmitted by the implants are within the physiological limit tolerated by the patient.[35]

It is suggested that the virtual axis connecting the interforaminal implant and the bars should be parallel to the mandibular hinge axis. This would enhance the hinging movement and optimize load distribution between implants and tissues.[36]

While rigid joint bar and clip connection (parallel-sided bar) may transmit more of the masticatory load to the implants and less to the denture-bearing mucosa, and this can explain the less posterior ridge resorption in these cases.[37]

However, with the semi-resilient bar and clip connection (tear shaped in cross-section bar); the overdenture design guarantee limited rotation movement during dorsal loading. This can explain the less posterior ridge resorption than that of resilient connection but slightly more than that of rigid connection.

Theoretically, after implant insertion, these cases resemble bilateral distal extension cases. There is liability for the denture to rotate around a fulcrum line extending between the two posterior implants.

The average dimension of the calculated bone area was comparable to most previous studies. The posterior alveolar ridge resorption rate between 0.15% and 2.63% per year strengthens the conclusions drawn by Michael *et al.* 2015 and De Jong *et al*., 2010.[38,39]

In the current study, the results confirmed that there was no significant difference between the three groups during the whole follow-up intervals. This can be attributed to the limited rotation that can be resisted by the wide coverage and the denture flanges maximum extension.

On the other hand, it was recognized that there was a significant difference within each group between the 1st interval and the 2nd interval. Moreover, this can explain the effect of time on the posterior ridge resorption.

Therefore, the results do not recommend a protocol encompassing intervals for rebasing and relining, but a regular check of the denture base fit is strongly recommended. Meanwhile, further longitudinal research study on the residual ridge resorption with different bar connections is mandatory.

Conclusion

Under the limitation of this study, it was concluded that:

- Two mandibular implants connected with bar is considered a viable treatment option in mandibular edentulism.
- The type and shape of the bar and clip connection do not significantly affect the posterior residual ridge resorption within the 1-year follow-up period.

References

1. Misch CE. Contemporary Implant Dentistry. Vol. 3. St. Louis, USA: CV Mosby; 2008. p. 812-3.
2. Heydecke G, Thomason JM, Awad MA, Lund JP, Feine JS. Do mandibular implant overdentures and conventional complete dentures meet the expectations of edentulous patients? Quintessence Int 2008;39:803-9.
3. Thomason JM, Feine J, Exley C, Moynihan P, Müller F, Naert I, *et al.* Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients - The York consensus statement. Br Dent J 2009;207:185-6.
4. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, *et al*. The McGill consensus statement on overdentures. Int J Prosthodont 2002;15:413-4.
5. Mericske-Stern R, Zarb GA. Overdentures: An alternative implant methodology for edentulous patients. Int J Prosthodont 1993;6:203-8.
6. Jacobs R, Schotte A, van Steenberghe D, Quirynen M, Naert I. Posterior jaw bone resorption in osseointegrated implant-supported overdentures. Clin Oral Implants Res 1992;3:63-70.
7. Alsabeeha NH, Payne AG, Swain MV. Attachment systems for mandibular two-implant overdentures: A review of *in vitro* investigations on retention and wear features. Int J Prosthodont 2009;22:429-40.
8. Tabata LF, Assunção WG, Barão VA, Gomes EA, Delben JA, de Sousa EA, *et al.* Comparison of single-standing or connected implants on stress distribution in bone of mandibular overdentures: A two-dimensional finite element analysis.

J Craniofac Surg 2010;21:696-702.
9. Naert I, Alsaadi G, van Steenberghe D, Quirynen M. A 10-year randomized clinical trial on the influence of splinted and unsplinted oral implants retaining mandibular overdentures: Peri-implant outcome. Int J Oral Maxillofac Implants 2004;19:695-702.
10. Jacobs R, van Steenberghe D, Nys M, Naert I. Maxillary bone resorption in patients with mandibular implant-supported overdentures or fixed prostheses. Prosthet Dent 1993;70:135-40.
11. Kreisler M, Schulze R, Schalldach F, d'Hoedt B, Behneke A, Behneke N. A new method for the radiological investigation of residual ridge resorption in the maxilla. Dentomaxillofac Radiol 2000;29:368-75.
12. Wilding RJ, Levin I, Pepper R. The use of panoramic radiographs to measure alveolar bone areas. J Oral Rehabil 1987;14:557-67.
13. Wright PS, Glantz PO, Randow K, Watson RM. The effects of fixed and removable implant-stabilized prostheses on posterior mandibular residual ridge resorption. Clin Oral Implants Res 2002;13:169-74.
14. Rowe DJ. Bone loss in the elderly. J Prosthet Dent 1983;50:607-10.
15. Watson I, MacDonald D. Oral mucosa and complete dentures. J Prosthet Dent 1982;47:133-40.
16. Cranin A, Klien M, Simons A. Atlas of Implantology. 2nd ed., Vol. 3-7. New York: Mosby Publishers Inc.; 1999. p. 234-55.
17. Jaffin R, Berman CL. The excessive loss of Branemark fixtures in Type IV bone: A 5-year analysis. J Clin Periodontol 1991;62:2-4.
18. Davarpanah M, Martinez H. Clinical Manual of Implant Dentistry. London: Quintessence Publishing Co. Ltd.; 2003. p. 67-89.
19. Scortecci G, Misch C, Benner K. Implants and Restorative Dentistry. NY, USA: Thieme; 2001. p. 411-57.
20. Lekholm U, Zarb G. Patient selection and preparation. In: Branemark P, Zarb G, Albrektson T, editors. Tissue Integrated Prostheses. Chicago: Quintessence Publishing Co.; 1990. p. 199-210.
21. von Gonten AS, Palik JF, Oberlander BA, Rugh JD. Nocturnal electromyographic evaluation of masseter muscle activity in the complete denture patient. J Prosthet Dent 1986;56:624-9.
22. Cooper C, Kosinski T, Rosenlichet J. Principles and Practice of Implant Dentistry. St. Louis, Missouri, USA: C.V. Mosby Co.; 2001. p. 178-99.
23. Ericsson I, Randow K, Glantz PO, Lindhe J, Nilner K. Clinical and radiographical features of submerged and nonsubmerged titanium implants. Clin Oral Implants Res 1994;5:185-9.
24. Ferrigno N, Laureti M, Fanali S, Grippaudo G. A long-term follow-up study of non-submerged ITI implants in the treatment of totally edentulous jaws. Part I: Ten-year life table analysis of a prospective multicenter study with 1286 implants. Clin Oral Implants Res 2002;13:260-73.
25. Misch CE. Contemporary Implant Dentistry. 3rd ed. St Louis, Baltimor, Boston, Chicago, London, Philadelphia, PA, Sydney, Toronto: C.V. Mosby Co.; 2008. 2008. p. 21, 32 180, 338.
26. Takahashi T, Gunne J. Fit of implants frameworks: An *in vitro* comparison between two fabrication techniques. J Prosthet Dent 2003;89:256-60.
27. Tan KB, Rubenstein JE, Nicholls JI, Yuodelis RA. Three-dimensional analysis of the casting accuracy of one-piece, osseointegrated implant-retained prostheses. Int J Prosthodont 1993;6:346-63.
28. Martínez-González JM, Barona-Dorado C, Cano-Sánchez J, Fernández-Cáliz F, Sánchez-Turrión A. Evaluation of 80 implants subjected to immediate loading in edentulous mandibles after two years of follow-up. Med Oral Patol Oral Cir Bucal 2006;11:E165-70.
29. Salloum M. Evaluation of Splinting on Immediately Loaded Implants in Mandibular Overdenture Patients. PhD. Thesis, Cairo University; 2005.
30. Preiskel H. Overdenture Made Easy: A Guide to Implant and Root Supported Prosthesis. 1st ed. London: Quintessence Publishing Co.; 1996. 1996. p. 81-112.
31. Xie Q, Närhi TO, Nevalainen JM, Wolf J, Ainamo A. Oral status and prosthetic factors related to residual ridge resorption in elderly subjects. Acta Odontol Scand 1997;55:306-13.
32. Kreisler M, Behneke N, Behneke A, d'Hoedt B. Residual ridge resorption in the edentulous maxilla in patients with implant-supported mandibular overdentures: An 8-year retrospective study. Int J Prosthodont 2003;16:295-300.
33. Porter JA Jr, Petropoulos VC, Brunski JB. Comparison of load distribution for implant overdenture attachments. Int J Oral Maxillofac Implants 2002;17:651-62.
34. Daas M, Dubois G, Bonnet A, Lipinski P, Rignon-Bret C. A complete finite element model of a mandibular implant-retained overdenture with two implants: Comparison between rigid and resilient attachment configurations. Med Eng Phys 2008;30:218-25.
35. Naert I, Gizant S, Vuylstoke M. A 5-year prospective randomized clinical trial on the influence of splinted and un-splinted oral implants retaining a mandibular overdenture: Prosthetic aspects and patient satisfaction. J Oral Rehabil 1999;16:195.
36. Naert I, Quirynen M, Theuniers G, van Steenberghe D. Prosthetic aspects of osseointegrated fixtures supporting overdentures. A 4-year report. J Prosthet Dent 1991;65:671-80.
37. Renouard F, Rangert B. Risk Factors in Implant Dentistry. 1st ed. Chicago: Quintessence; 1999.
38. de Jong MH, Wright PS, Meijer HJ, Tymstra N. Posterior mandibular residual ridge resorption in patients with overdentures supported by two or four endosseous implants in a 10-year prospective comparative study. Int J Oral Maxillofac Implants 2010;25:1168-74.
39. Raedel M, Lazarek-Scholz K, Marré B, Boening KW, Walter MH. Posterior alveolar ridge resorption in bar-retained mandibular overdentures: 10-year results of a prospective clinical trial. Clin Oral Implants Res 2015;26:1397-401.

How to cite this article: Badr AMI, Hassan AGA. Radiographic evaluation of posterior alveolar ridge resorption in implant-retained mandibular overdentures using three different bar modalities. Int Dent Med J Adv Res 2017;3:1-6.