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PATTERN OF POSTERIOR RESIDUAL RIDGE RESORPTION UNDER MANDIBULAR IMPLANT HINGING OVERDENTURES: A 5 –YEAR RETROSPECTIVE STUDY

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ABSTRACT

Purpose: This 5-year retrospective study aimed to investigate and compare the effect of bar designs of two-implant-retained overdentures (2-IRO) on pattern of the residual ridge resorption (RRR) of the posterior mandibles using 3-D Cone Beam Computed Tomography (CBCT) imaging.

Materials and Methods: Forty five edentulous patients treated with mandibular 2-IRO opposing maxillary complete denture were selected for the study. According to bar designs; the enrolled patients were divided into three groups: Group BC (n=19) patients treated with two-implant overdentures retained by a bar joint with a plastic retentive clip. Group BL (n=14) patients treated with two-implant overdentures retained by locator attachments on the top of milled bar. Group BD (n=12) patients treated with two-implant overdentures retained by a straight bar with a plastic retentive clip & distally cantilevered ball attachments. The pattern of posterior RRR was evaluated by using CBCT imaging after 5 years post-treatment.

Results: The overall vertical means of RRR differences were highly significant between three bar groups (BC, BD, and BL) using One Way ANOVA test with LSD post hoc. For group BL, no significant differences were revealed in height and width (for both buccal and lingual sides) of alveolar bone when comparing molar and premolar areas. For group BD, the reduction in RRR recorded highly significant differences ($p<0.001$) in height and width (for lingual side only) with statistical significant increase at molar than premolar areas.

Conclusion: Taking the limitation of this study into considerations; Mandibular posterior residual ridge resorption occurs irrespective of 2-IRO design. The impact of bar design on the rate of residual ridge resorption is a matter of controversy. Unless limited by the available restorative space; milled bar design with locator retainer could be considered the bar design of choice regarding the rate and pattern of RRR.

KEY WORDS: Residual ridge resorption, mandible, CBCT, implant bar overdenture.

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INTRODUCTION

Tooth loss is inevitably associated with major changes of soft and hard tissues after tooth extraction during early healing phase. However, continuous residual ridge resorption (RRR) after tooth loss was revealed up to 25 years of complete denture wearing. [1] This resorptive atrophy presumably is influenced and modulated by individually varying factors, such as condition of the bone, denture-wearing habits, and unfavorable loading pattern. [2]

Implant-retained overdentures are used when the prosthesis relies on mucosal tissue support while the retention provided by the retentive elements attached to implants. On the other hand, implant-tissue supported (hybrid) overdenture defines the type of prostheses which get their retention and anterior support from implant superstructures and their posterior support from mucosal tissues. In these cases, the tissue support is achieved by a hinging movement around the implant superstructure. [3]

Mandibular two-implant overdentures (2-IRO) are currently considered as the minimal standard of care, simpler, and more cost effective for completely edentulous patients than implant fixed prostheses. [4]

Various overdenture attachment systems can be used to enhance retention and stability for 2-IRO. The appropriate choice of an attachment can be made on the basis of their biomechanical features at a given state of the atrophied mandible to provide prosthesis stabilization with regard to horizontal forces. [5]

However, overdenture designs supported by only few anterior implants might lead to progressive resorption of the posterior alveolar ridges. [3] This resorption may be localized to the most posterior areas of the alveolar ridge especially when the occlusal resiliency in the clip did not compensate for oral mucosa resiliency. Therefore, the sleeve rests on the bar acting as a fulcrum. [6-8]

Although bar/clip attachment was the mostly used retention system for overdentures, combining stud attachments with splinting bar may provide high patient satisfaction and good clinical outcomes. [9,10] The position and type of attachments on the connecting bar are important in determining the direction of overdenture movements when loads are placed in the molar region. [11]

This design directs the forces of mastication closer to the crest of the ridge, thus decreasing the lever arm mechanics on the supporting implant structure and provides long lasting performance of clinical function prior to failure of the resilient portion without loss of its retentive capacity. [10] Even with angulated implants, the stud attachments could be positioned parallel to each other at the same height and equal distance from the midline on the connecting bar, thus reducing prosthetic complications. [11]

Placing ball attachments distal to the bar abutments may create a fulcrum line between the two studs, around which, the prosthesis will rotate anteroposteriorly. [12] This design provides indirect retention for the whole system through the anteriorly situated clip/bar attachment but on the other hand, allows some freedom of movement that may increase the rate of RRR. [3,13]

The extent of load transition to the posterior residual ridge is dependent on how the connecting bar allows vertical and/or rotational denture movements. [6,14] In this sense, Jacobs et al. [15] in a retrospective study reported that bar-supported overdenture on two implants was associated with worse posterior RRR over time compared to implant-supported fixed prostheses and showed annual posterior RRR two to three times that of conventional complete denture wearers. Controversially, Kordatzis et al. [16] found a lower resorption rate of the posterior mandible in patients wearing implant overdentures supported by two implants compared with conventional denture wearers over a period of 5 years. However, Tymstra et al.[17] reported a statistically insignificant difference in RRR under overdentures on two implants, four implant-supported overdentures, or conventional complete dentures after ten years of denture insertion.

Wright and Watson[24] compare the posterior RRR in patients wearing mandibular overdentures supported by parallel-sided and ovoid Dolder bars. They concluded that the posterior bone resorption was not significantly influenced by the design of the prefabricated bar after 8 years from denture insertion. However, this controversy encouraged this retrospective comparative study to investigate the effect of different bar designs used to retain mandibular 2-implant overdentures on pattern of mandibular posterior bone resorption after 5 years from prostheses insertion.

MATERIALS AND METHODS

This retrospective study included data from 45 patients (28 males and 17 females with age ranged between 52 and 71 years) who treated with mandibular two implant bar-retained overdentures opposed by maxillary complete dentures. All patients were selected from Prosthodontics Department, Faculty of Dentistry, Mansoura University.

Patient selection

All patients were enrolled in this study according to the following inclusion criteria: Patients were above 50-years with two implants installed in the mandibular canine areas. All patients were received maxillary complete denture opposed by mandibular bar retained overdentures. They were free from any metabolic, muscular, or neurogenic disorders that affect bone and muscles function. Patients who did not recall for at least one visit every year of follow-up were entirely excluded.

According to these inclusion criteria, charts of 53 were selected for this study. 8 patients were excluded from the study as follows; four patients refuse to participate in the study. One patient could not be contacted and three patients were missed at the 5th year recall visit. Only 45 patients were enrolled in this retrospective study. Informed consent was written for each patient, and approval from the Faculty Ethical Committee was obtained.

According to the cast bar design, patients were divided into three groups as follows:

- *Group BC: patients **(n=19)** treated with two-implant overdentures retained by a bar joint with a plastic retentive clip.*
- *Group BL: patients **(n=14)** treated with two-implant overdentures retained by locator attachments on the top of milled bar.*
- *Group BD: patients **(n=12)** treated with two-implant overdentures retained by a straight bar with a plastic retentive clip & distally cantilevered ball attachments.*

The exact bar materials used in the study are outlined in Table 1. All bar designs were located on the top of the alveolar crest, leaving a 2-mm clearance space beneath the bar for oral hygiene purposes. All spaces under bar designs were blocked-out with wax intraorally and the block-out discs were used for individual attachments on the bar. The plastic clips and/or matrices were directly picked up to the dentures with autopolymerized acrylic resin, while the patients closed in centric occlusion. Semi-anatomical acrylic teeth were used for balanced lingualized occlusion. During follow-up visits, the patients received every year checking for denture fit, retention and occlusion. The matrices were replaced and the dentures were relined, when necessary.

Bone measurements

The patients were subjected to two consecutive 3-D Cone Beam Computed Tomography (CBCT), initial preoperative record of implant planning (T0), and the final record after 5-years post-insertion (T5),

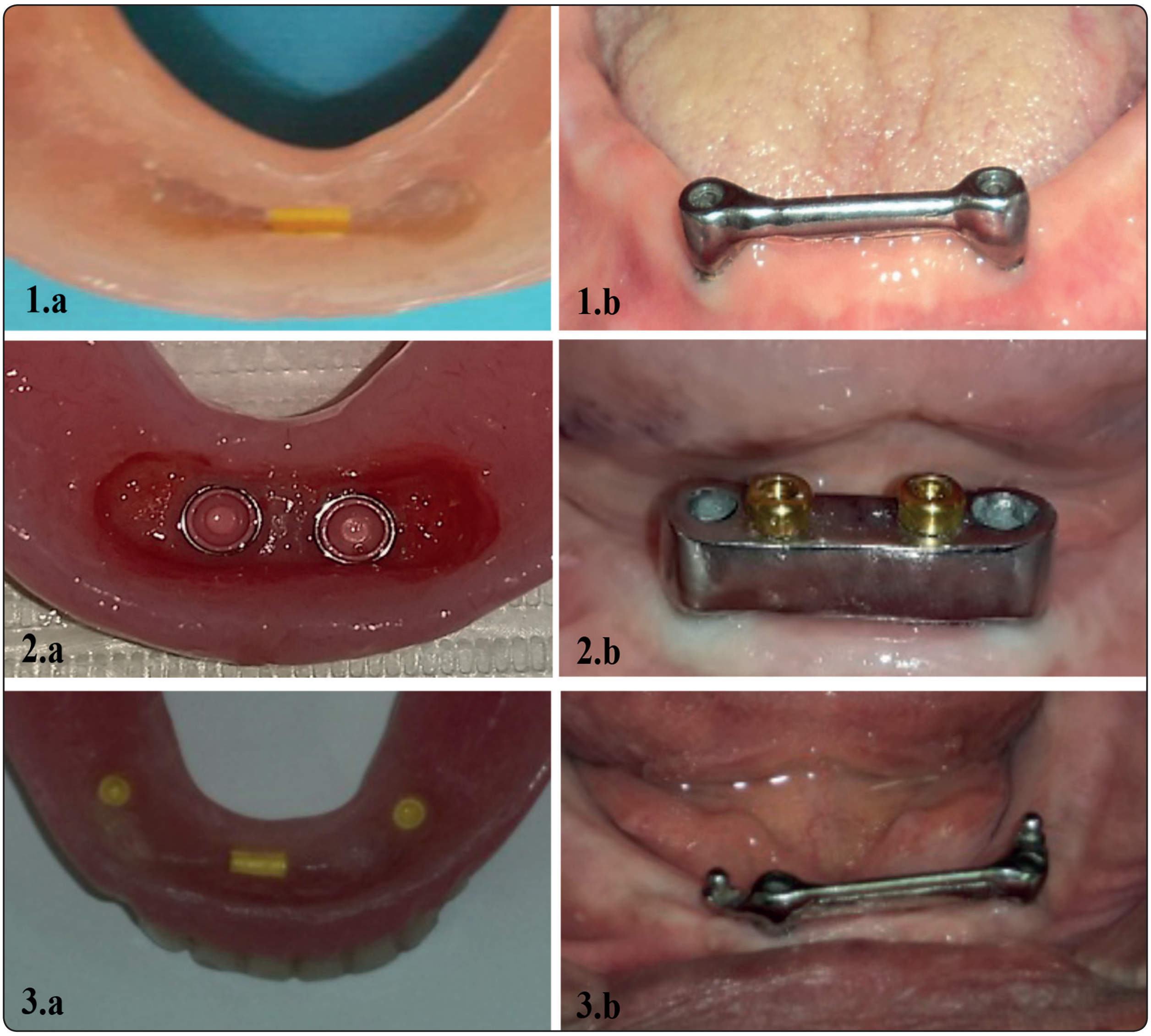

Fig (1) Bar Joint Designs: BC group: bar with a plastic retentive clip (1. a&b). BL group: bar with locator attachments (2. a&b). BD group: bar with distally cantilevered ball attachments (3. a&b).

TABLE (1) Joint Bar Designs Used in the Study for Two Implant-Retained Overdentures

Bar Joint design	Description	Bar type (manufacture)	Stud type (Manufacturer)	Casting material	Matrices/Patrices
BC	Standard straight bar/ clip attachment	OT bar multiuse, RHEIN 83, Bologna, Italy	----------	Cr-Co	Yellow clip
BL	Cast Bar with top Locator attachments	Waxed square bar	Drill & Tap Locator ZEST-ANCHORS, Escondido, CA, USA	Cr-Co	Pink patrice
BD	Straight bar with distal ball attachments	VSP-GS bar, BREDENT, Senden,Germany	VKS-OC ball; BREDENT, Senden, Germany	Cr-Co	Yellow clip Yellow matrice

respectively. The CBCT scans were taken with an iCat machine (Imaging Sciences International, Hatfield, Pa) with a 16 X 22-cm field of view with a voxel size of 0.5 mm. the exposure setting was mA/80 kV and a scanning time of 17.5 sec. The images were taken with a slice thickness of 1.5 mm and a slice distance of 1 mm. Bone measurements were made directly on the cross-sectional images of the CBCT using computer software.

For standardized measurements, reference lines were traced as perpendiculars from the mandibular plane (MP) to the ridge crest (RC). Four regions on each side of sagittal window were identified; at premolar (PM1, PM2) and molar (M1, M2) sites. PM1 was represented by tangent line to the anterior border of the mental foramen, second premolar (PM2), first molar (M1), and second molar (M2) regions were consecutively located 7 mm further distally (Fig 2. A).

To set the reference points in each coronal section (Fig 2. B) , a vertical line (VL) was drawn from the most upper point of RC to the most inferior point of the lower border of the mandible (LBM) through the long axis of the bone segment. The height of the alveolar bone (H) was defined as the distance from RC to LBM. To standardize the most upper point of RC in two consecutive coronal sections; the angle between VL and MP was recorded in the initial record. The width was measured in the initial record at a horizontal line perpendicular to VL and 4 mm below RC. The horizontal line in the final record was drawn perpendicular to VL at a fixed distance and angle from MP in the initial record. The buccal and lingual measurements represented by the horizontal distance from VL in coronal scans to the buccal (B-point) and lingual (L-point) bone surfaces respectively.

The CBCT measurements were done by the same radiologist using the same technique, and were repeated twice with an interval of 2 weeks to evaluate the reproducibility of the measurements, and the precision was calculated (the coefficient of variation to confirms the examiner's measurements a high exactness). Calculated differences in the alveolar ridge dimensions at T5 from T0 were expressed in tenth of millimeters. Positive values indicated resorption, and negative values indicated the bone apposition.

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. Quantitative data were described using mean, standard deviation after testing normality using Shapiro-Wilk test. Significance of the obtained

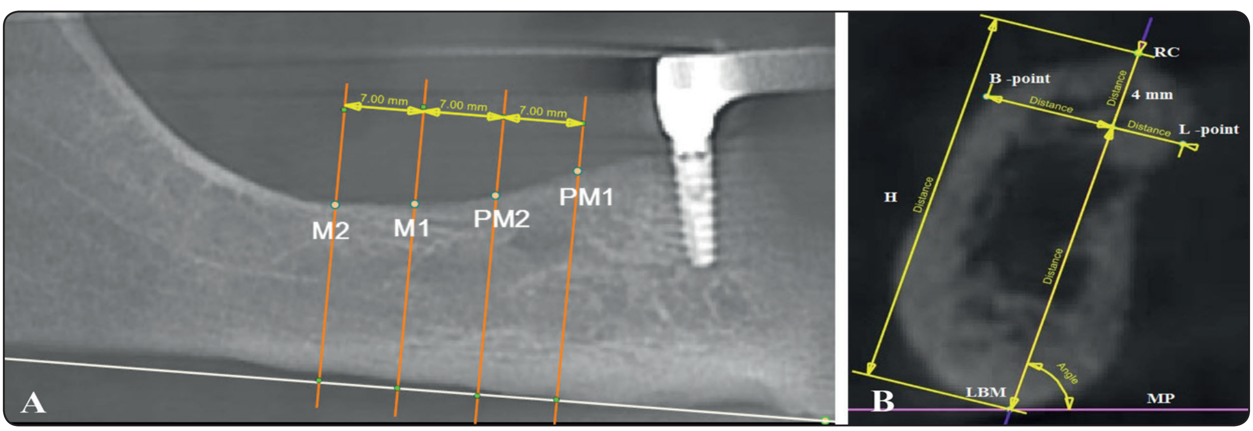

Fig (2) Sites For Radiographic Measurements: Sagittal view (A). Coronal section (B) results was judged at the 5% level. One Way ANOVA test was used for normally quantitative variables, to compare between more than two groups with LSD post hoc to detect within groups significance .Student t test was used for parametric quantitative variables, to compare between two studied groups.

Intra-observer correlation coefficient (ICC) was previously established according to Karaca et al. (18) to evaluate the reliability of the measurements that were performed by the same examiner at the two different time points. The reliability of the measurements was defined as 'poor' if the ICC was <0040, as 'acceptable' if the ICC was between 0040 and 0.70, and as 'good' for ICC values >0.70.

RESULTS

Comparing overall posterior ridge resorption between BC, BL and BD bar groups is presented in table (2). The vertical means of ridge resorption between three bar groups (BC, BD, and BL) were compared using One Way ANOVA test with LSD post hoc. The overall differences in vertical RRR were highly significant (p<0.001). Also, there was a statistically significant difference between groups in the vertical ridge resorption using Student t test. However, the buccal ridge resorption (F=11.39) was significantly different (p<0.001) when comparing BC group to BD and BL bar groups. Similarly; the lingual ridge resorption (F=62.56) was significantly different (p<0.001) with BC group.

Comparing posterior residual ridge resorption between premolar and molar sites in BC, BL and BD bar groups is presented in Table (3) and Fig (3). Group BC demonstrated highly significant differences reduction (p<0.001) in height (molar than premolar areas) and width (both buccal and lingual) of alveolar bone (t: Student t test, p <0.05). For group BL, no significant differences were revealed in height and width (for both buccal and lingual sides) of alveolar bone when comparing molar and premolar areas. With respect to group BD, it recorded highly significant differences reduction (p<0.001) in height and width (for lingual side only) of alveolar bone at molar than premolar areas.

TABLE (2) Comparison of Overall Posterior Residual Ridge Resorption Between BC, BL and BD Bar Groups Using One Way- ANOVA Test.

	BC n=19	BD n=12	BL n=14	Test of significance
	Mean ± SD	Mean ± SD	Mean ± SD	
Height	0.766±0.41[ab]	0.285±0.38[ac]	0.973±0.41[bc]	F=19.62 P<0.001*
Buccal	0.499±0.15[ab]	0.342±0.22[a]	0.362±0.18[b]	F=11.39 P<0.001*
Lingual	0.61±0.14[ab]	0.284±0.16[a]	0.33±0.17[b]	F=62.56 P<0.001*

X: mean ***SD: standard deviation***

F: One Way ANOVA test **** p value significant < 0.05***

ABC : similar letters denote significant difference within groups using post hoc LSD

TABLE (3) Comparison of the posterior residual ridge resorption between premolar and molar sites in each BC, BL or BD bar group.

	BC n=19			BL n=14			BD n=12		
	Premolar X ± SD	Molar X± SD	P value	Premolar X ± SD	Molar X ± SD	P value	Premolar X ± SD	Molar X ± SD	P value
Vertical Bone loss	0.55 ±0.3	0.98 ±0.38	p<0.001*	0.973 ±0.41	0.998 ±0.42	p=0.82	0.285 ±0.38	1.27 ±0.31	p<0.001*
Buccal Bone loss	0.58 ±0.09	0.423 ±0.16	p<0.001*	0.363 ±0.18	0.348 ±0.18	p=0.76	0.342 ±0.22	0.31 ±0.19	p=0.566
Lingual Bone loss	0.54 ±0.09	0.68 ±0.13	p<0.001*	0.33 ±0.17	0.366 ±0.14	p=0.35	0.284 ±0.16	0.614 ±0.16	p<0.001*

X: mean ***SD: standard deviation***

t:Student t test ****p value significant <0.05***

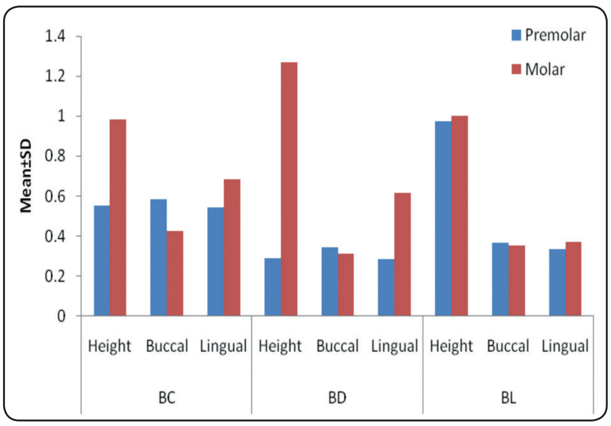

Fig. (3) Posterior residual ridge resorption pattern between premolar and molar sites in each BC, BL or BD bar design.

DISCUSSION

In this study, the residual ridge measurements were measured in the vertical and horizontal dimensions. [19,20] The decision to use CBCT imaging technique in this study was made since the vertical RRR often appears to be normal or to have minimal signs of resorption in 2D radiographs, while buccolingual dimensions may have already severely decreased. [18]

According to previous reports, [19-21] the buccal and lingual measurements were calculated in this study by using horizontal lines at a fixed distance from the mandibular inferior border to detect any changes in the mandibular bone width. After 5-years; the results of this study revealed a mean vertical RRR of 0.766±0.41, 0.285±0.38 and 0.973±0.41 for BC, BD, and BL groups, respectively. These findings may be attributed to the built-in possibility of rotation of two-implant-retained overdentures. [7,13,14,16,17]

According to the calculation made by Kordatzis and associates, [16] the present study estimated an annual rate of posterior bone resorption 0.15, 0.05, and 0.19 mm for BC, BD, and BL groups, respectively. These findings agree with the findings reported in the literature. Kordatzis et al. [16] estimated 0.14 mm annual RRR with bar/clip stabilizing overdentures on 2 implants. However, the annual rate of posterior vertical bone resorption in another study conducted by Wright and Watson [14] was 0.01 mm for the resilient joint group.

It was noticed that BD group demonstrated less resorption (mean 0.285 mm) compared to the other bar groups BC & BL that had mean 0.766, and 0.973 mm respectively. The mechanism of force transfer to the posterior residual ridge could influence the pattern of resorption between the molar and premolar regions associated with each bar design. [5] In the hinging bar overdenture, the prosthesis loads the soft tissue over the buccal shelf and the posterior ridge allowing the prosthesis to move toward the tissue and then rotates as described by van Steenberghe et al. [3] and Misch. [11] In this sense, the highly significant difference in RRR between molar and premolar sites in other groups (BC and BD) might result from denture base rotation around anterior fulcrum. This explanation is concurred with Sennerby and colleagues[2] who reported that the resorption was minimal in adjacent to the implants and more pronounced far posteriorly.

The increased resiliency of locator attachment in addition to the vertical walls of the milled bar might allow the denture base to move in a vertical direction without any rotation during function. [3] These results appeared to be confirmed by Ahmad et al. [21] and Calyton[22]; who concluded that the vertical displacement may permit the mucosa to be loaded and induce ridge resorption.

The presence of precision ball attachments distal to the bar abutments provide implant support in the premolar region and move the hinge axis of denture rotation more posteriorly than canine region. [6,11] The stress concentration in molar region may affect the local blood supply in mucosa under the denture base. Consequently, a significant and uneven loss of the alveolar bone will occur as explained by the previous studies. [15,16,21] Also, the presence of distally extended ball could protect the underlying residual ridge in the premolar area from excessive loading as stated by Mosnegutu et al. [23]

Regarding the ridge resorption in buccal and lingual aspects, the observed mean for buccal bone loss at the end of the 5-year study was 0.49, 0.34, and 0.36 with BC, BD, and BL respectively. Also, the observed mean for lingual bone loss was 0.61, 0.28, and 0.33 with BC, BD, and BL respectively. Both BD and BL groups was significantly different in horizontal bone resorption when compared to BC group $P<0.001$ ($F=11.39$ for buccal, and $F=62.56$ for lingual).

The higher horizontal bone resorption with the hinging straight bar/clip may be explained by the dependence of the denture base on flange extension over the posterior ridge to resist the lateral movement that could exert lateral stresses on the ridge slopes during function[11]. However, the vertical rigid walls provided by the milled bar in BL group or the distally extended connectors of the ball attachments in BD group could provide better horizontal stability of the denture base and limits its lateral movements as stated by Heckmann et al. [5]

Within the limitations of this 5-year radiographic retrospective study of different bar retained 2-implant mandibular overdenture, it could be concluded that:

1- The impact of bar design on the rate of residual ridge resorption is a matter of controversy. Unless limited by the available restorative space, milled bar design with locator retainer could be considered the bar design of choice regarding the rate and pattern of residual ridge resorption.

2- Joint bar design is not biologically accepted regarding both vertical and horizontal bone loss and is not recommended for cases with compromised ridges. On the other hand, milled design bar with locator retainer and bar design with cantilevered ball retainer could be suggested for better horizontal stabilization.

3- Whenever it is possible, this study strongly recommend replacement of conventional plastic retentive clip by suitable sized precision attachment for better control of stress distribution along the residual alveolar ridge

COMPETING INTERESTS

The authors report no conflicts of interest related to this study.

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