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Tomographic Assessment of Different Attachment Sizes in Implant Supported Overdenture

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TOMOGRAPHIC ASSESSMENT OF DIFFERENT ATTACHMENT SIZES IN IMPLANT SUPPORTED OVERDENTURE

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ABSTRACT

Objective: This research was carried to evaluate which ball size mounted on bar splinting two implants supporting overdenture is more favorable regarding bone height and density.

Material &methods: Two implants(Tut Dental Implant System,ECDI Cairo, Egypt) splinted by bar (OT bar Multiuse attachments,Cas,RHEIN 83, ITALY) carrying two balls (OT Cap attachments, Cas, RHEIN 83 Italy) were inserted in n=10/gp. Patients were divided into two groups according to the size of the balls used which were either micro1.8mm or macro 2.5mm (control group). For all patients overdentures were constructed & conventional tomograms were taken. Crestal bone height & density around the implants in zone-1(osseointegration-zone) and zone-2 at insertion, six and twelve months were measured and statistically analyzed (Student-t-test, $p \leq 0.05$).

Results: Crestal bone heights: The two groups showed bone resorption however, statistically significant difference between the two groups was found, where micro-size ball showed less bone resorption with mean difference0.57±0.08 from insertion to twelve months in comparison to macro-size ball which showed 1.03±0.20 mean difference from insertion to twelve months. Bone density: The two groups showed increase in bone density. In zone-1: Statistically significant difference was found between the two groups, where micro-size ball showed less increase in bone density with mean difference 26.19±4.02from insertion to twelve months in comparison to macro-size ball which showed 44.12±7.34 mean difference from insertion to twelve months. In zone-2: Statistically non-significant difference was found between the two groups , where micro-size ball showed mean difference 59.02±2.59 from insertion to twelve months in comparison to macro-size ball which showed 59.96±6.26 mean difference from insertion to twelve months.

Conclusion: Micro-size balls show less bone resorption however, macro-size balls show more increase in bone density.

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INTRODUCTION

The treatment of completely edentulous mandible with two implant retained overdenture is well-accepted treatment option and is now considered the first choice for edentulous patients. [1] Patient satisfaction with implant-retained overdentures is related to esthetics and function. The clinical comfort achieved is dependent on many factors including the degree of retention provided by proper location and orientation of implants, fitness of the prosthesis and the use of attachment elements as bar and clips, balls or magnets. [2] Although magnets and studs are less expensive and easier to use, provide more favorable load transfer to bone yet, bar with additional attachments provide greater retention and stability, permit splinting of implants, mask excessive residual ridge atrophy and has been reported to be more successful. [3-10]

Reviewing the previous studies [11-12] it was found that implants splinted with a bar or left with ball attachments, rated significantly higher stability and chewing comfort for the mandibular overdenture than implants with magnet attachments, thus patients strongly preferred bar-clip and ball-socket attachments over magnet attachments.

Trying to modify the form of the bar, Leonard et. al, [13] presented a procedure for fabrication of cobalt-chromium milled bar with four ball attachments supporting a mandibular overdenture and found that the prosthesis met the requirements for masticatory efficiency, natural esthetics, and maintenance of health of residual tissues.

The rapid rise in requests for radiographic examinations in dentistry has been associated with the growing popularity of oral implantology in the management of partial or total edentulism in general. Oral implant imaging can involve three distinct imaging modalities: conventional tomography, spiral multislice CT, and CBCT. Their superiority in implant imaging over plain radiographs is attributable to their ability to produce cross-sectional images along the arches. These images provide details of bone morphology and dimensions as well as locations of vital structures. [14]

Dental implants are often a predictable treatment option for replacement of missing teeth; however, presurgical assessment is critical to avoid problems related to inadequate bone volume, axial alignment relative to occlusal loads, or location of critical structures such as the mandibular canal. Standard panoramic and periapical radiographs do not provide cross- sectional information and are therefore insufficient for implant site evaluation. Three-dimensional imaging techniques such as computerized tomography (CT) and conventional tomography can provide the needed information; however, many implants are still placed without the benefit of 3D imaging because of the increased cost to the patient or lack of availability. [15]

Conventional tomography, provides cross-sectional views of proposed implant sites. With conventional tomography, the x-ray tube moves in a straight line in one direction while the film moves in the opposite direction. Only objects lying in a plane coinciding with the pivot point of a line between the tube and the film remain in focus. Studies that have assessed the accuracy of conventional tomography for implant site assessment have reported mixed results. One reason for this is that blurring and magnification error that can adversely affect interpretation of the tomographic images. A study of 235 endosseous implants, found that conventional tomography resulted in a statistically non significant discrepancies between the planned prosthetic and the actual bone trajectories in the mandibular anterior area. On the other hand, conventional tomography was 2.5 times more accurate in predicting implant size selection than panoramic and periapical radiographs.[16]

In this study two implants splinted by a bar carrying two ball attachments were used to combine the advantages of bar by allowing splinting of implants and better retention and stability of the prosthesis with the advantage of less load transfer to bone provided by the freedom of movement of ball attachment. The idea of this research was aroused to evaluate whether the difference in sizes of ball attachments would affect the surrounding supporting structures or not using conventional tomographic radiology.

MATERIALS AND METHODS

The University's Clinical Research Ethics Board approved the research protocol including the exclusion/ inclusion criteria and the informed consent. The inclusion criteria required that participants should be completely edentulous no more than five years, medically and psychologically suited for implant surgery, able to complete study forms, and willing to commit to one year of participation in the trial after receiving new dentures. Clinical and radiographic examination of the patients' residual alveolar ridge revealed adequate bone height, width (Type2AB). [17] Volunteers were excluded from the study if they had: received treatment previously with oral implants, need for additional pre-prosthetic surgery, inadequate inter-occlusal distance, insufficient bone height for at least a 10 mm mandibular implant, or a history of systemic, neurologic , autoimmune, metabolic or hormonal disorders that may affect bone quality, delay post operative healing or contribute to bone resorption.

Twenty completely edentulous patients were selected from the out-patient of the prosthodontic departments with age ranging between 52 and 65 years. All patients were subjected to routine clinical and radiographic examinations before inserting the implants. Due to limited financial resources, the decision was made to provide a mandibular overdenture retained by 2 implants (Tut Dental Implant System; Egyptian Co. for dental ECDI) Cairo, Egypt) inserted bilaterally in the canine region. The implants were splinted by using OT BAR (OT bar Multiuse attachments,Cas,RHEIN 83, ITALY) with two OT CAP ball attachments (OT Cap atachments, Cas, RHEIN 83 Italy) to provide retention of the overdenture. Implants with diameter (3.9 x 13 mm) were placed in bone to the level of the cortical plate and the oral mucosa was sutured over it. Following a 3-month healing period, the implants were exposed to receive healing abutments. An alginate impression (Alginmax, Major Prodotti. Dentari SPA. Moncalieri. Italy) was made using stock tray to pour a cast upon which a special tray was made. Two weeks later the healing abutments were replaced with castable plastic cylinder bar abutments (Tut Dental Implant System;Egyptian Co.for dental implants(ECDI) Cairo, Egypt)) which were screwed into position with retaining screws. Definitive impression of the abutments and the residual ridge was taken with closed tray (indirect impression technique) using polyether impression material (Impregum F; 3M ESPE, St. Paul, Minn) manipulated according to the manufacturer's instructions. After removal of the impression from the patient's mouth, the castable plastic cylinder abutments were unscrewed to be replaced by the healing abutments. The implant replicas were screwed into the castable plastic cylinder abutments which were fitted carefully in the impression to pour the definitive cast for fabrication of the bar.

Castable plastic pattern of OT bar was cut to a suitable length and adhered to the castable plastic cylinder abutments on the definitive cast. Two marks were made to divide the bar into three equal thirds and two OT castable plastic ball attachments were adhered on the two marks .

According to the size of the two balls attachments the patients were divided into two groups:

GroupI: received macro size balls having 2.5mm diameter (Fig 1).

Group II: received micro size balls having 1.8mm diameter (Fig 2).

Fig (1) Macro size ball

Fig (2) Micro size balls

The overdenture bar, balls and abutments were casted following the conventional casting methods in cobalt-chromium alloy (Remanium GM 380+; Dentaurum, Ispringen, Germany) The assembly was tried in the patient's mouth and checked for marginal fit, contour and accurate seating. The assembly was screwed then a primary alginate impressions (Alginmax, Major Prodotti. Dentari SPA. Moncalieri. Italy) for the upper and lower jaws were made, to obtain study casts upon which special trays were made. Final impressions were made using polyether impression material (Impregum F; 3M ESPE, St. Paul, Minn), to obtain master casts upon which occlusion blocks were made. Centric occluding relation was recorded following the conventional wax wafer technique. Setting up of teeth was done according to modified lingualized occlusion using modified cuspless teeth (Vita-pan acrylic teeth, Vita Bad Sackingen-Germany). The waxed up dentures were tried in the patient's mouth, then flasked and processed into high impact heat cure acrylic resin (Lucitone199, Dentsply, York, PA-USA).

Relief of the fitting surface of the overdenture was done above the ball attachments until the overdenture was fully seated with the nylon caps of the ball attachments properly seated above the balls. Self cure acrylic resin (Lucitone 199; Dentsply) was inserted in the relief area to pick up the nylon caps and the patient was instructed to close in centric until complete polymerization has taken place. Any excess material was removed and the mandibular overdenture was removed and left for bench curing for about 30 minutes. Any necessary adjustments were carried out to eliminate occlusal interference and patients were instructed to maintain strict oral hygiene measures and return for recall appointments after six and twelve months.

Digital tomography procedures

Digital tomograms were taken with the Promax 3D Max (PlanmecaCo., Helsinki, Finland), digital x-ray device. The Promax 3D Max provides 4 slices as selected by the operator (3 cross-section and 1longtudinal) using one sweeping method. The narrow x-ray beam makes one sweeping movement and the rotation center moves simultaneously along the image layer with 6mm slice thickness. The angle of the first exposure is +7° counterclockwise, while the angle of the third exposure is +7° clockwise.

Automatic exposure control was used to control density and contrast of the images. The tomograms were exposed and assessed for diagnostic quality by an oral and maxillofacial radiologist.

Image analysis

The Images of the study were analyzed radiometrically and radiodensitometrically.

Radiometric analysis

Planmeca Romexis software used for capturing, viewing, and processing images acquired with Planmeca's digital x-ray devices. It is fully Dicom compatible. Regarding the cross-section view, two lines were drawn parallel to the long axis of the implant on the buccal and lingual surfaces Fig 3. The two lines were extended from the alveolar crest to the apical end of the implant and tangent to the implant serration then the average of the two sides were calculated.

Radiodensitometric analysis

IDRISI Kilimanjaro software was used to assess the radiodensity around the implants under investigation. IDRISI software divides the area surrounding the dental implant into two zones with standardized width {zone1 (osseointegration zone) and zone 2} Fig 4. The software analyzes the images through the following steps; image restoration, image enhancement, and density measurement. Image restoration technique allow for the geometric correction of the images. The procedure was followed by image enhancement technique which allows contrast adjustment of all the images, then implant edge enhancement, followed by subtracting the implant from the background image (surrounding bone). Finally, the density measurements were calibrated by quantifying the image on 256 grey scales. Zero scale was given to the totally radiolucent region and 255 *was* given to the totally radiopaque region while values in between represent the grey shades.

Fig (3) Cross-sectional tomographic view showing the buccal and lingual plate of bone.

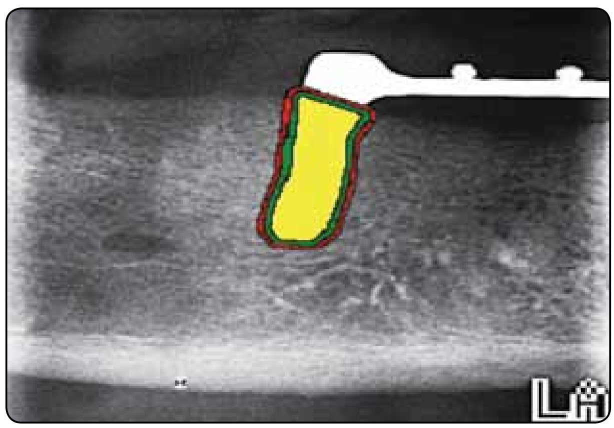

Fig 4: Tangential tomographic view showing zone 1(green zone) and zone 2 (red zone)

Statistical analysis

Instat for windows, version 3.036 (Statistical Services Center, University of Reading, UK) was used for data analysis. Student-t-test was used to compare the different effect of micro and macro ball attachments mounted on a bar retaining overdenture on crestal bone height surrounding the implant and on bone density. The significance level was set at $p \leq 0.05$.

RESULTS

Effect of different ball sizes on the crestal bone height surrounding the implants

TABLE (I) Mean and standard deviations of the effect of different ball sizes on crestal bone heights surrounding the implants

	Micro- ball		Macro-ball	
	Mean	±sd	Mean	±sd
At-insertion	2.88 mm	0.26	2.8 mm	0.27
After six months	2.60 mm	0.398	2.27 mm	0.28
After twelve months	2.31 mm	0.296	1.77 mm	0.32

Mean and standard deviations of the effect of different ball sizes on crestal bone height surrounding the implants in table I shows decrease in the crestal bone height surrounding the implants throughout the study period in both groups.

TABLE (II) Mean differences and standard deviations of the effect of different ball sizes on crestal bone heights surrounding the implants

	Micro- ball		Macro-ball		t-value	p-value
	Mean difference	±sd	Mean difference	±sd		
0-6 m	0.27mm	0.06	0.54mm	0.12	5.000	<0.0001
6-12m	0.3mm	0.06	0.49mm	0.09	7.856	<0.0001
0-12m	0.57mm	0.08	1.03mm	0.20	9.550	<0.0001

Mean difference, standard deviations, and student t test are shown in table II. Student-t-test showed statistically extremely significant difference between micro and macro sizes ball attachments on crestal bone height surrounding the implants throughout the study period where macro-sized ball attachment showed higher crestal bone height reduction than micro-sized ball attachment.

Effect of different ball sizes on the bone density around the implants

Table (III) Mean and standard deviations of the effect of different ball sizes on the bone density of zone (1) around implants

	Micro- ball		Macro-ball	
	Mean	±sd	Mean	±sd
At-insertion	108.44	4.527	90.187	1.147
After six months	118.32	6.065	110.56	4.35
After twelve months	134.63	6.15	134.307	7.69

Mean and standard deviations of the effect of different ball sizes on bone density of zone (1) around implants in table III shows increase in bone density in both groups throughout the study period.

Table (IV) Mean differences and standard deviations of the effect of different ball sizes on the bone density of zone (1) around implants

	Micro- ball		Macro-ball		t-value	p-value
	Mean difference	±sd	Mean difference	±sd		
0-6 m	9.88	2.01	20.37	3.94	10.606	<0.0001
6-12m	16.31	3.26	23.7	4.39	6.085	<0.0036
0-12m	26.19	4.02	44.12	7.34	9.582	<0.0001

Mean difference, standard deviations, and student t test are shown in table IV. Student-t-test showed statistically extremely significant difference between micro and macro sizes ball attachments in bone density in zone 1 around implants through the period from 0-6months & 0-12months and statistically very significant difference from 6-12months where macro-sized ball attachment showed higher increase in bone density than micro-sized ball attachment throughout the study period.

Table (V) Mean and standard deviations of the effect of different ball sizes on the bone density of zone (2) around implants

	Micro- ball		Macro-ball	
	Mean	±sd	Mean	±sd
At-insertion	131.59	2.03	127.39	14.08
After six months	152.94	2.986	148.409	15.89
After twelve months	190.61	2.82	187.35	19.275

Mean and standard deviations of the effect of different ball sizes on the bone density of zone (2) around implants in table V shows increase in bone density in both groups throughout the study period.

Table (VI) Mean differences and standard deviations of the effect of different ball sizes on the bone density of zone (2) around implants

	Micro- ball		Macro-ball		t-value	p-value
	Mean difference	±sd	Mean difference	±sd		
0-6 m	21.35	2.98	21.02	2.27	0.394	0.817
6-12m	37.66	3.91	38.94	5.486	0.8497	0.4008
0-12m	59.02	2.59	59.96	6.26	0.6205	0.5386

Mean difference, standard deviations, and student t test are shown in table VI. Student-t-test howed statistically non significant difference between micro and macro sizes ball attachments regarding bone density in zone (2) throughout the study period.

DISCUSSION

Implants were placed in the canine region bilaterally (B and D) regions) as in this position the bar splinting these implants is straight rather than curve, thus having less potential load per surface area compared to implants splinted in the premolar region (A and E regions) with curve bar. [17]

Nowadays it is documented that crestal bone resorption is not only unavoidable , but also time related.[18] In this study crestal bone height reduction was about 0.57mm in case of micro-size ball and1.03 in case of macro-size ball which complies with the success criteria of Albrektsson et al [19] being lower than 1.5mm yearly resorption after abutment connection. Bone loss may be attributed to the masticatory load applied to the posterior parts of the overdenture resulting in unfavorable torquing forces on the balls and abutments. The greater reduction in the macro-size cases in comparison to micro-size may be attributed to the increased profile height of the ball (lever arm) magnifying the torque on crestal bone around the implant. [20]This was in agreement with Kenney and Richards [21] who found that increasing profile height of stud attachments increases the lateral load on the implant and surrounding tissue.

The increase in bone density (zone-1and zone-2) of micro-size and macro-size balls agrees with the results of Quirynen etal [22]which demonstrated an increase in density of peri-implant bone structures over six months to four years period after implant placement. This increase is considered a positive response of bone to load applied within its physiologic limit and adaptive capacity. [23]

The significant increase in bone density (zone-1) in case of macro- size than micro-size balls may be attributed to the fact that the larger surface area of macro-size ball gives greater retentive force in comparison to the micro-size ball which in turn creates significantly higher stresses. [24] This increase in stresses affects directly the thickness and approximation of bone trabeculae causing greater increase in density. [25-26]

Regarding zone-2, the non significant difference between micro-size and macro-size balls regarding bone density may be attributed to dissipation of stresses before reaching the far away zone.

CONCLUSION

Within the limitations of this study it was concluded that:

Micro-size ball attachments show less crestal bone height reduction however, macro-size ball attachments show more increase in bone density in case of implant supported overdenture.

Conventional tomography may be represented as an alternative modality to overcome increased cost and lack of availability of CT and CBCT in the three dimensional evaluation of implant site.

REFERENCES

1- Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, et al.: The McGill consensus statement on overdentures.Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24-25, 2002. Int J Oral Maxillofac Implants 2002;17: 601-2.

2- Brian H, Williams, Kent T, Ochiai, Satoru Hojo, Russell Nishimura, and Angelo A. Caputo: Retention of maxillary implant overdenture bars of different designs.J Prosthet Dent 2001;86:603-7.

3- Federick DR, Caputo AA.: Effects of overdenture retention designs and implant orientation on load transfer characteristics. J Prosthet Dent 1996;76:624-32.

4- Naert I, Quirynen M, Hooghe M, van Steenberghe D.: A comparative prospective study of splinted and unsplinted Branemark implants in mandibular overdenture therapy: a preliminary report. J Prosthet Dent 1994;71:486-92.

5- Jemt T, Book K, Linden B, Urde G.: Failures and complications in 92consecutively inserted overdentures supported by Branemark implants in severely resorbed edentulous maxillae: a study from prosthetic treatment to first annual check-up. Int J Oral Maxillofac Implants 1992;7:162-7.

6- Van Steenberghe D, Quirijnen M, Calberson L, Demanet M. A prospective evaluation of the fate of 697 consecutive intra-oral fixtures modum Branemark in the rehabilitation of edentulism. J Head Neck Pathol 1987;6:53-8.

7- Engquist B, Bergendal T, Kallus T, Linden U.: A retrospective multicenter evaluation of osseointegrated implants supporting overdentures. Int J Oral Maxillofac Implants 1988;3:129-34.

8- Naert I, De Clerq M, Theuniers G, Schepers E. :Overdentures supported by osseointegrated fixtures for the edentulous mandible: a 2.5-year report. Int J Oral Maxillofac Implants 1988;3:191-6.

9- Davodi AD, Nishimura R, Beumer J 3rd. An implant-supported fixed removable prosthesis with a milled tissue bar and Hader clip retention as a restorative option for the edentulous maxilla. J Prosthet Dent 1997;78:212-17.

10- Mericske-Stern R, Probst D, Fahlander F, Schellenberg M:Within-subject comparison of two rigid bar designs connecting two interforaminal implants:patients' satisfaction and prosthetic results.Cin Implant Dental Res. 2009;11:228-37

11- Naert I, Alsaadi G, Quirynen M.: Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: A 10-year randomized clinical study Int J Prosthodont 2004;17:401-10.

12- Cune M, van Kampen F, van der Bilt A, Bosman F.:Patient satisfaction and preference with magnet, bar-clip, and ball-socket retained mandibular implant overdentures: a cross-over clinical trial Int J Prosthodont 2005 ; 18: 99-105.

13- Leonard G. Lowe, Vladimir M. Shcherbukhin, Dip Dent Techb.: An implant-supported, cobalt-chromium milled bar and non flanged attachment-retained overdenture to rehabilitate the edentulous mandible Top of Form. J Prosthet Dent 2009;102:46–51.

14- Anson CM, Chau and Kanl fung: Comparison of radiation dose for implant imaging using conventional spiral tomography, and cone- beam computed tomography. Oral Surg, Oral Med, Oral Pathol, and Oral Endod.2009; 107: 559-565.

15- Luis A. Perez, Sharon L. Brooks, Hom- Lay Wang and Robert M Ebner.:Comparison of linear tomography and direct ridge mapping for the determination of edentulous ridge dimensions in human cadavers. Oral Surg, Oral Med, Oral Pathol, and Oral Endod.2005; 99: 748-754.

16- Peltola JS, Mattila M.: Cross-sectional tomograms obtained with four panoramic radiographic units in the assessment of implant site measurements. Dentomaxillofac Radiol 2004; 33:295–300.

17- Mich,C. 11. Classification of partially and completely edentulous arches in implant dentistry In: Contemporary implant dentistry. St.Louis.C.V.Mosby, 1993 :201-221.

18- Akça K, Eser A, Canay S.: Numerical simulation of the effect of time-to-loading on peri-implant bone. Med Eng Phys. 2010 :32:7-13.

19- Albrektsson T, Zarb G, Worthington DP and Eriksson RA: The long-term efficiency of currently used dental implants. A review and proposed criteria of success. Int J. Oral maxillofac. Implants 1986.;1:11-24.

20- Braggen U, Burgin W, Long WP et al: Digital subtraction radiography for the assessment of changes in peri-implant bone density. Int J Maxillofac Impl 1991; 6:160-166.

21- Kenney R, Richards MW. Photoelastic stress patterns produced by implant-retained overdentures. J Prosthet Dent 1998;80:559-564

22- Quirynen M; Naert I; Van Steenberghe D and Nys L: A study of 589 consecutive implants supporting complete fixed prosthesis. Part I: Peridontal aspects. J. Prosthet. Dent 1992; 68: 655-663.

23- Page ME : Systemic and prosthodontic treatment to prevent bone resorption in edentulous patients. J. Prosth. Dent 1975;33: 483-488.

24- Berg T, Caputo AA. Load transfer by a maxillary distal-extension removable partial denture with cap and ring extracoronal attachments. J Prosthet. Dent 1992:68:784-789.

25- Baker J. and Goodkind RJ : Theory and practice of precision attachment removable partial dentures. PP 35-51, 123-125. CV Mosby Co st Louis Toronto, London,1981.

26- Misch CE: Principles for screw retained prostheses in contemporary implant dentistry. PP 669-686 St. Louis, Mosby,1993.