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A Comparative Evaluation of Locator Versus Ball and Socket Attachment in Implant Retained Mandibular Overdenture Cases Using CBCT

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A COMPARATIVE EVALUATION OF LOCATOR VERSUS BALL AND SOCKET ATTACHMENT IN IMPLANT RETAINED MANDIBULAR OVERDENTURE CASES USING CBCT

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ABSTRACT

An overdenture retained by two implants is considered the first treatment choice for edentulous mandible.

Purpose: To evaluate which solitary attachment; ball and socket or locator is less destructive to crestal bone around implants and to distal aspect of the ridge.

Materials and Methods: Fourteen completely edentulous patients received mandibular over dentures retained by two implants. Patients were divided into two groups; Group-I received ball and socket attachment while Group-II received locator attachment. For each patient radiographic cone beam tomography was taken at denture insertion, nine and eighteen months after denture insertion. Measurements were taken on crestal bone height around implants and distal aspect of the ridge.

Results: *Crestal bone height:* Both groups showed bone resorption however, statistically significant difference between the two groups was found where ball and socket attachment showed more bone resorption. *Distal aspect of the ridge:* Both groups showed bone resorption however, statistically significant difference between the two groups were found where locator showed more bone resorption.

Conclusion: Locator attachment is more compatible with crestal bone height around the implants however; ball and socket attachment is more compatible with bone height in the distal aspect of the ridge in case of implant-retained overdenture.

KEYWORDS: Implant, Locator , Ball and Socket attachment,Overdenture, CBCT

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INTRODUCTION

The 2002 McGill Consensus Conference[1] suggested that restoration of edentulous mandible with conventional denture is no longer the most appropriate first-choice prosthodontic treatment. Attendees produced a consensus statement that the first treatment choice for edentulous mandible was an overdenture retained by two implants. This type of implant overdenture permits better masticatory function than conventional complete dentures thus, improving their psychological well-being.[2-4]

Retention and stabilization for overdenture are provided by features of denture-bearing area and attachment components, as bar and clips, or solitary attachments as balls, O-rings or newly introduced locater attachment. [5-8] Individual implants with ball attachments have had the same favorable clinical results in mandible as rigidly splinted implants.[9] In comparison to bar and clip attachment, ball attachments may be less costly, less technique sensitive, less dependent on implant position, easier to clean and to replace, easier to adjust and to control the amount of retention, require less interarch space, and are better able to distribute forces. [9-11]

For implant retained overdenture, it has been recommended that implants should be placed parallel to one another and to the path of insertion of the prosthesis, especially when attachments are contemplated.[12-14] Nowadays, locater attachments are capable of correcting an inter-implant angulations up to 40°.[15] Regarding the height of attachment Preiskel et al [13]advocated that increasing the height of attachment, complicates the alignment. Limited interarch space often restricts the prosthetic armamentarium to low-profile attachments and prevents using O-ring attachments and bars.[16] Locater attachments provide low profile design which provides critical advantage in tight interocclusal spaces.[17]

Single attachments as ball attachment, O-ring attachment, or locater attachment may be the best choice in patients experiencing problems with oral hygiene because of their superior accessibility.[18] Moreover, Takanashi et al.[19] estimated that the time required to fabricate mandibular overdenture retained by implants with ball attachments was not significantly different than the time needed for conventional denture treatment. The potential for mucosal hyperplasia is more easily reduced with solitary attachments. [20] It has been shown that solitary ball attachment is available with varying degrees of retention.[21] Locater attachment is also available with varying degrees of retention in addition to its dual retention design which provides combination of inside and outside retention ensuring long-lasting retention life.

Today, more radiographic techniques are available than before to guide clinicians in implant assessment, Panoramic radiography can be considered for primary evaluation in order to obtain information about bone height and to some extent, information of horizontal distances. Intra-oral and panoramic radiographs give information in two dimensions only. The assessment of location of mandibular canal, mental foramen and the angulations of the alveolar crest is a prerequisite for appropriate implant assessment. Hence, radiographic examination has to, in some patients, include cross-sectional tomography.[22]

During the last decade, there has been a growing trend to use 3-dimensional (3D) imaging to improve dentomaxillofacial diagnosis. At first, this was achieved by the use of conventional single and later multislice computerized tomography (MSCT). Because conventional CT protocols are generally associated with relatively high radiation dose levels, alternative CT protocols for facial bone visualization and modeling have been developed to deal with this issue without significant loss of image quality. In this respect, cone-beam CT (CBCT) holds promising potential for oral and craniofacial imaging applications. [23]

Thus, this study was conducted to evaluate which solitary attachment either ball and socket or locater is less destructive to crestal bone height around implant and to distal aspect of the ridge using CBCT.

MATERIALS AND METHODS

Fourteen completely edentulous male patients with age ranging between 57 to 65 years were included in the study. All patients were motivated to the treatment and they signed an informed consent form to cooperate and follow the recommendations and instructions. Ethical approval for the project was granted by The Human Research Ethics Committee of Ain-Shams University, Cairo, Egypt; including exclusion/ inclusion criteria, and the informed consent. Inclusion criteria dictated being completely edentulous for at least two years before starting the study, freedom from systemic, neurologic, autoimmune, metabolic or hormonal disorders that may affect bone quality, or contribute to bone resorption. Clinical and radiographic examination of the patients› residual alveolar ridge revealed adequate bone height, width (Type2AB) [24], firm healthy mucosa and freedom of any pathological signs, bony undercuts, or neoplasia. Exclusion criteria included smokers, drug or alcohol abuse, systemic condition preventing surgery, any physical conditions that could affect follow-up, psychiatric problems and disorders to the implant area related to a history of head and neck radiation. Patients with clenching habits, bruxism, abnormal ridge relation or tempro-mandibular joint disorders were also excluded.

Complete dentures were constructed to all patients following the conventional techniques, using alginate impression (Alginmax, Major Prodotti. Dentari SPA. Moncalieri. Italy) in stock tray for primary impression and medium body rubber base (Swiss TEC, Coltene, Whaledent, Altstatten, Switzerland) in a specially constructed special trays for secondary impression. Occlusion blocks were fabricated on the poured master casts. 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).[25]Waxed up denture was tried in the patient's mouth, then flasked and processed into high impact heat cure acrylic resin (Lucitone 199, Dentsply, York, PA-USA). Laboratory remounting was done before finishing the denture and occlusal discrepancies were adjusted. Lower denture was duplicated for fabrication of clear acrylic resin stent (Vertex Rapid Simplified; Vertex-Dental BV, Zeist, The Netherlands) to act as a surgical guide for implant positioning.

For each patient two implants (SBM screwvent® implants, Zimmer Dental Inc., Carlsbad, CA, USA) were inserted bilaterally in the canine region. Using surgical stent the mandibular canine areas were identified to start drilling using the pilot drill followed by the use of sequential implant drills in order of increasing diameter under copious irrigation. After the final preparation of the two implant sites, each implant (3.7 x 13mm) was inserted into its site and cover screws were then threaded into the implants, flap was repositioned and sutured.

After three months patients were randomized into two groups according to the type of attachments they received.

Group-I: Received ball and socket attachment (Zimmer Dental Inc., Carlsbad, CA,USA) fig (1) in the form of :

Male part: Consisting of metallic ball abutment of cuff height 2mm. Ball abutment was inserted into the implant and screwed using hex tool.

Female part: Consisting of resilient retention cap snapped in metal housing to be picked-up in the denture fitting surface.

Group II: Received Locater attachment (Zest Anchors, INC. Escondido, CA, USA.) fig (2) in the form of:

Female part: Consisting of metallic locater abutment of cuff height 2mm. Locater abutment was inserted into the implant and rotated into its position using locater abutment driver. Locater torque wrench was used for tightening the abutment.

Male part: Nylon pink male pivot which provides intermediate (three pounds) level of retention was chosen. Using Locater male seating tool, nylon pink male pivot was firmly pushed inside the empty metal cap to be picked-up in denture fitting surface.

Complete seating of abutments was verified by radiographing the implant abutment interface. Abutments with their attachments were marked and relieved on the fitting surface of the mandibular overdenture to create enough space to accommodate overdenture abutments and attachments. The denture was tried in the patient's mouth to ensure complete seating. A mix of self cure acrylic resin (Lucitone 199; Dentsply) was applied in the relieved region for direct pick- up of the attachments and the patient was instructed to close in centric during this procedure. Any necessary adjustments were carried out to eliminate occlusal interference and the denture was delivered to the patient and checked after 24 and 72 hrs for any needed adjustment and to ensure that the patient was satisfied with esthetic, stability and retention of the denture.

Imaging

Forty two dental CBCT examinations were performed with a Promax 3D Max (Planmeca Co., Helsinki, Finland). The imaging parameters for the Promax 3D Max were 10-16 mA and 84 kVp with a 0.5 mm fixed focal spot. The field of view (FOV) was the sole option for Promax 3Dmachine to minimize the radiation dose, a FOV of 50 mm height and 80 mm diameter was used for single view of the mandible. The total scanning time was 18seconds for one volume, while the actual exposure time was only 6 seconds. The nominal voxel size was 0.16 mm. Image analysis was carried out using Planmeca Romexis software, fully Dicom compatible and Java based software. The acquired set of axial images was reconstructed into bi-dimensional sections (transaxial views and

Fig. (1) Ball abutment

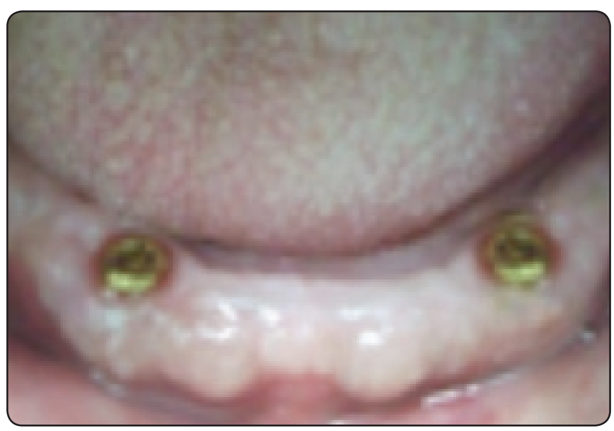

Fig. (2) Locator abutment

panoramic views). The transaxial and panoramic views are images of sections perpendicular to the axial plane and calculated along parabolic arches located by users at the dental arch. 3D coordinates of the reconstruction volume were used to calculate crestal bone level using unique craniometric anatomical landmarks.

Radiographic assessment of crestal bone level:

a. Around the implant:

Craniometric points (marginal bone level & the apical end of the implant) were identified and the correspondent linear measurements were determined electronically by the same examiner twice each, independently. Time interval between these repeated measurements for inter-examiner reliability determination was 7 days. For each patient, the points were located during first reading session, and then correspondent measurements were obtained by computer tools. In the predetermined image for each case, the observer had to decide whether implant and crestal bone were clearly visible.

Mesial and distal crestal bone level were calculated from the reconstructed panoramic view by drawing a line parallel to the implant serration and extended from the crestal bone to the apical end of the implant. On the other hand, buccal and lingual bone levels were calculated using the cross-sectional views (fig3A,B).

b. Distal aspect of the ridge:

Regarding distal aspect of the alveolar ridge, a line was drawn parallel to the line drawn distal to the implant, and 1cm distal to the mental foramen (molar area). Then, bone height will be calculated from both panoramic and cross-sectional views.

Crestal bone levels relative to the implant reference points and the distal aspect of the ridge were measured at mesial, distal, buccal, and lingual surfaces three times: at overdenture insertion (baseline level) and after nine and eighteen months of functional loading.

Average readings of the four surfaces at each interval for both crestal bone height around the implant and the distal aspect of the ridge were calculated and tabulated for statistical analysis

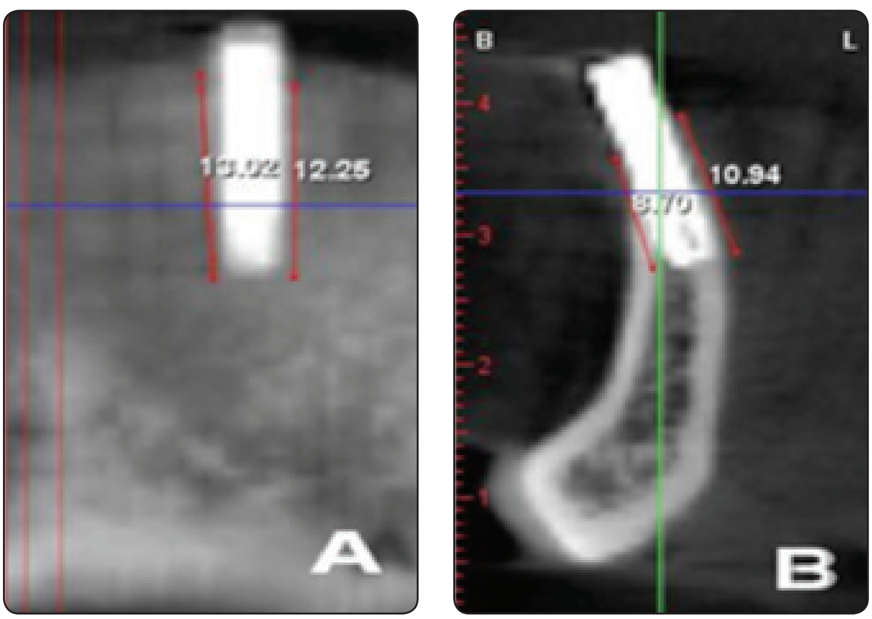

Fig. (3A) Measurement of marginal bone level relative to the reference point on the implant blue lines indicate mesial (left) and distal (center) measurement locations.

Fig.3-B) Measurement of marginal bone level relative to the reference point on the implant blue lines indicate buccal (left) and lingual (center) measurement locations. The long green line (right) indicates the length measurement.

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 overdenture retained by ball and socket attachment or locator attachment on crestal bone surrounding the implants and bone in distal aspect of ridge supporting the overdenture. The significance level was set at $p \leq 0.05$.

RESULTS

Effect of different attachments on crestal bone height around the implants supporting overdenture

Mean and standard deviations of the effect of different attachments on crestal bone height surrounding the implants are shown in table (1). This table shows decrease in bone height throughout the study period in both groups.

Mean difference, standard deviations and student-t -test of crestal bone height changes using the studied attachments are shown in table (2). Student-t-test shows statistically extremely significant differences between using ball and socket attachment and locator attachment on crestal bone height surrounding the implants throughout the study period where ball and socket attachment shows higher decrease in crestal bone height than locater attachment.

Effect of different attachments on the distal aspect of the ridge

Mean and standard deviations of the effect of different attachments on bone height in distal aspect of the ridge are shown in table (3). This table shows a decrease in bone height throughout the study period in both groups.

TABLE (1) Mean, and standard deviations of the effect of different attachments on crestal bone height surrounding the implants.

	Ball		Locator	
	Mean	±sd	Mean	±sd
At-insertion	12.85 mm	0.44	12.49mm	0.59
At-nine-months	12.24mm	0.44	12.07mm	0.59
At-eighteen months	11.75mm	0.44	11.83mm	0.59

TABLE (2) Mean differences, standard deviations and result of student t-test of the effect of different attachments on crestal bone height surrounding the implants.

	Ball		Locator		t-value	p-value
	Mean difference	±sd	Mean difference	±sd		
0-9 m	0.611mm	0.08	0.42mm	0.06	7.028	<0.0001
9-18m	0.48 mm	0.08	0.24mm	0.048	9.530	<0.0001
0-18m	1.095mm	0.0999	0.66mm	0.09	12.149	<0.0001

TABLE (3) Mean, and standard deviations of the effect of different attachments on bone in distal aspects of the ridge.

	Ball		Locator	
	Mean	±sd	Mean	±sd
At-insertion	32.01mm	1.44	31.58mm	1.92
At-nine-months	31.81mm	1.45	31.297mm	1.93
At-eighteen months	31.62mm	1.45	30.99mm	1.93

TABLE (4) Mean differences and standard deviations of the effect of different attachments on bone in distal aspects of the ridge.

	Ball		Locator		t-value	p-value
	Mean difference	±sd	Mean difference	±sd		
0-9 m	0.205mm	0.03	0.29mm	0.05	5.45	<0.0001
9-18m	0.19mm	0.04	0.31mm	0.05	7.012	<0.0001
0-18m	0.39mm	0.05	0.60mm	0.07	9.134	<0.0001

Mean difference, standard deviations, and student t test of bone loss on the distal aspect of the ridge using the studied attachments are shown in table 4. Student-t-test shows statistically extremely significant differences between using ball and socket attachment and locator attachment on bone in the distal aspects of the ridge throughout the study period where locater attachment shows higher decrease in bone height than ball and socket attachment.

DISCUSSION

The success of implant treatment relies on the amount of bone available. Radiological exams are recommended to acquire information on both quantity of bone, and to localize anatomical landmarks. In periapical and panoramic radiographs, information on bone width is lacking and the height may be misestimated both because of potential distortion caused by positioning errors and variable magnification. Thus, the cross-sectional imaging technique is recommended to accurately localize anatomical landmarks such as mental foramen, and to obtain information on the amount of bone.[26]

When complex motions are used, conventional tomography is the most cost-effective method available with the lowest radiation risk and therefore is recommended for majority of patients. However, the very sensitive radiological approach is the main drawback of conventional tomography.[27]

Helicoidal scanning techniques and use of cone beams with a multi-array detector have been developed to provide volumetric images through

CT. This new technology provides cross-sectional images without superimposition or blurring, and decreases the risk of radiation significantly.[28,29]

For the applied CBCT technology, investigations already showed high standard diagnosis opportunity and measurement accuracy pre-conditioning optimal software-based implant planning. Radiation exposure for the patient is relatively low and corresponds to a threefold digital panoramic dose and less than a tenth of a similar FOV medical 64-slice multidetector CT investigation.[30]

In this study crestal bone height reduction was about 1.095mm with ball and socket attachment and 0.656mm with locater attachment which complies with the success criteria of Albrektsson etal[31] 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 abutments. For two implants supporting mandibular overdenture, the implants act as fulcrum with two lever arms; one from the fulcrum to the distal extension of the denture and the other from the fulcrum anteriorly to the incisal edge. Less crestal bone resorption around the implant supporting the locater attachment in comparison to the ball attachment was found due to the difference in the matrix patrix relationship of the two attachments around which the denture was rotating.[32] In case of group II where we used locater attachment the design of the locater (supra-radicular) transferred the fulcrum point close to the fixture thus reducing lever arm and torque and allowing less crestal bone resorption.[33] The privileges of locator attachment are related to its design which allows space of 0.2 mm for vertical resiliency and 8^{o} hinging in any direction thus allowing the attachment to move in both the vertical plane and hinge axis. Throughout this locator can favorably distribute forces along the long axis of the implant.[34] On the contrary, with ball attachment the higher bending moments explained the high values of bone loss observed in peri- implant bone.[35]

The resorption in distal aspect of the ridge was higher with locator than ball, this can be explained by the fact that the vertical gap delayed the axial contact between the female and male parts. Therefore, with locator attachment, implants support only a weak part of the contact force with higher involvement of the denture bearing area.[34,36] This was emphasized by the fact that forces falling on implant supported overdenture are distributed between implants and denture supporting structures. Since the manner by which the attachment design distributes the forces determines the net effect on the supporting structures and as locater decreases forces falling on crestal bone surrounding the implant therefore, the net result of forces falling on distal aspect of the ridge increases in case of locater in comparison to ball and socket attachment explaining the increased bone loss in distal aspect of the ridge in case of locater.[37,38]

CONCLUSION

Within the limitations of this study, it can be concluded that depending on the health of distal aspect of the ridge the decision will be made to use either ball and socket attachment or locator attachment. CBCT evaluation of crestal bone level adjacent to implants and at the distal aspect of the ridge revealed that locater attachment is more compatible with crestal bone height around implant however, ball and socket attachment is more compatible with bone height in the distal aspect of the ridge in case of implant-retained overdenture.

REFERENCES

1. Feine JS, Carlsson GS, Awad MA, Chehade A, Duncan WJ, Gizani S, Head T,Lund JP,WM,Wismeijer D. The McGill consensus statement on overdentures. Int J Prosthodont 2002; 15:413-414.

2. Naret I, Gizani S, Vuylsteke M, Van Steenberghe D. A 5-year randomized clinical trial on the influence of splinted and unsplinted oral implants in the mandibular overdenture therapy. Part 1: Peri-implant outcome. Clin Oral Implants Res 1998; 9: 170-177.

3. Wismeijer D, Vermeeren JI, vanWass MA. Patient satisfaction with overdentures supported by one-stage TPS implants. Int J Oral Maxillofac Implants 1992; 7: 51-55.

4. Kent G, Johns R. Effects of osseointegrated implants on psychological and social well-being: a comparison with replacement removable prostheses. Int J Oral Maxillofac Implants 1994; 9: 103-106.

5. Cune MS, De Putter C, Hoogstraten J. Treatment outcome with implant retained overdentures: part I-clinical findings and predictability of clinical treatment outcome. J Prosthet Dent 1994;72:144-151.

6. Jemt T, Chai J, Harnett J, Health MR, Hutton JE, Johns RB. A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. Int J Oral Maxillofac Implants 1996; 11:291-298.

7. Gotfredsen K, Holm B. Implant-supported mandibular overdentures retained with ball or bar attachments: a randomized prospective 5-year study. Int J Prosthodont 2000; 13:125-130.

8. Wismeijer D, Van Waas MA, Mulder J, Vermeeren JI, Kalk W. Clinical and radiological results of patients treated with three treatment modalities for overdentures on implants of the ITI Dental Implant System. A randomized controlled clinical trial. Clin Oral Implants Res 1999; 10:297-306.

9. Sadowsky SJ. The implant-supported prosthesis for the edentulous arch: design considerations. J Prosthet Dent 1997; 78:28-33.

10. Wismeijer D, Van Waas MA, Vermeeren JI, Mulder J, Kalk W. Patient satisfaction with implant-supported mandibular overdentures. A comparison of three treatment strategies with ITI-dental implants. Int J Oral Maxillofac Surg 1997;26:263-267.

11. Menicucci G, Lorenzetti M, Pera P, Preti G. Mandibular implant-retained overdenture: a clinical trial of two anchorage systems. Int J Oral Maxillofac Implants 1998;13:851-6.

12. Khadivi V. Correcting a nonparallel implant abutment for a mandibular overdenture retained by two implants: A clinical report. J Prosthet Dent 2004; 92: 216-219.

13. Preiskel HW. Stud attachments and magnets. In: Overdentures made easy: A guide to implant and root supported prostheses. London: Quintessence; 1996: 89-97.

14. Sergio MO, Geoffrey ATh, John RA, Thomas DT, and Dimitri P. Retention forces of spherical attachments as a function of implant and matrix angulation in mandibular overdentures: An Invitro study.J.Prosthet Dent 2009; 101:231-238.

15. Walton JN, Huizinga SC, Peck CC. Implant angulation: a measurement technique, implant overdenture maintenance and the influence of surgical experience. Int. J. Prosthodont; 2001:14:523-530.

16. Pasciuta M, Grossmann Y, Finger I. A Prosthetic solution to restoring the edenulous mandible with limited interarch space using an implant tissue supported overdenture: A clinical report. J Prosthet Dent 2005; 93:116-120.

17. Ansgar CC, Lohkwork-song, Alvin G, Wee, Neo Tec-Khin. Prosthodontic management of edentulous patient with limited oral access using implant-supported prosthesis: A clinical report. J Prosthet Dent 2006 ; 96: 1-6.

18. Batenburg RH, Meijer HJ, Raghoebar GM, Vissink A Treatment concept for mandibular overdentures supported by endosseous implants: a literature review. Int J Oral Maxillofac Implants 1998; 13:539-545.

19. Takanashi Y, Pernord JR, Chehade A, Klemetti E, Savard A, Lund JP. Does a prosthodontist spend more time providing mandibular two -implant overdenture than conventional dentures? Int J Prosthodont 2002; 15: 397-403.

20. Krennmair G, Ulm C. The symphyseal single tooth implant for anchorage of a mandibular complete denture in geriatric patients: a clinical report. Int J Oral Maxillofac Implants 2001; 16: 98-104.

21. Sadowsky SJ. Mandibular implant-retained overdentures: a literature review. J Prosthet Dent 2001; 86:468-73.

22. Grondahl H-G, Grondahl K. Radiographic examination of the implant patient. In: Lang NP, Lindhe J, EDS. Clinical periodontology and implant dentistry.5th ed. Oxford,UK: Blackwell Munksgaard / Blackwell Publishing Ltd, 2008:600-622.

23. Loubele M, Van Assche N, Carpentier K, Maes F, Jacobs R, van Steenberghe D, Suetens P. Comparative localized linear accuracy of small-field cone-beam CT and multislice CT for alveolar bone measurements. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:512-518.

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

25. Mich,C. Maxillary denture opposing an implant prosthesis: Hydroxyapatite augmentation and modified occlusal concepts. In: Contemporary implant dentistry. St.Louis.C.V.Mosby, 1999 :629-746.

26. Bou Serhal C, Jacobs R, Flygare L, Quirynen M, Van Steenberghe D. Perioperative validation of localisation of the mental foramen. Clin Oral Implants Res 2002; 31:39-43.

27. Bou Serhal C, Van Steenberghe D, Quirynen M, Jacobs R, Flygare L. Localisation of the mandibular canal using conventional spiral tomography: a human cadaver study. Clin Oral Implants Res 2001; 12:230-236.

28. Ludlow JB, Davies-Ludlow LE, Brooks SL. Dosimetry of two extraoral direct digital imaging devices: NewTom cone beam CT and Orthophos Plus DS panoramic unit. Dentomaxillofac Radiol 2003; 32:229-234.

29. Hashimoto K, Arai Y, Iwai K, Araki M, Kawashima S, Terakado MA.. Comparison of a new limited cone beam computed tomography machine for dental use with a multidetector row helical CT machine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 95:371-377.

30. Ludlow JB and Ivanovic M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology 2008; 106: 930-938.

31. Albrektsson T, Zarb G, Worthington DP , Worthington DP, Eriksson RA.. The long-term efficiency of currently used dental implants. A review and proposed criteria of success. Int J. Oral maxillofac. Implants1986; 1:11-25.

32. Celik G, Uludag B. Photoelastic stress analysis of various retention mechanisms on 3-implant retained mandibular overdentures. J Prosthet dent 2007; 97:229-235.

33. Jingade RK, Rudraprasad IV, Sangur R. Biomechanics of dental implants: A FEM study. J. Indian Prosthodont.Soc. 2005; 5:18-22.

34. Schnneider AL. The use of self aligning low maintenance overdenture attachment. Dent Today 2000; 19: 24-26.

35. Meijer HJ, Starmans FJ, Steen WH, Bosman F. Location of implants in the interforaminal region of the mandible and the consequences for the design of the superstructure. J Oral Rehabil 1994; 21:47-56.

36. Chun HJ, Park DN, Han, Heo SJ,, Heo MS. Stress distribution in maxillary bone surrounding overdenture implants with different overdenture attachments. J Oral Rehabil 2005; 32:93-105.

37. Thayer HH and Caputo AA. Occlusal force transmission by overdenture attachments, additional studies. J. Prosthet. Dent 1979; 41:266-271.

38. Porter J A, PetropoulosVC, Brunski JB. Comparison of load distribution for implant overdenture attachments. Int.J.Oral Maxillofac. Implants 2002; 17:651-662.