Three Design Concepts of 4-Implants Assisted Mandibular Complete Overdentures: Implant Mobility and Marginal Alveolar Bone loss

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ABSTRACT:

Background. The rehabilitation of edentulous patients continues to be a major challenge to dentistry. Treating edentulous mandible with implant-assisted complete overdenture is aimed to reduce pain and discomfort, improve function (retention, stability) and stimulate psychosocial well-being.

Purpose. The purpose of this study was to compare three design-concepts for mandibular complete overdentures assisted by 4-implants regarding the implant mobility and marginal alveolar bone loss.

Materials and Methods. Three groups of different 4-implant-assisted mandibular complete overdentures were inserted: In group A, each mandibular 4-implant-assisted overdenture was retained by four solitary ball attachments, in group B, each mandibular 4-implant-assisted overdenture was retained by anterior bar and bilateral posterior ball attachments and in group C, each mandibular 4-implant-assisted overdenture was retained by two bilateral posterior instant adjusting bars. Implant mobility and marginal alveolar bone loss were evaluated at the time of initial loading (T0) and 6 (T1), 12 (T2) &18 (T3) months thereafter.

Results. Group C demonstrated the highest Implant mobility and marginal alveolar bone loss values followed by Group A while Group B recorded the lowest values. Posterior implants demonstrated a significant increase in Implant mobility and marginal alveolar bone loss values than anterior implants.

Conclusions. It is possible to conclude that: (1) Four-implant-assisted mandibular complete overdentures retained by anterior bar and bilateral posterior ball attachments can be considered the best design concept in this study regarding the implant stability and preservation of peri-implant marginal alveolar bone. (2) Regardless the design concept, the four-implant-assisted overdentures can be considered as a promising treatment option for rehabilitating completely edentulous mandible.

Key words. Implants assisted overdenture, mandibular complete overdenture, mandibular 4-Implants assisted complete overdentures and implant overdenture.

INTRODUCTION:

Complete-denture wearers frequently report problems with masticatory function, typically caused by poor retention and instability of the mandibular prosthesis (Fontijn-Tekamp et al., 2000).

The use of implant overdentures can overcome these problems and has proved to be reliable in the long-term and satisfactory to the patient (Gotfredsen et al. 1989; Wismeijer et al. 1995, 1997, 1999 and Mericske-Stern et al. 1994, 2000).

The primary aims of treating edentulous patients with implant-assisted overdentures are to reduce pain and discomfort, to improve function (retention, stability) and, to stimulate psychosocial well-being (Tolstunov, 2009).

The use of a minimal number of implants that is adequate for prosthodontic support and retention is of economic benefit to the patient (Ochiai et al., 2004). The disadvantages of the overdenture retained only by two anterior implants as reported by Jemt et al. (1996) are; poor implant support, stability and decrease in occlusal force, bone loss in the edentulous regions due to stresses transmitted to it as a result of rotation of the denture base around the anterior implants and increase in prosthetic maintenance appointments due to wear of the attachments.

The use of more than two implants has been recommended to assist a mandibular overdenture in clinical situations that require increased retention and stability (Mericske-Stern et al., 2000).13. R. Mericske-Stern, T.D. Taylor and U. Belser, Management of the edentulous patient, Clin Oral Implants Res 11 (2000), pp. 108–125. View Record in Scopus | Cited By in Scopus (50)

Adding two posterior implants may be an alternative to treatment with implants placed in the mandibular anterior region to prevent rotational movements of the prosthesis (Kreisler et al 2003 and Krennmair et al 2008).

The retention and stabilization of implant assisted mandibular overdenture are provided by features of the denture-bearing area and the attachment components, such as bar and clips, balls, or magnets. (Jemt et al, 1996 and wismeijer et al, 1999).

Bar is attachment system compatible with the majority of the implant systems currently available (Uludag et al, 2007). Strong (2006**)** considered the bar-retained overdenture to be superior to the attachment-only-retained format.

Payne et al (2000) stated that distal support by two bars placed bilaterally provide for amore stable overdenture. Many clinicians avoid cross-arch mandibular bar splinting when the implants are positioned posterior to the foramina (Strong, 2006**).**

Recently, pre-fabricated instant adjusting bar can be placed directly and without any tension on every pair of (none) parallel implants. It adjusts itself automatically, fully stress-free to the implant up to an angulation of 18°, when threading the fixation screws. The idea of adjustable bar connection is based on a simple joint-like system (Biesaga, 2004).

It is very important to know the effect of any treatment design concept on the well-being of the patients. This study aimed to compare three design-concepts for mandibular complete overdentures assisted by 4-implants regarding the implant mobility and marginal alveolar bone loss.

MATERIAL AND METHODS

Patient Selection

15 male patients aged between 55-60 years were selected for this study. They were healthy with no systemic diseases related to the bone resorption. They had completely edentulous maxilla and mandible with sufficient inter-arch space. The residual ridges were healthy and showed normal bony trabecular pattern. History of radiation therapy, smokers and alcoholics, and TMJ disorders were exclusion criteria. Detailed written information about treatment strategy was provided to all participants, and then they signed an informed consent.

Surgical and prosthetic procedures

Surgical planning was predominantly based on clinical inspection and orthopantomograms. For each patient diagnostic digital panoramic radiograph using prefabricated acrylic template with metallic balls was made to evaluate the alveolar bone at proposed implant positions, to establish relation to vital structures and to detect the proper implant length. Ridge mapping was used to measure the width of the ridge clinically in the canine and first molar area.

Complete denture was constructed for every patient. After one month of using denture, an acrylic template was constructed and four holes were drilled at planned implant positions (at canines and first molars areas) to be used as a surgical guide for implants placement.

After local anesthesia, four Acid-etched Roughened Titanium (ART) screw type fixtures (Dyna Helix ® TM Implants Holland_3.6 mm diameter and 11.5 mm length) were surgically inserted (in canines and first molars areas of mandibular residual alveolar ridge) using one stage flapless surgical technique (Fig. 1).

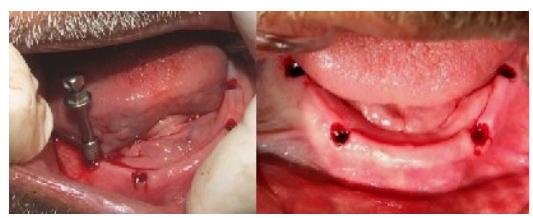

Fig 1. Four implants inserted in mandibular canines and first molars areas.

Post-insertion panoramic radiograph was made to evaluate the implant direction and depth (Fig. 2).

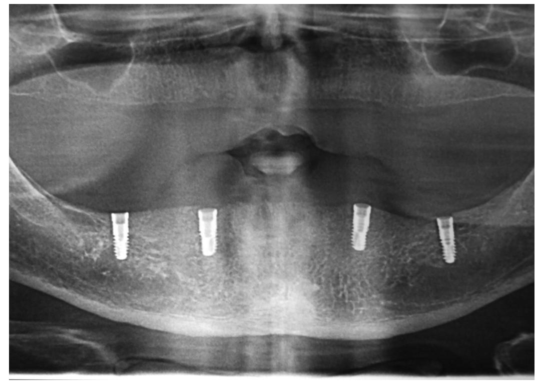

Fig 2. Post-insertion panoramic radiograph.

Suitable healing abutments (Dyna Healing Abutments Octa) were screwed into these fixtures (Fig. 3).

Fig 3. Healing abutments screwed into their fixtures.

Following the early progressive loading protocol (Attard and Zarb 2005), mandibular denture was completely relieved from the healing abutments and the patient was instructed not to remove it during mastication. Two weeks after surgery, the healing abutments were replaced by ball attachments and the denture base was relined with soft liner. After 3 months, the prosthesis is attached to the implants by the definitive overdenture attachments.

According to the mandibular 4-implant-assisted complete overdenture design concepts used in this study, the patients were randomly classified into three equal groups:

Group (A): In which the mandibular 4-implant-assisted overdenture was retained by four single ball attachments (Fig. 4).

Fig 4. Four implants assisting mandibular overdenture retained by four single ball attachments.

Group (B): In which the mandibular 4-implant-assisted overdenture was retained by anterior instant adjusting bar (IAB) and two posterior single ball attachments (Fig. 5).

Fig 5. Four implants assisting mandibular overdenture retained by anterior instant adjusting bar (IAB) and two posterior single ball attachments.

Group (C): In which the mandibular 4-implant-assisted overdenture was retained by two bilateral posterior IABs (Fig.6).

Fig 6. Four implants assisting mandibular overdenture retained by two bilateral posterior IABs.

In groups A and B, an elastic band 1 mm high was placed under each ball attachments. The metal matrices (Dyna Ball Matrix XL 2 pcs) were seated on their balls and the denture base was carefully relieved to verify adequate space over them. The lingual portion of the denture opposite the attachments was perforated so that most of the excess acrylic resin can escape. The self cure acrylic resin (pick-up material) was applied in the relieved area of the denture. The denture was seated in the patient mouth with firm finger pressure and the patient was guided to close gently in centric occlusion until setting of the acrylic resin. The excess acrylic resin was removed from the intaglio and outer surfaces of the denture.

In groups B and C, each pre-fabricated Instant Adjusting Bar was tightened according to the manufacturer instructions (Biesaga, 2004) as follow: Two IAB Octa extension abutments of 2 mm height were tightened into their two fixtures with single slot screwdriver.The distance between the centers of the two bar abutments was measured, then subtracting 4.5 mm, and cut each I.A. Bar Round into the proper length then the cut end was polished. The I.A. Bar Round was inserted between each two joints, and I.A. Bar fixation screw was tightened in position. For each bar, two IAB gold riders were incorporated directly in the opposing fitting surface area of the mandibular overdenture using autopolymerizing resin and following the method described by De Vries and Meijer, 1999.

Finally, the dentures were polished, and the occlusion was reexamined carefully for any adjustment. The overdentures were delivered and the patients were instructed not to remove the overdentures during mastication.

Implant mobility (using the Periotest system) and marginal alveolar bone loss (using periapical radiograph) were evaluated at the time of initial loading (T0) and 6 (T1), 12 (T2) &18 (T3) months thereafter.

The stability of each implant was measured at the abutment level using the Periotest system (Periotest; Siemens, Bensheim, Germany) and recorded as (PTVs). Three measurements were made at each time interval, and the most frequently recorded PTV was used in the data analysis.

Radiographic evaluation was done using a standardized periapical long-cone paralleling technique. The periapical films were digitized using a black and white translucent scanner (AcerScan 620PT) the radiographic images were standardized at 600 dots per inches (dpi). To detect magnification errors, the ratio between implant dimensions in the radiographs and actual implant dimensions was used to modify the apparent measurement of peri-implant bone levels in the radiographs to obtain their actual values.

Lines and reference points (Fig. 7) were traced using Corel draw program (Corel Draw_Version 8TM). Peri-implant marginal alveolar bone loss was measured along vertical and horizontal planes as was described by Elsyad and Shoukouki (2010). The distance between implant abutment base (A point) and first bone to implant contact (B point) indicated vertical bone level. The distance between the marginal bone level (C point) [which represents the intersection point of a tangent to the horizontal bone crest (CD line) and another tangent to the crater-shaped defect (CB line)] and the implant perpendicularly indicated horizontal bone level. Vertical (VBLO) and horizontal (HBLO) bone losses were calculated by subtracting corresponding bone levels at T1, T2, and T3 from bone levels at T0. Vertical and horizontal bone losses were measured in mm at mesial and distal surface of each implant and the mean was subjected to statistical analysis.

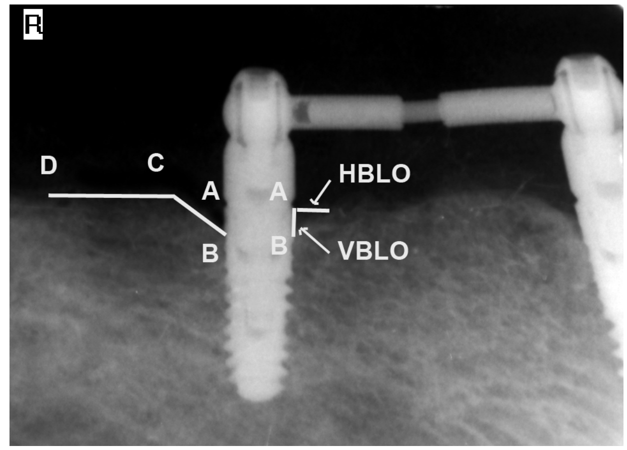

Fig. 7. Traced lines and reference points for measuring the marginal bone changes.

Statistical analysis

The normal distribution of data was verified by Kolmogorov-Smirnov test. The data were non parametric. PTVs, VBLO, and HBLO were compared between groups using separate Kruskal-Wallis tests. Subsequently, post hoc tests (Dunn) were used for pair wise comparisons between groups. To compare between different observation times for each group, Friedman test was used followed by Wilcoxon's signed rank test for comparison between each 2 times. Mann Whitney test was used to compare between anterior and posterior implants in each group. Spearman rho test was used to test the correlation between PTVs and VBLO and HBLO. The data were analyzed using SPSS® software version 17 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at .05 for all analyses.

RESULTS:

Of 60 implants placed, two posterior implants failed (one in group A and another one in group C) after 15 months yielding a 96.7% success rate. All patients attended the regular follow up visits without drop out. The failed implants were removed and the remaining implants were maintained to retain the overdentures with ball attachments.

Descriptive statistics for PTVs, VBLO and HBLO are presented in table 1, 2 and 3 respectively. There was a statistically significant differences in PTVs (table 1), VBLO (table 2) and HBLO (table 3) between tested groups at all observation times (Kruskal-Wallis test, $p<.01$). Group C demonstrated the highest PTVs, VBLO and HBLO values followed by Group A and Group B recorded the lowest values (Dunn test, $p=.012$ and .029 for anterior and posterior implants respectively).

With exception of PTVs of anterior implants in group A, all PTVs, VBLO and HBLO values differ significantly between observation times (Freidman test, $p<.05$)(Fig , , and respectively). The PTVs decreased significantly with advance of time in group A and B and increased in group C. There was a significant increase in

VBLO and HBLO in all groups with advance of time (Wilcoxon's signed rank test, $p<.05$). The rate of vertical bone resorption was fast during the first 6 months after loading (T1), and then becomes slower afterwards at T2 and T3 (Fig).

Comparing anterior and posterior implants in all groups, Posterior implants demonstrated a significant increase in PTVs, VBLO, and HBLO than anterior implants (Mann Whitney test, $p<.05$) in group C at all observation periods and in group B at second observation period (T2) (table4)

PTVs demonstrated a significant positive correlation with VBLO (Spearman rho test, p=.00, correlation coefficient=.46) and with HBLO (Spearman rho test, p=.027, correlation coefficient=.23)

Table 1: Comparison of Periotest values (PTVs) between groups:

	6 months after loading (T1)		12months after loading (T2)		18 months after loading (T3)	
	Anterior implants	**Posterior implants**	**Anterior implants**	**Posterior implants**	**Anterior implants**	**Posterior implants**
Group (A)						
X±SD	-7±1.58	-8±1.58	-9.2±1.48	-8±1.58	-9.8±1.30	-8.6±2.07
M(min:max)	-7(-9:-5)	-8(-10:-6)	-9(-11:-7)	-8(-10:-6)	-10(-11:-8)	-8(-12:-7)
Group (B)						
X±SD	-7.6±1.14	-8.8±1.30	-10.2±1.92	-8.2±1.48	-10.6±1.51	-9.6±1.51
M (min-max)	-8(-9:-6)	-9(-10:-7)	-11(-12:-7)	-8(-10:-6)	-10(-13:-9)	-9(-12:-8)
Group (C)						
X±SD	14±1.94	.80±7.94	13.2±1.92	-.4±8	-1±7.9	13.6±3.5
M (min-max)	15(11-16)	-3(-3:15)	13(11-15)	-.4(-5:14)	-4(-6:13)	14(10:19)
Kruskal-Wallis test (p value)	.008	.007	.006	.009	.008	.006

X: mean, SD: Standard Deviation, M: Median, Min: minimum, Max: maximum

Table 2: Comparison of vertical bone loss in mm (VBLO) between groups:

	6 months after	12months after	18 months after loading

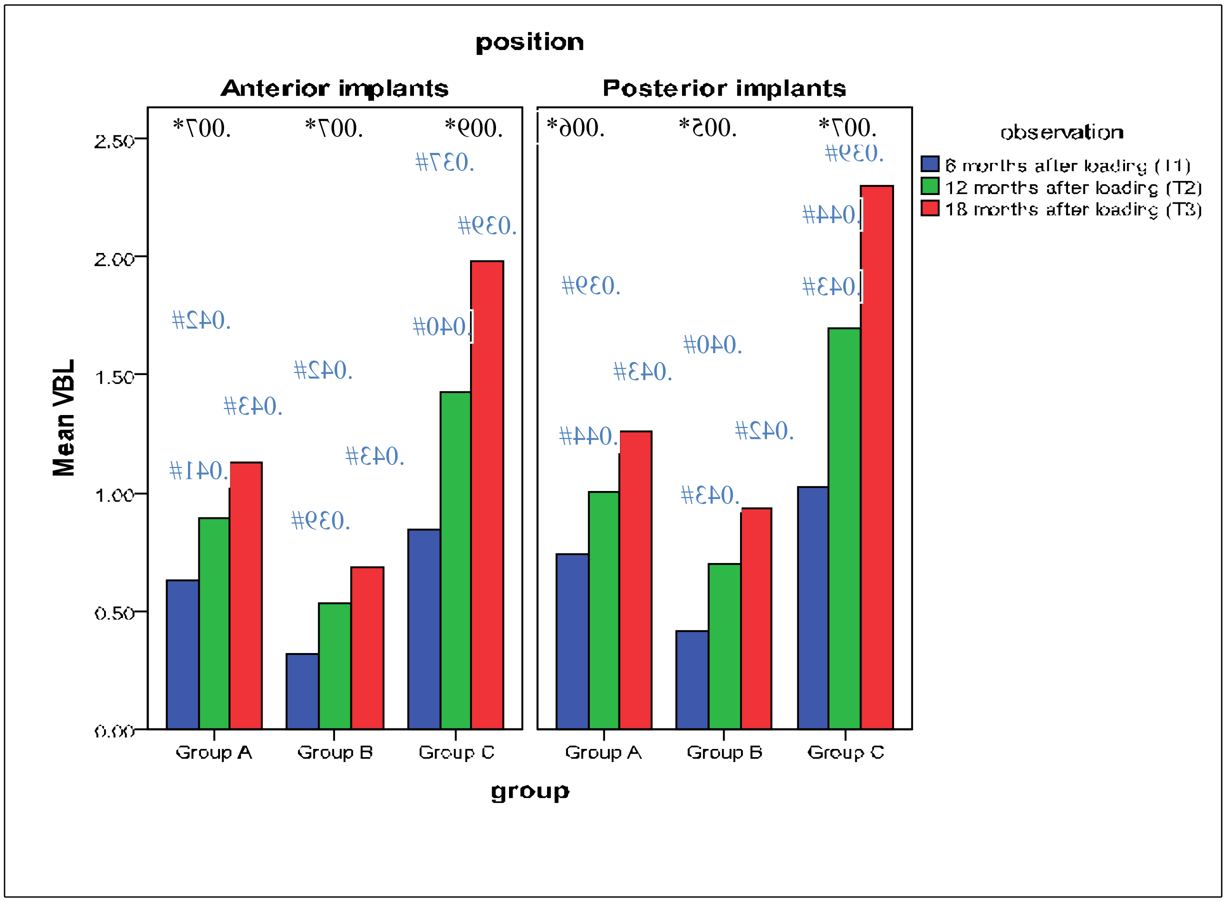

Fig. 9. Bar chart shows comparison of VBLO between observation periods. * Significant *p* value of Friedman test. # Significant *p* value of Wilcoxn test

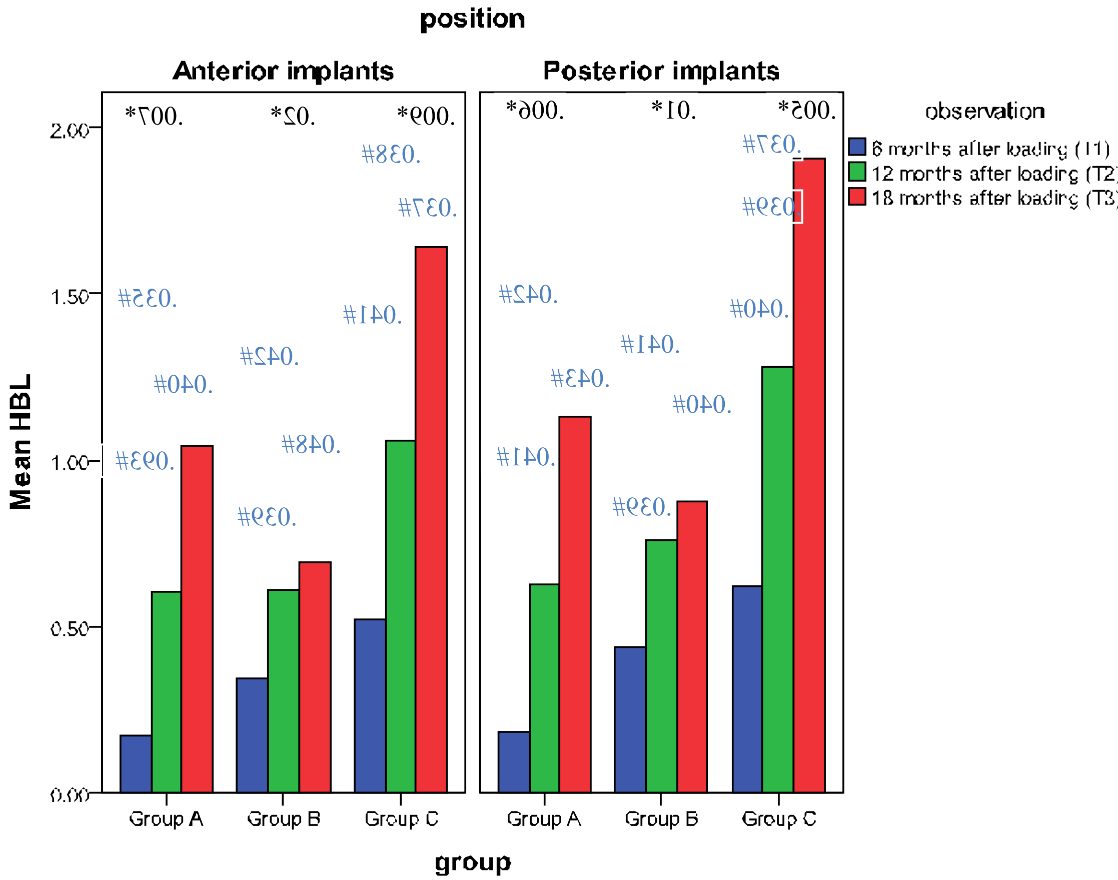

Fig. 10. Bar chart shows comparison of HBLO between observation periods. * Significant *p* value of Friedman test. # Significant *p* value of Wilcoxn test.

DISCUSSION:

Male patients were selected for this study to avoid the possibility of osteoprotic changes in the jaw bones which are commonly observed in post menopausal women. These changes may impair the integration process and increase the implant marginal bone loss (August et al., 2001).

All patients were healthy and free from systemic diseases that might affect the jaw bone quality and the crestal bone loss. Fiorellini et al. (2002) observed altered bone and mineral metabolism possibly interfering with the integration process in diabetic patients. Cranin (1991) reported that the long term use of corticosteroids generates a systemic loss of bone mass, delayed wound healing and modify a patient's response to bacterial infection. Curtis (1996) found that chemotherapy treatment causes malnutrition of osseous tissue, xerostomia and mucosal inflammation.

Patients with a minimum interarch distance of 20 mm were selected for this study to provide enough space for placement of the implant attachments and the superstructures. This was supported by Rungcharassaeng and Katz (2000) who stated that the minimum clearance between the top of the implant fixtures and the tissue surface of the overdenture is 7 mm for the bar placement. Also, Peterson et al. (2003) mentioned that there must be adequate interarch space to accommodate for the attachment.

The residual ridges were healthy and showed normal bony trabecular pattern to allow suitable chance for successful osseointegration. Wood and Vermilyea (2004) pointed out that there must be proper quantity and quality of bone into which dental implants are placed. The presence of too much loose trabecular bone pattern may limit early stability of an implant and may also require a longer integration time.

The progressive immediate loading of implants was selected to provide earlier delivery of the final superstructure and long term serviceability.

The results of this study illustrated peri-implant marginal bone loss in Group A and B less than 1.2 mm after 12 months of loading in addition to a significant decrease in implant mobility. Also the rate of VBLO and HBLO in all groups was fast during the first 6 months after loading (T1), and then becomes slower afterwards at (T2) and (T3)**.**

This may be due to the reduction of stresses transmitted to the peri-implant bone as a result of the effect of posterior implants that prevent rotation of the denture base around the anterior implants. This is in agreement with Kreisler et al, 2003 and Krennmair et al, 2008 who stated that adding two posterior implants prevents rotational movements of the prosthesis around the anterior implants and creates a stable prosthesis.

In the present study Group B recorded the lowest Implant mobility and marginal alveolar bone loss values at all observation times. This may be the result of the congregation between the advantages of posterior implants and the splint effect of the anterior bar through preventing axial rotation and implant micromotion. This is in agreement with Naert et al, 1994, Menicucci et al, 1998, Gatti et al, 2000 and Romeo et al, 2002 who found that splinting of immediately loading implants together with a bar within a short period of time will prevent axial rotation and implant micromotion and hence improve osseointegration. Slot et al, 2010 proved that, if a bar between implants is loaded, the load is mainly distributed to the bone surrounding the two neighboring implants while in case of solitary attachments (ball attachments), the load is distributed to the surrounding bone of that one implant.

On, the other hand, it could be argued that splinting of implants is not a definite requirement for osseointegration with the early loading protocols in the anterior mandible(Attard and Zarb, 2005)

Nevertheless, the Group C demonstrated the highest implant mobility and marginal alveolar bone loss values at all observation times.The precision bar attachments are manufactured either to allow a small element of rotational and/or vertical movement in the anchorage when dissipating occlusal forces applied to the overdenture or none (Hobkirk et al., 2003).

Comparing anterior and posterior implants of all groups in this study, posterior implants demonstrated a significant increase in PTVs, VBLO, and HBLO than anterior implants. Similarly Romanos and Nentwig, 2006, reported a higher failure rate in the posterior mandible after immediate loading. Ericsson et al., 2002, suggested that immediate loading approach has so far to be strictly limited to the inter-foramina area of the edentulous mandible.

CONCLUSIONS:

It is possible to conclude that: (1) Four-implant-assisted mandibular complete overdentures retained by anterior bar and bilateral posterior ball attachments can be considered the best design concept in this study regarding the implant stability and preservation of peri-implant marginal alveolar bone. (2) Regardless the design concept, the four-implant-assisted overdentures can be considered as a promising treatment option for rehabilitating completely edentulous mandible.

RECOMMENDATION:

Future studies will be devoted to compare between these design-concepts in regard to preservation of mandibular residual alveolar ridges.

BIBLIOGRAPHY:

- Attard NJ and Zarb GA: Immediate and early implant loading protocols: A literature review of clinical studies. J Prosthet Dent 2005; 94:242-258.
- August M, Chung K,Chang Y and Glowacki: Influence of estrogen status on endosseous implant integration. J Oral Maxillofac.Surg. 2001; 59:1285
- Batenburg RH, Raghoebar GM, Van Oort RP, Heijdenrijk K, Boering G. Mandibular overdentures supported by two or four endosteal implants. A prospective, comparative study. Int J Oral Maxillofac Surg 1998;27:435-9.
- Biesaga RK: Dyna Instant Adjusting Bar Connection Manual engels. Dyna Dental Engineering BV–07/2004; 4-5. Netherlands.
- Christensen GJ.: Why switch to digital radiography? J Am Dent Assoc. 2004 Oct;135(10):1437-9.

- Colomina LE: Immediate loading of implant-fixed mandibular prosthesis: A prospective 18-mont follow-up clinical study-preliminary report Implant Dent 2001; 10:23-29.
- Cranin AN: Endosteal implants in patient with corticosteroid dependence .J Oral Implant.1991; 17:41
- Curtis JW: Implant placement and restoration following bone marrow transplantation of chronic leukemia. Inter.J Oral Maxillofac. Implants.1996; 11:81
- DR, Unger JW, Elswick RK, Beck DA: Prospective clinical evaluation of mandibular implant overdentures: Part I- retention, stability, and tissue response. J Prosthet Dent 1995; 73: 354-363.
- Dudic A, Mericske-Stern R. Retention mechanism and prosthetic complications of implant-supported mandibular overdentures: Long-term results. Clin Implant Dent relat Resarh 2002; 4: 212-219
- Elsyad MA, Shoukouki AH. Resilient liner vs. clip attachment effect on peri-implant tissues of bar-implant-retained mandibular overdenture: a 1-year clinical and radiographical study. Clin Oral Implants Res. 2010;21:473–480.
- English CE. Biomechanical concerns with fixed partial dentures involving implants. Implant Dent. 1993;2:221-242.

- Ericsson I, Nilner K: Early functional loading using Branemark dental implants. Int J Perio Rest Dent 2002; 22: 9-19.

- Fiorellini JP, Chen PK, Nevins M and Nevins ML: A retrospective study of dental implants in diabetic patients. J Periodon. Restorative Dent.2002; 20:366

- Fontijn-Tekamp FA, Slagter AP, van der Bilt A, van't Hof MA, Witter DJ, Kalk W, et al.: Biting and chewing in overdentures, full dentures, and natural dentitions. *J Dent Res. 2000;* 79:1519–1524.

- Gatti C, Haefliger W and Chiapasco M: Implant-retained mandibular overdentures with immediate loading: A prospective study of ITT implants. tnt I Oral Maxillofac Implants 2000; 15: 383-388.

- Geertman ME, Boerrigter EM, Van Waas MA, van Oort RP. Clinical aspects of a multicenter clinical trial of implant-retained mandibular overdentures in patients with severely resorbed mandibles. J Prosthet Dent 1996;75:194-204.

- Geng JP, Tan KB, Liu GR. Application of finite element analysis in implant dentistry: a review of the literature, J. Prosthet. Dent. 85 (2001) 99–119.

- Gotfredsen, K., Hjorting–Hansen, E., Harder, F. & Hildestead,P. [Thereaction ofpatientsto mandibular osseointegrated dental prosthesis/implants].Tandlaegebladet (1989)93: 237–241.

- Hatcher, D. C., Dial, C. & Mayorga, C. (2003) Cone beam CT for pre-surgical assessment of implant sites. Journal of California Dental Association 31: 825-833.
- Hobkirk JA, Watson RM and Searson LJJ: Introducing dental implants. London, Churchill Livingstone, 2003, 63-80& 118, pp 3-18.
- http://www.tinmandental.com/index.php?page=infibra_ribbon_system retrieved at 5-12-2012
- Hutton JE, Heath MR, Chai JY, Harnett J, Jemt T, Johns RB. Factors related to success and failure rates at 3-year follow-up in a multicenter study of overdentures supported by Branemark implants. Int J Oral Maxillofac Implants 1995;10:33-42.
- Ichikawa T, Horiuchi M, Wigianto R, Matsumoto N. In vitro study of mandibular implant-retained overdentures: the influence of stud attachments on load transfer to the implant and soft tissue, Int. J. Prosthodont. 9 (1996) 394–399.
- Isidor F: influence of forces on pen-implant bone. Clin Oral Impl Res 2006; 17: 8-18.
- Jemt T, Chai J, Harnett J. A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. Int J Oral Maxillofac Implants 1996;11:291-8.
- Kim, K. D., Jeong, H. G., Choi, S. H., Hwang, E. H. & Park, C. S.

(2003) Effect of mandibular positioning on preimplant site measurement of the mandible in reformatted ct. International Journal of Periodontics and Restorative Dentistry 23: 177-183.

- 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. The International Journal of Prosthodontics. 2003; 16: 295–300.

- Krennmair G, Krainhofner M and Piehshinger E. Implant supported maxillary overdentures retained with milled bars: Maxillary anterior versus maxillary posterior conceptA retrospective study. Int J Oral Maxillofac Implants 2008;23:343-352

- Ledermann PD, Schenk RK, Buser D. Long-lasting osseointegration of immediately loaded, bar-connected TPS screws after 12 years of function: a histologic case report of a 95-year-old patient. Int J Periodontics Restorative Dent 1998;18:552-63.

- Loubele, M., Guerrero, M. E., Jacobs, R., Suetens, P. & van Steenberghe, D. (2007) A comparison of jaw dimensional and quality assessments of bone characteristics with cone-beam CT, spiral tomography, and multi-slice spiral CT. International Journal of Oral and Maxillofacial Implants 22: 446-454.

- Manz MC: Factors associated with radiographic vertical bone loss around implants placed in a clinical study. Ann. Periodontology.2000; 5:104

- Meijer U, Joos U, Mythii J, Stamm T, Hohoff A, Fillies T, Stratmann U and Wiesmann HP: Ultrastructural characterization of the implant/bone interface of immediately loaded dental implants. Biomaterials 2004; 25: 1959-1967.
- Mericske-Stern R, Zarb GA. Overdentures: an alternative implant methodology for edentulous patients. Int J Prosthodont 1993;6:203-8.
- Mericske–Stern, R., Taylor, T. & Belser, U. Management of the edentulous patient. Clinical Oral Implants Research (2000)11: 108–125.
- Mericske–Stern,R.,SteinlinSchaffner,T.,Marti,P.&Geering, A.H. Peri-implant mucosal aspects of ITI implants supporting overdentures: a five-year longitudinal study. Clinical Oral Implants Research (1994) 5: 9–18
- Misch CE: Dental Implant Prosthetics. Missouri, Etsevier Mosby, 2005.
- Mishal M,Desouza, Sabitam.Ram & Kartikbhanushali " management of atrophic mandibular ridges with mini dental implant system – a case report" the j of indian prosth. Society, july2005; 5,3,158:60.
- Naitoh, M., Katsumata, A., Nohara, E., Ohsaki, C. & Ariji, E. (2004)

Measurement accuracy of reconstructed 2-D images obtained by multi-slice helical computed tomography. Clinical Oral Implants Research 15: 570-574.

- Ochiai KT, Williams BH, Hojo S, Nishimura R, Caputo AA. Photoelastic analysis of the effect of palatal support on various implant-supported overdenture designs. J Prosthet Dent 2004;91:421-7.

- Payne AG, Solomons YF. The prosthodontic maintenance requirements of mandibular mucosa and implant supported overdentures. A review of literature. Int J Prosthodont 2000;13: 238-43.

- Romanos G, Nentwig G: Immediate versus delayed functional loading of implants in the posterior mandible: a 2-year prospective clinical study of 12 consecutive cases. Int J Perio Rest Dent. 2006; 26: 459- 469.

- Romeo F, Chiapasco M, Lazza A, Casentini P, Ghisolfi M, Iorio M and Vogel G: Implant-retained mandibular overdentures with ITI implants: A comparison of 2-year results between delayed and immediate loading. Clin Oral Impl Res 2002; 13: 495-501.

- Rungcharassaeng K and Kan JYK: Immediately loaded mandibular implant bar overdenture: A surgical and prosthodontic rationale. mt I Periodont Rest Dent 2000; 20:71-79 Peterson U, Ellis E, Hlupp JR and Tucker MR: Contemporary Oral and Maxillofacial surgery. Missouri, Mosby, 2003 , pp 305-342

- SchnitmanPA,WohrlePS,RubensteinJE,DaSilvaJD,WangNH.Ten-year results for Branemark implants immediately loaded with fixed prostheses at implant placement. Int J Oral Maxillofac Implants 1997;12:495-503.

- Siddiqui A A. Immediate Loading of AdVent™ Implants with a Mandibular Bar Overdenture Restoration: Technique from an International, Prospective, Multicenter Study. Sulzer Dental Inc.2001.

- Slot W, Raghoebar GM, Vissink A, Huddleston Slater JJ, Meijer HJA. A systematic review of implant-supported maxillary overdentures after a mean observation period of at least year. J Clin Periodontol 2010; 37: 98–110.

- Strong S M. Conversion from Bar-Retained to Attachment-Retained Implant Overdenture: Case Report Dent Today. Jan 2006.

- Tahaniri L Devlin H and Tiong K: Current prospective in residual ridge remodeling and its clinical implication .A review. J Prosth. Dent. 1998; 80:224

- Tolstunov L: Management of biomechanical complication of implant-supported restoration of a patient with combination syndrome: a case report. J Oral Maxillofac Surg. 2009 Jan;67(1):178-88.

- Uludag B, Sahin V and Celik G. Fabrication of a maxillary implant-supported overdenture retained by two cemented bars: A clinical report J Prosthet Dent May 2007;97:249-51

- Vazquez L, Saulacic N, Belser U, Bernard JP.: Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: a prospective clinical study of 1527 consecutively treated patients. Clin Oral Implants Res. 2008 Jan;19(1):81-5. Epub 2007 Oct 22.

- Wismeijer, D., Van Waas, M.A. & Vermeeren, J.I. Overdentures supported by ITI implants: a 6.5-year evaluation of patient satisfaction and prosthetic after-care. International Journal of Oral and Maxillofacial Implants (1995) 10: 744–749.

- Wismeijer, D., Van Waas, M.A., Mulder, J., Vermeeren,J.I. & 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. Clinical Oral Implants Research (1999) 10: 297–306.

- Wismeijer, D., Van Waas, M.A., Vermeeren, J.I., Mulder, J. & Kalk, W. Patient satisfaction with implant-supported mandibular overdentures.A comparison of three treatment strategies with ITI dental implants. International Journal of Oral and Maxillofacial Surgery (1997) 26: 263–267.

- Wood MR and Vermilyea ST: A review of selected dental literature on evidence-based treatment planning for dental implants: Report of the Committee in Fixed Prosthodontics of the Academy of Fixed Prosthodontics. J Prosth. Dent.2004; 92:447 Menicucci 0, Lorenzetti M, Pera P and Preti 0: Mandibular implant-retained overdenture: A clinical trial of two anchorage systems. mt J Oral Maxillofac Implants 1998; 13: 85 1-6.