Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/mjafi

Original Article

A clinico radiographic study of immediate loading implants in rehabilitation of mandibular ridges

Col M. Viswambaran^{a,*}, Lt Gen Vimal Arora, AVSM, VSM^{**}, PHDS^b,
Brig S.H. Gupta^c, Col R.K. Dhiman^d, Maj N. Thiruvalluvan^e

^a Commanding Officer, Military Dental Centre, Jabalpur 482001, India

^b DGDS & Colonel Commandant, O/o DGDS, Adjutant General's Branch, IHQ, MoD, L Block, New Delhi 110001, India

^c Commandant, AFDC, New Delhi 110010, India

^d Commanding Officer, 14 Corps Dental Unit, C/o 56 APO, India

^e Graded Specialist (Prosthodontics), Military Dental Centre, Ambala Cantt, India

ARTICLE INFO

Article history:

Received 13 August 2013

Accepted 30 December 2013

Available online 22 August 2014

Keywords:

Implant

Overdenture

Immediate loading

Bar attachment

Ball attachment

ABSTRACT

Background: Numerous studies regarding the immediate loading of splinted implants retaining/supporting mandibular dentures have reported promising results, but studies comparing splinted and unsplinted attachments for supporting overdentures with immediate loading are limited. Scientific literature is sparse comparing various attachment systems and patient satisfaction in response to immediately loaded implant supported overdentures.

Methods: A total of 30 completely edentulous patients male or female, in the age group of 54–78 years (mean age 65 years), wearing conventional complete dentures were selected and randomly divided in to two groups. A total of 60 implants were placed in the interforaminal area of the mental symphysis (two implants per patients) in 30 patients. Two types of attachment systems namely Ball for group-A and Bar for group-B were used and immediate loading done. Implants were evaluated clinically and radiographically at baseline, 1 month, 3 months, 6 months and 9 months. All clinical and radiographic parameters were subjected to statistical analysis.

Result: The implant survival rate for group-A (ball attachment) was 93.3% and implant survival rate for group-B (bar attachment) was 93.3%. The overall implant survival rate was not dependent on the attachment system. There was no significant difference in the crestal bone loss in mesial, and distal side in implants with respect to ball and bar attachment for different period of observation ($F = 0.25$; $P = 0.910$; $F = 0.07$; $P = 0.992$ respectively).

Conclusion: Overdenture supported by two implants should be the minimum gold standard in the rehabilitation of completely edentulous patients.

© 2014, Armed Forces Medical Services (AFMS). All rights reserved.

* Corresponding author. Tel.: +91 (0) 9165269306 (mobile).

E-mail address: mviswambaran@rediffmail.com (M. Viswambaran).

0377-1237/\$ – see front matter © 2014, Armed Forces Medical Services (AFMS). All rights reserved.

<http://dx.doi.org/10.1016/j.mjafi.2013.12.015>

Introduction

The clinical replacement of lost natural teeth by osseointegrated implants has represented one of the most significant advances in prosthetic dentistry. The long and meticulous work of Branemark and his team led to the development of the concept of osseointegration and dental implants.¹ Compared to all other dental disciplines, implant dentistry has enjoyed far more innovation and progressive developments in recent years namely in the development of new implant systems, the propagation of new and improved diagnostic procedures and the introduction of novel surgical techniques. Diagnosis of the edentulous situation is very much essential in order to treat the patient with the available prosthetic options. The prosthetic options may be removable or fixed implant supported/retained overdenture. Different protocols have been described in the literature for surgical placement and prosthetic loading of implants for patients selected for implant supported overdentures. The protocols can be either a one stage or two stage procedures.^{2,3} During the last 15 years, various authors have questioned the gold standard of 'two stage protocol' recommended by Branemark et al.^{4,5} They were of the opinion that one stage protocol with immediate loading is equally effective.^{6,7}

In spite of the documentation and anecdotal claims of success of complete denture therapy using dental implants, patients and prosthodontist often disagree about what constitutes a successful denture experience. Criteria for quality standards in denture fabrication have been articulated; however these problems do not address patient-mediated factors such as patient ability to handle dentures and patient opinion about treatment outcome. Various retention mechanism have been used in implant supported overdenture like bar and clips, ball, locator, magnets and precision attachments each allowing certain degree of freedom in movement of the prosthesis.⁸ Attachments are mechanical devices for the fixation, retention, and stabilization of prosthesis. Attachment systems provide resistance to movement of the implant prosthesis and help in dissipating the load in function.

Scientific literature is sparse comparing various attachment systems and patient satisfaction in response to immediately loaded implant supported overdentures. Therefore this study was carried out to evaluate the treatment outcomes of completely edentulous patients rehabilitated with immediately loaded implant supported mandibular overdenture retained by two different attachment systems (Ball versus Bar).

Material and methods

A total of 30 completely edentulous patients (male or female), in the age group of 54–78 years (mean age 65 years), were selected. The basic inclusion criteria were edentulous patients in need of an overdenture and in whom at least one implant could be placed bilaterally. Selection was based on clinical and radiographic examination. Routine orthopantomograms and lateral radiographs were supplemented with tomographic examinations in the mandible (Fig. 1). The primary selection

Fig. 1 – Cone beam CT evaluation.

of patients was based on an evaluation of the bone morphology according to Lekholm and Zarb. The patients selected were non-smokers, free from any systemic disease, non-bruxers, having adequate interarch space, with sufficient quality and quantity of bone and prepared to comply with the follow-up and maintenance programme. All patients received an upper and lower complete denture approximately three months before implant placement.

The implant system used in this study was Ez Hitec implants (Life Care India Private Limited). It is a tapered self thread internal hex implant with selective integrated surface. A total of 60 implants (in 30 patients) were placed in the interforaminal area of the mental symphysis (two implants per patients) and immediate loading done with implant supported overdentures. Each patient was rehabilitated with an Ez Hitec implant (3.75×10 mm) placed in the region of 33 and 43. Divisions into different groups (ball and bar) were based on random sampling method. 15 persons chosen by randomization had a ball attachment system (Group-A) (Fig. 2); and the remaining 15 persons a bar attachment system (Group-B) (Fig. 3).

Surgical and prosthodontic protocols for group-A: ball attachment - Prophylactic antibiotics were prescribed for all patients. All the surgical procedures were carried under strict aseptic conditions. Surgery was performed under local anesthesia (lignocaine 20 mg/ml with adrenaline 1:80,000). After achieving adequate local anesthesia, crestal incisions were placed on the site indicated for implant placement with No.12 B.P. blade. Full thickness flaps were elevated using periosteal

Fig. 2 – Group-A – ball attachment system.

elevator. Osteotomy was carried out following manufacturer's recommendations. Sequential drilling with copious irrigation was carried out till the desired dimensions were achieved. Implants of selected dimension were placed at a speed of

20–30 rpm using life care implant driver. During implant placement care was taken for maintenance of parallelism between implants. Ball attachment was secured over the implant by using the dalla bona hex driver. The full thickness flap was closed with 5–0 silk sutures to achieve primary closure. The intaglio surface of the denture was relived at sites corresponding to the implant. After attaching the O-ring assembly to the implant, undercuts were blocked out and the O-rings were retrieved in the denture by means of direct pickup technique using autopolymerising acrylic resin. The denture was finished, polished and occlusion was adjusted accordingly. After one week, sutures were removed and all the patients were reviewed at regular intervals.

Prosthetic protocols for group-B: bar-clip attachment - The surgical placement of dental implants was similar to the procedure already described for the ball attachment. Impression was made with closed tray technique using polyether (3M, Germany) (Fig. 4), lab analogs attached, poured with type IV dental stone (Kalabhai, India) and the cast retrieved. Healing abutments were placed over the implants and full thickness flap was closed with 5–0 silk sutures. Castable non hexagonal UCLA [University of California, Los Angeles] sleeves were attached to the lab analog on the cast. Pre-fabricated bar pattern sleeves were used for connecting adjacent implants with pattern resin. The pattern was invested in phosphate bonded investment and casting carried out with conventional casting procedures. It was finished and polished. The maxillary complete denture was duplicated and working cast fabricated with type IV dental stone. Face bow recording was made and subsequently transferred to Hanau wide view

Fig. 3 – Group-B – bar attachment system.

Fig. 4 – Closed tray impression technique.

articulator. The intaglio surface of the mandibular denture was relieved to accommodate the bar attachment. Bar attachment was placed on the cast and brass clips with plastic sleeves were placed in position. Autopolymerising resin was used for incorporation of bar-clip attachment using window technique. The healing abutments were removed and bar attachment placed in situ using hex driver. OPG was done to evaluate the accurate fit of bar attachment and implant. Maxillary and mandibular complete dentures were inserted and occlusal adjustments carried out (Fig. 5).

Post-operatively; all the implants in both the groups were evaluated with the following clinical parameters and radiographic method at baseline, 1 month, 3 months, 6 months and 9 months. 1. Implant stability & mobility, 2. Modified plaque index, 3. Bleeding index, 4. Probing depth at four sites around implant (mesial, buccal, distal and lingual) and 5. Marginal bone loss (mesial and distal).

The implant stability was measured with the help of Resonance frequency analyzer (OSSTELL Stampgatan, Sweden) and the implant mobility with periotest (Medizintechnik Gulden) (Fig. 6).

Soft tissue evaluation was done using modified plaque index, bleeding index and probing depth. For modified Plaque Index and bleeding Index, the implants were evaluated at four sites (buccal, lingual, mesial, and distal). Probing depth was also evaluated at four sites around implant (mesial, buccal, distal and lingual) using a force-controlled calibrated periodontal probe (Florida Probe®, Florida probe corporation, Gainesville, FL, USA) with a constant probing force of 15 g.

Standardized radiographs for the implants were taken using the long cone paralleling technique. Mean marginal bone loss was measured on the radiographs at the mesial and distal sides of the implants. A computer loaded with Corel DRAW™-11 software was used to analyze the radiographs (Fig. 7). The IOPA radiographs were transferred to the computer, enlarged to actual size (known actual implant dimensions). Linear distance measurements were made from first bone to implant contact to the implant shoulder (junction between polished collar and rough surface exactly at the starting point of first thread) on the mesial and distal sides of the implant.

General satisfaction, ability to masticate and esthetic outcome of the prostheses were recorded and quantified with a verbal rating scale (VRS), at 1 week, 1 month, 3 months, 6 months and 9 months following insertion of implant supported prosthesis.

Results

General Linear Model with age as co-variate has been used to test the differences with respect to attachments and periods. Site has not been considered here as a factor because site differences were found not to be significant with respect to both the attachments. The ANOVA results showed that there was no difference in the mean stability between the two attachments ($F = 0.000$, $P = 0.985$). The period effects were significant ($F = 17.59$, $P = 0.0001$) for which pair-wise comparison

Fig. 5 – Implant supported overdentures.

Fig. 6 – Evaluation of implant stability.

Table 2 – Descriptive statistics: mobility by attachment.

Variable	Attachment	N	Mean	Median	St dev	SE mean	Min	Max	Q1	Q3
Mobility	Ball	140	–3.32	–4.000	0.807	0.068	–4.000	–1.000	–4.000	–3.000
	Bar	140	–2.92	–3.000	0.674	0.057	–4.000	–1.000	–3.000	–3.000

When we analyzed the results of evaluation of patient satisfaction and masticatory capacity, there was no significant difference between ball and bar attachment for general satisfaction and masticatory capacity (Ball: $T = 0.00$, $P = 1.000$; Bar: $T = -0.37$, $P = 0.717$).

The bleeding index scores of all the patients for all the periods was identical and equal to one, however the scores were higher for the two failure cases (one each in bar and ball groups). Therefore statistical analysis was not carried out.

Plaque index scores were also identical for all patients during all periods (except the failure cases), therefore statistical analysis was not carried out.

Discussion

Implant supported prosthesis to a large extent have reduced the problems associated with conventional complete dentures and have greatly improved retention, stability, function, patient satisfaction and masticatory capacity.⁹

There are basically three protocols described in literature for prosthetic loading of dental implants which are delayed, early or immediate loading protocols. The delayed occlusal loading protocol refers to implant prosthesis with occlusal load after 3 months of implant placement in the mandible and 6 months in the maxilla. Early occlusal loading refers to an implant supported restoration in occlusion between 2 weeks and 3 months after implant placement. Immediate occlusal loading refers to an implant supported restoration in occlusion between 72 h after implant placement.^{10,11}

The immediate loading concept challenges the conventional healing time of 3–6 months where the prosthesis is loaded on the day of implant surgery.¹² Immediate loading of dental implants was first proposed by Ledermann in the year

1979. He had placed four end-osseous implants (Straumann, Switzerland) in the inter-foramina area and loaded immediately with a bar supported overdenture.¹³ Since then numerous clinical studies have proved that immediate loading in completely edentulous patients is a reality and has more than 90% survival rate.^{14,15}

Various attachment systems have been used in implant supported overdenture like bar and clips, ball, locator, magnets and precision attachments to augment retention and stability. Numerous studies regarding the immediate loading of splinted implants retaining/supporting mandibular dentures have reported promising results, but studies comparing splinted and unsplinted attachments for supporting overdentures with immediate loading are limited. Other studies focused on evaluation of treatment outcomes of immediately loaded implants based on clinical parameters like peri-implant tissue health and marginal bone loss. However, only a few studies have carried out comprehensive evaluation of treatment outcomes including patient satisfaction and masticatory capacity. Therefore this study was carried out to evaluate treatment outcomes of completely edentulous patients rehabilitated with immediately loaded implant supported mandibular overdenture retained by two different attachment systems (Ball versus Bar).

The implant system considered for this study was a root form implant (Ez–Hitec, Life Care India Private Limited) that has 1 mm implant collar with micro and macro groves with roughened surface for osteoconductive action. This design increases initial stability, shortens healing period and is highly recommended for immediate loading. A critical consideration while case planning an attachment restoration is vertical space. Adequate space is required to allow room for the attachment and the acrylic/denture tooth over the assembled complete attachment. Selection of an attachment

Table 3 – Tukey simultaneous tests: all pair-wise comparisons mesial versus period, site& attachment.

Level period	Difference of means	SE of difference	Adjusted T-Value	Adjusted P-value
Period = 0 subtracted from:				
1	0.1964	0.01654	11.87	0.00001
3	0.5161	0.01654	31.20	0.00001
6	0.7304	0.01654	44.15	0.00001
9	1.0304	0.01654	62.69	0.00001
Period = 1 subtracted from:				
3	0.3196	0.01654	19.32	0.00001
6	0.5339	0.01654	32.28	0.00001
9	0.8339	0.01654	50.41	0.00001
Period = 3 subtracted from:				
6	0.2143	0.01654	12.95	0.00001
9	0.5143	0.01654	31.09	0.00001
Period = 6 subtracted from:				
9	0.3000	0.01654	18.14	0.00001

Table 4 – Tukey simultaneous tests: all pair-wise comparisons distal versus period, site& attachment.

Level period	Difference of means	SE of difference	Adjusted T-value	Adjusted P-value
Period = 0 subtracted from:				
1	0.2036	0.01607	12.67	0.00001
3	0.5196	0.01607	32.34	0.00001
6	0.7393	0.01607	46.00	0.00001
9	1.0268	0.01607	63.89	0.00001
Period = 1 subtracted from:				
3	0.3161	0.01607	19.67	0.00001
6	0.5357	0.01607	33.34	0.00001
9	0.8232	0.01607	51.23	0.00001
Period = 3 subtracted from:				
6	0.2196	0.01607	13.67	0.00001
9	0.5071	0.01607	31.56	0.00001
Period = 6 subtracted from:				
9	0.2875	0.01607	17.89	0.00001

with excessive height can result in a restoration that is over-contoured or has a thin, weak area subject to breakage. A wide gap of 2 mm or more between the bottom of the bar and the soft tissue will allow easy passage of saliva and food particles as well as cleaning tools. Hygiene maintenance in this situation is very easy. A small gap of 1 mm or less between the bottom of the bar and the soft tissue will cause plaque and calculus accumulation. Removable prosthesis using attachment systems require a minimum 15 mm or more interarch space. The total height of the Hader bar and clip assembly may be as low as 4 mm, rather than the 5–7 mm required for O-ring systems. Removable prosthesis using attachment systems require a minimum 15 mm or more interarch space. Therefore the cases selected in this study were based on a strict inclusion criteria of minimum of 15 mm interarch space.

Randomization was carried out to divide the patients in two groups, group-A (Ball attachment) and group-B (Bar attachment). Random sampling method was employed so that there was no preferential treatment in selection which might introduce selectivity bias. Various researchers have recommended either two or four implants in the inter-foramina region in mandible to retain or support an over denture.^{16,17} Although with increase in number of implants enhances retention and support, it also increases cost, hygiene measures and complicate designs. Clinical studies have proved that the number of implant used to retain an overdenture does not influence the treatment outcomes.¹⁸ Systematic reviews and randomized clinical trials have also concluded that two implant supported overdenture should be the minimum gold standard treatment for edentulous patients.^{19,20} We have also used the well accepted, scientifically proven and cost effective concept of two implants in the inter-foramina region of the mandible to support an overdenture.

Various attachment systems are available and there is adequate scientific data to support their routine use in clinical practice for implant retained/supported overdentures. These include ball (Dallabona, locator systems), bar (round bar, Hader bar, Doldar bar) and magnetic attachments. We preferred ball and bar attachments since these are commonly employed in routine clinical practice for retention of overdentures compared to magnets and there is enough scientific data to support their routine use.^{5,8}

After going through the results of evaluation of implant stability using RFA, it was found that there was no difference of mean stability of ball and bar attachment with respect to location of implant. It was also found that there was no significant difference of implant stability while comparing both attachments ($F = 0.000$, $P = 0.985$). However the mean stability of the implants was statistically significant when compared with different period of observations ($F = 0.000$, $P = 0.985$). This indicated the increase of mean stability of both for ball and bar attachment with time. These findings confirm the results of the study conducted by Mats Kronstrom et al.²¹ They reported increase in RFA values with time after immediate loading. In our study there was no statistically significant difference of mean implant stability at the end of 6 and 9 months which indicated stable matured bone–implant interface.

Evaluation of implant mobility using periotest had shown that with the exception of two implants, all implants

consistently produced readings between –8 and 0 at baseline, 1 month, 3 months, 6 months and 9 months. The values of periotest also decreased with time which indicated osseointegrated implants. This finding confirm the results of the clinical trial conducted by Liao KY et al.²² They reported increased PTV values over time with immediate loading. Clinical lack of implant mobility does not always coincide with a direct bone–implant interface. However, when observed clinically, lack of mobility usually means that at least a portion of the implant is in direct contact with bone, although the percentage of bone contact cannot be specified.

When we analyzed the results of evaluation of probing depth, it was observed that there was no significant association between probing depth and period of observation. Probing depth remained more or less stable throughout the evaluation period suggestive of healthy peri-implant tissues. This may be due to adequate oral hygiene maintenance by the patient during post-operative evaluation period. These findings are not in accordance with multicenter longitudinal study by Van Steenberghe et al who concluded that there is a decrease of probing depth over time,²³ and George et al²⁴ who reported significant greater probing depths with increasing time. The Consensus report of the 1996 workshop in periodontics concluded that there is no clear evidence of value of probing depth. Clinically increasing probing depth may be an indication of failing implant and charting the probing depth does aid in monitoring peri-implant health over time.

The bleeding index scores in both the groups were equal to one (isolated bleeding spots on probing) throughout the evaluation period in all successfully osseointegrated implants. In cases of failed implants higher scores were recorded. In this present study there were two cases, one each in ball and bar attachment group, where high bleeding index scores were recorded during month evaluation period. Collaborating with other clinical parameters, these cases were labeled as implant failures and excluded from study sample.

The amount of crestal bone loss is an important criteria for judging the success rates of implant.²⁵ Previous studies have shown that marginal bone loss do occur post-loading. Mean crestal bone loss ≥ 1.5 mm during the first year after loading and ≥ 0.2 mm/year thereafter during the post-operative evaluation period is considered to be within normal limits. Our study is also in agreement with this observation and confirmed the findings of previous clinical studies in which mean crestal bone loss ≥ 1.5 mm during the first year after loading and ≥ 0.2 mm/year thereafter is considered to be one of the major success criteria.²⁶ There was no statistical significant difference of marginal bone loss between ball and bar attachment. This is in accordance with other studies.^{27,28}

Participant satisfaction is one of the important goals in the rehabilitation of edentulous patients. Various methods are in use for evaluation of patient satisfaction like Visual Analog Scales, Verbal Rating System and Oral Health Impact Profile. Cork et al concluded VRS is as efficient as VAS with advantages like being a simple, time saving method which is easier for the patient to understand.²⁹ Verbal rating system was utilized in our study to evaluate patient satisfaction and masticatory efficiency. The overall success of any treatment modality depends on patient satisfaction and improvement in

masticatory capacity. When we analyzed the results of evaluation of patient satisfaction and masticatory capacity, it was found that there was significant improvement in general satisfaction with these attachments and it was statistically significant (ball attachment $T = -9.10$, $P = 0.0001$ and bar attachment $T = -11.32$, $P = 0.0001$). There was also significant improvement in masticatory capacity with ball ($T = -11.50$, $P = 0.0001$) and bar attachments ($T = -22.33$, $P = 0.0001$). These findings are in accordance with result of clinical studies.^{30,31} There was no significant difference between ball and bar attachment for general satisfaction and masticatory capacity ($T = 0.00$, $P = 1.000$; $T = -0.37$, $P = 0.717$). These findings are in accordance with study conducted by Cune M et al in which the authors evaluated patient satisfaction, clinical and prosthetic outcomes of two implant mandibular overdenture with different attachment types.³²

From our experience, both the attachment systems proved to be effective for retention of complete dentures, but required frequent maintenance. Frequent post-treatment recall check up at least once in every 3 months is recommended in the first year to minimize complications. Controversy persists as to whether the bar or stud design requires more maintenance. Ball attachments need more maintenance when compared to bar attachment. The most common complication is alteration of contour and this might require the repair of matrix. The silicone rings need frequent changing. With bar attachment the most common complication is clip attachment fracture. The matrix of O-rings needs to be changed after every 6–12 months depending on the type of implant system used.

In our study there were two failures, one each in group-A: ball attachment and group-B: bar attachment in both the sites (33 and 43). The implant survival rate for group-A (ball attachment) was 93.3% and implant survival rate for group-B (bar attachment) was 93.3%. The overall implant survival rate was not dependent on the attachment system. This is in accordance with longitudinal study by Bergendahl T and Engquist B who reported no difference in implant survival rate between patients restored with ball or round bar attachment with survival rate of 100% and 75.4% in the mandibular and maxillary overdentures respectively.³³

Sufficient scientific literature supports the claim that implant supported overdenture effectively rehabilitates completely edentulous patients with improved retention, stability patient satisfaction and masticatory capacity but conventional complete denture is still widely used for the same. Immediate loading protocol is equally effective as early and delayed loading protocols. Overdenture supported by two implants should be the minimum gold standard in the rehabilitation of completely edentulous patients. The selection of a specific attachment system whether ball or bar attachment does not affect the overall success or patient satisfaction. It is important to follow the manufacturer's recommendations and adhere to the standard surgical and prosthodontic protocols for better results.

Conflicts of interest

This study has been funded by research grants from O/O DGAFMS, New Delhi.

REFERENCES

1. Branemark Per-Ingvar. Osseointegration and its experimental background. *J Prosthet Dent*. 1983;50:339–410.
2. Weber Hans-Peter, Cochram David L. The tissue response to osseointegrated implants. *J Prosthet Dent*. 1998;79:79–89.
3. Branemark PI, Adell R, Breine U, Hanson BO, Lindstrom J, Ohlsson A. Intraosseous anchorage of dental prosthesis-experimental studies. *Scad J Plast Reconstr Surg*. 1969;3:81–100.
4. Tallarico Marco, Vaccarella Anna, Marzi Gian Carlo. Clinical and radiological outcomes of 1 versus 2 stage implant placement: 1 year results of a randomised clinical trial. *Eur J Oral Implantol*. 2011;4:13–20.
5. Roe P, Kan JY, Rungcharassaeng K, et al. Immediate loading of unspilited implants in the anterior mandible for overdentures: a case series. *J Oral Maxillofac Implants*. 2010;25:1028–1035.
6. Di Stefano D, Lezzi G, Scarano A, Perrotti V, Piattelli A. Immediately loaded blade implant retrieved from a after a 20 year loading period: a histologic and histomorphometric case report. *J Oral Implantol*. 2006;32:171–176.
7. Linkow LI, Donath K, Lemons JE. Retrieval analysis of a blade implant after 231 months of clinical function. *Implant Dent*. 1992;1:37–43.
8. Trakas Theodoros, Michalakos Konstantinos, Kang Kiho, Hirayama Hiroshi. Attachment systems for implant retained overdentures: a literature review. *Implant Dent*. 2006;15:24–34.
9. Thomason JM. The Mc Gil Consensus statement on overdentures. Mandibular 2- implant overdentures as the first choice standard of care for edentulous patients. *Eur J Prosthodont Restor Dent*. 2002;10:95–96.
10. Attard Nikolai J, Zarb George A. Immediate and early loading protocol: A literature review of clinical studies. *J Prosthet Dent*. 2005;94:242–258.
11. Misch Carl E, Wang Hom-Lay, Misch Craig M, Sharawy Mohamed, Lemons Jack, Judy Kenneth WM. Rationale for the application of immediate load in implant dentistry: part I. *Implant Dent*. 2004;13:207–217.
12. Gotfredsen K, Hjorting-Hansen E. Histologic and histomorphologic evaluation of submerged and non submerged titanium implants. In: Laney WR, Tolam DE, eds. *Tissue Integration in Oral, Orthopedic and Maxillofacial Reconstruction*. Chicago: Quintessence; 1990:31–40.
13. Stricker A, Gutwald R, Schmelzeisen R, Gellrich NG. Immediate loading of 2 interforaminal dental implants supporting an overdenture: clinical and radiographic results after 24 months. *Int J Oral Maxillofac Implants*. 2004;19:868–872.
14. Chiapasco M, Gatti C, Rossi E, Haefliger W, Markwalder TH. Implant retained mandibular overdentures with immediate loading. A retrospective multicenter study on 226 consecutive cases. *Clin Oral Impl Res*. 1997;8:48–57.
15. Biglani M, Lozada JL. Immediately loaded dental implants – influence of early functional contacts on implant stability, bone level integrity and soft tissue quality: a retrospective 3 and 6 year analysis. *Int J Oral Maxillofac Implants*. 1996;11:126–127.
16. Goodacre CJ, Kan JY, Rungcharassaeng K. Clinical complications of osseointegrated implants. *J Prosthet Dent*. 1999;81:537–552.
17. VanKampen FM, van der Bilt A, Cune MS, Bosman F. The influence of various attachment types in mandibular implant-retained overdentures on maximum bite force and EMG. *J Dent Res*. 2002;81:170–173.
18. Visser A, Raghoobar GM, Meijer HJ, Batenburg RH, Vissink A. Mandibular overdentures supported by two or four endosseous implants - A 5 year prospective study. *Clin Oral Implants Res*. 2005;16:19–25.

19. Cehreli MC, Karasoy D, Akca K, Eckert SE. Meta-analysis of methods to assess implant stability. *Int J Oral Maxillofac Implants*. 2009;24:1015–1032.
20. Feine JS, Carlsson GE, Awad MA, et al. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as the first treatment choice for edentulous patients. *Gerodontology*. 2002;19:3–4.
21. Kronstrom Mats, Davis Ben, Loney Robert, Gerrow Jack, Hollender Lars. A prospective randomized study on the immediate loading of mandibular overdentures supported by one or two implants: 12 month follow up report. *Int J Oral Maxillofac Implants*. 2010;25:181–188.
22. Liao KY, Kan JY, Rungcharassaeng K, Lozade JL, Herford AS, Goodacre CJ. Immediate loading of two free standing implants retaining a mandibular overdenture: one year pilot prospective study. *Int J Oral Maxillofac Implants*. 2010;25:784–790.
23. Van Steenberghe D, Kilinge B, Linden U, Quirynem M, Herrmann I, Garpland C. Periodontal indices around natural and titanium abutments: a longitudinal multicenter study. *J Periodontol*. 1993;64:538–541.
24. George D, Zafiropoulos GG, Murat Y, Hubertus S, Nisengard RJ. Clinical and microbiological status of osseointegrated implants. *J Periodontol*. 1994;65:766–770.
25. Lekholm U, Herrman I, Folmer T, Henry P, Laney WR. Osseointegrated implants in the treatment of partially edentulous jaws: a prospective 5-year multicenter study. *Int J Oral Maxillofac Implants*. 1994;9:626–635.
26. Smith Dale E, Zarb George A. Criteria for success for osseointegrated endosseous implants. *J Prosthet Dent*. 1989;62:567–572.
27. Cehreli Murat Cavit, Karasoy Durdu, Kokat Ali Murat, Akca Kivnac, Eckert Steven E. A systematic review of marginal bone loss around implants retaining or supporting overdentures. *Int J Oral Maxillofac Implants*. 2010;25:163–180.
28. Gotfredsen K, Holm B. Implant supported overdentures retained with ball or bar attachment: a randomized prospective 5-year study. *Int J Prosthodont*. 2000;13:125–130.
29. Cork RC, Isaac I, Elsharydah A, Saleemi S, Zavisca F, Alexander L. A Comparison of the verbal rating scale and the visual analog scale for pain assessment. *The Internet Journal of Anesthesiology*. 2004;8(1).
30. Awad MA, Lund JP, Dufresne E, Feine JS. Comparing the efficacy of mandibular implant retained overdentures and conventional dentures among middle aged edentulous patients; satisfaction and functional assessment. *Int J Prosthodont*. 2003;16:117–122.
31. Thomason JM, Lund JP, Dufresne E, Feine JS. Patient satisfaction with mandibular implant overdentures and conventional dentures 6 month after delivery. *Int J Prosthodont*. 2003;16:467–473.
32. Cune M, Burgers M, van Kampen F, de Putter C, van der Bilt A. Mandibular overdenture retained by two implants: 10 yr results from a crossover clinical trial comparing ball-socket and bar-clip attachment. *Int J Prosthodont*. 2010;23:310–317.
33. Bergendal T, Engquist B. Implant supported overdentures- a longitudinal prospective study. *Int J Oral Maxillofac Implants*. 1998;13:253–262.