AL-AZHAR
Dental Journal
For Girls

The Official Publication
of The Faculty of Dental
Medicine For Girls,
Al-Azhar University
Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 8, No. 1, January (2021) — PP. 7:17

Effect of Two Loading Protocols on Supporting Structures of Symphyseal Implant Supported Mandibular Overdenture

Mai A. abdel efatah[1*], Yasmeen F. AlMahdy[2], Asmaa A. ashour[3]

Codex : 02/21.01

azhardentj@azhar.edu.eg

http://adjg.journals.ekb.eg

DOI: 10.21608/adjg.2021.14083.1171

Restorative Dentistry
(Removable Prosthodontics, Fixed Prosthodontics, Endodontics, Dental Biomaterials, Operative Dentistry)

ABSTRACT

Purpose: To evaluate the influence of 2 different loading protocols on single implant supported overdentures, immediate and conventional protocols on the supporting structures regarding: The extent of resorption of peri-implant bone and clinical evaluation of peri-implant soft tissue. **Material and Methods:** ten completely edentulous patients was selected to receive single implant supported overdenture. They have been divided after the insertion of implant into two groups according to time of loading. Group I received ball and socket attachment and loaded after 3 months of surgical procedures, while Group II was loaded within 7 days from surgery. Then all patients were evaluated clinically regarding probing depth, bleeding and plaque index and radiographically at the day of loading, 3, 6 and 9 months postoperatively. **Results:** comparison between the two groups in marginal bone loss was insignificant except in the first two periods, while probing depth was insignificant except at (6 to 9 month). For bleeding and plaque index, it was insignificant except at time of insertion for bleeding index. **Conclusions**: Immediate loading of single implants supporting a ball-retained mandibular overdenture is associated with more marginal bone resorption when compared with delayed loading of implants after 9 months follow up but it still can be used with single implant supported overdenture. Clinically, immediate loading had probing depth and bleeding index higher than delayed loading, while for plaque index for both loading protocols was almost the same.

KEYWORDS

Single implant, Immediate loading, Overdenture.

INTRODUCTION

Complete edentulism is a chronic, weakening and everlasting condition. A set of complete dentures is only a palliative treatment [1,2].

- Paper extracted from Master thesis titled: "Effect of Two Loading Protocols on Supporting Structures of Symphyseal Implant Supported Mandibular Overdenture"

1. Dentist at ministry of health, Cairo, Egypt.
2. Professor of Removable Prosthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.
3. Lecturer of Removable Prosthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.

* Corresponding author email: mai.ahmed4417@yahoo.com

A variety of problems from which patients suffer with their dentures, regarding to the lower denture[3].

The advent of osseointegrated dental implants has provided additional treatment options for edentulous patients [4]. Authors found that patients provided with an implant supported overdenture reported an increased ability to bite, eat and chew, without losing their dentures [5]. Also, by placing implants in the edentulous mandible, bone resorption can be limited resulting in subperiosteal growth because of the change in function which leads to a change in structure [6].

Implant-supported overdentures have expanded rapidly as a successful treatment modality [7]. There are many different choices when selecting the implant overdenture treating option for completely edentulous mandible [8].

The use of a single central mandibular implant to retain the mandibular denture has been evolving lately as a compromising solution. Implant success, prosthetic outcome and patient satisfaction are equivalent whether 1 or 2 implants are used for support of mandibular overdentures[2]. Patient fulfillment and function of the prosthesis was found in a previous review not dependent on the number of implants. But in fact, it is due to the transition from conventional mucosal support to an implant supported denture which is noticeable in the trials reviewed [9].

A finite element method (FEM) study on the number of implants required to retain an overdenture suggested that single implants were able to bear the load and dissipate it to the underling bone well [2]. It was found that high implant success and acceptable primary stability is obtained by placing implant in the midline where favorable bone quality and quantity is found, even for immediately loaded implants [10].

Osseointegration was defined as "the direct connection of bone with the surface of an implant exposed to a functional load". According to Brånemark's original protocol, dental implants Osseointegration, irrespective of their design or system, required an uninterrupted healing period of three months in the mandible and six months in the maxilla. At placement time, the primary factor for success was found to be loading condition that is accomplishing primary stability. It was found that lack of integration during initial phases of bone healing will be caused by any excessive micromotion [11] .

The stability of the implant is divided into primary, secondary and tertiary stability which depends on the surface of implant and direct mechanical connection of the bone surrounding it. When it obtained immediately after the implant placement, it is termed primary stability. While the one achieved after osseointegration is called secondary stability. The preservation of osseointegration is termed tertiary stability [12].

Over the last few decades, significant development in implant systems have led to the evolution of alternative loading protocols, such as immediate and early loading. [13] Loading protocols definitions presented by a previous consensus, were used for the calibration of the systematic reviews:[14] Conventional dental implants loading is "Dental implants are allowed to heal for a period of 3 to 6 months after implant placement without connection of prosthesis". While early loading of dental implants is defined as "A prosthesis is connected to the dental implants between 1 week and 2 months following implant placement". Furthermore, Immediate loading of dental implants is defined as "A prosthesis is connected to the dental implants within 1 week following implant placement" [14, 15].

When immediately loaded implants reach a state of clinical osseointegration, they have a long-standing expectedness, as the conventionally loaded implants. A key factor in immediately loaded implants success was found to be primary stability because with its high degree, it helps in the resistance against micromotions which is "the movement of

the surface of implant against the bone surrounding it during functional loading" [16].

Advantages of immediate loading can be concluded in that it is an one-stage implant surgical protocol, short treatment time, lower cost, and reduce the checking of implant stability [17]. Immediate loading special advantage is meeting patients' expectations specially in edentulous elders as 100% agreement of them preferring this procedure to others [18].

Dental implants success is evaluated through the peri-implant condition which affects the prognosis of osseointegration. This can be clinically by gingival and plaque index, peri-implant probing depth, and implant mobility and radiographically by assessing the peri-implant alveolar bone [19].

Implants can be called successful implant when it has implant survival's principles which include absence of pain or tingling sensation, peri-implant infection, mobility, and absence of unceasing peri-implant radiolucency [20] .

This study aimed to evaluate the effect of two loading protocols (immediate and conventional) on single implant supported overdentures supporting structures.

MATERIAL AND METHODS

10 completely edentulous patients with age range from 45-60 years old, were selected from the out-patient clinic of Faculty of Dental Medicine for Girls, Al-Azhar University.

Selection of patients was done according to the inclusion, and exclusion criteria. Inclusion criteria were patient with Angle class I jaw relation, reasonable inter-arch distance, the covered mucosa is healthy, firm and compressible by palpation and Patients must be apparently free from debilitating systemic diseases. While Exclusion criteria were Patient with TMJ problems, heavy smoker, thin flappy ridge, history of failed implant supported fixed prosthesis, or history of radiotherapy in head and neck region and Parafunctional habits, (clenching, grinding, bruxism).

Patients were divided into two equal groups according to loading protocols, five patients in each group. Before implant surgery, all patients signed informed-consent form and both groups had the same surgical protocol for implant placement.

Upper and lower complete dentures were made for each patient. For each patient a preoperative radiograph was taken for bone evaluation, to detect any bony pathological lesion or remaining roots.

A custom made radiographic template was constructed to be used with cone beam radiograph to detect the correct position of implant with metallic ball 5mm in diameter over the mandible midline. After the radiographic procedure was completed, the radiograph template was modified by removing metallic sphere and making circular hole at the site of implant placement converting it to a surgical template.

Before implant placement, Local infiltration to the implant site at the midline buccally and lingually was given. The surgical procedure was initiated with flapless technique with seating of the prepared surgical stent on the mandibular residual ridge.

The surgical placement of the implant was following the standard procedures respective to the multysystem protocol. Self-taping tapered Implant (multisystem srl,lissone-Italy) with (D) of 3.2 mm and (L) of 10 mm were screwed in clockwise direction into the prepared site vertically until it reached the full length.

After implant placing and according to the time of loading of the implant, patients were divided into 2 equal groups, 5 in each group:

Group I: This group received mandibular overdenture with conventional loading and were given 3 months healing period for complete implant bone osseointegration before loading of the attachment. Covering screws were used at surgery. The implant is then loaded after 3 months using a ball abutment after removing of the covering screw

Group II: This group received an immediately loaded mandibular overdenture.

The fitting surface of the lower complete denture was prepared then the implant was loaded in the 7th day after surgery using a ball abutment and a matrix.

According to patients grouping, ball attachments and their housings were picked up. In Group I, covering screws were located by the aid of the surgical stent of the patient and they were then removed. Ball and socket attachment was then applied after 3 months. In Group II, ball attachment was already applied during the surgery, however the implant loading was done at the 7th day of surgery by picking up the metal house and the matrix (Fig. 1).

Figure (1) Final placement of implant with ball and socket attachment.

In the tissue bearing surface, the denture was painted with a soft liner opposing to the ball attachment area, and with the addition of silicon based-cold curing- soft liner (Softliners, mollosil®, Detaxe, Germany),relining procedures were performed. This step was performed at the pickup time and remained for 3months (till the next follow up visit).

The finished prosthesis was then placed in the patient's mouth and checked for retention and occlusion. Final adjustments were made and the patient was instructed for good oral hygiene measurements and soft diet.

All patients in both groups were evaluated both clinically and radiographically at the day of loading, 3, 6 and 9 months postoperatively. All follow-up procedures were done in the same manner through all the follow-up period and recorded in each patient's chart.

Radiographic evaluation:

Standardized intra-oral indirect peri-apical parallel digital radiographs were taken (Orix-Aet, ARDET, S.V.R., Milano, Italy). Intraoral film plate (sensor size 2) and holder with individually constructed radiographic acrylic templates were used following the parallel technique.

The digital image displayed on the monitor was evaluated and finally exported in Joint Photographic Experts Group (JPEG) file format. Image analyzed using the special software of the Digora system using implant shoulder and first contact between bone and implant as reference points. The distance between the two references points (implant shoulder and first contact between bone and implant) which represent the amount of vertical bone loss, were measured at right and left aspects.

The distance from the implant cylindrical head to the apex of the implant was measured, and was then used to divide the known original length of the implant from the finish line to the apex to calculate the magnification factor. The magnification factor was then multiplied to the measured distance on right and left sides of implant to derive the actual distance of bone loss according to the equation:

Corrected marginal bone level = measured marginal bone level × (actual implant length / measured implant length)

The radiography taken at the denture loading session (3 months after surgery for group I and after 7 days with group II) was used to establish the base line radiograph.

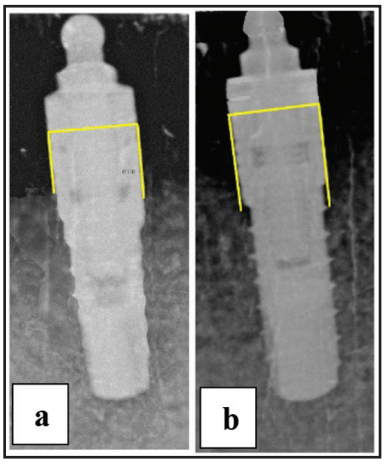

Figure (2): Radiographic evaluation: a-immediate loading after 9 months b-delayed loading after 9 months

Clinical evaluation

The parameters for implant evaluation were documented at follow-up visits at the day of loading, 3, 6, and 9 months later for each implant.

- **Probing depth**: at four sites per implant (mid-mesial, mid-distal, mid-buccal, mid-lingual) the probing depth was measured using Williams's periodontal probe. Then, the average of them was determined for each implant.
- **Bleeding index:** It was introduced to assess sulcus bleeding. When bleeding was visible 20 sec after probing
- **Plaque index**: It was introduced to assess biofilm formation around ITI implants; at four areas; labial, lingual, mesial and distal

All recorded data during follow up period for each patient was tabulated and statistically analyzed

Statistical Analysis

All recorded data for each patient were tabularized and statistically analyzed.

The Software (SPSS 12) was used for computations. Microsoft Word and Excel were used to generate graphs and tables. Descriptive analysis of data was summarized as means, standard deviation, maximum and minimum.

RESULTS

I- Radiographic evaluation:

Comparison of mean marginal bone loss between group I and group II:

It revealed significant difference in means $p< 0.05$ (0 to 3 months right and left sides, 3 to 6 months left side), while it was revealed that there was insignificant difference in means > 0.05 (3 to 6 months right side, 6 to 9 months right and left side) as presented in table (1) and fig (3).

Table (1): *Comparison of mean marginal bone loss between group I and II:*

Side	Follow up period	group I M±SD	group II M±SD	P value
Right	**0 to 3 Months**	0.73 ± 0.06	1.6 ± 0.36	0.0007*
	3 to 6 Months	0.23 ±0.12	0.60 ± 0.40	0.0829
	6 to 9 Months	0.10 ± 0.01	0.10 ± 0.04	1.000
Left	**0 to 3 Months**	1.86 ±0.15	1.6± 0.35	0.0027*
	3 to 6 Months	- 0.03 ±0.06	0.60 ± 0.36	0.0082*
	6 to 9 Months	0.27±0.32	- 0.10±0.04	0.5045

M=mean *P= probability level*

** = significant (P≤ 0.05)*

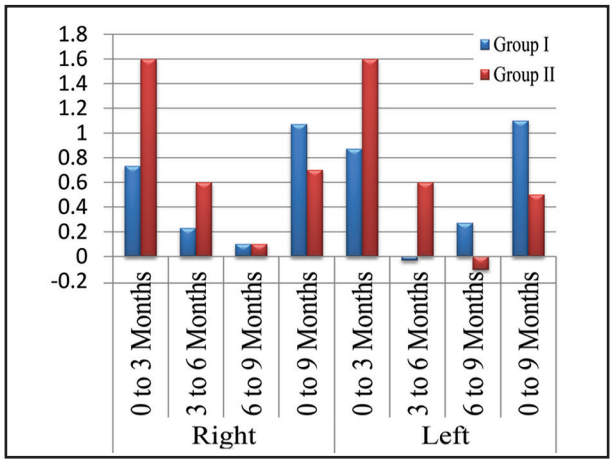

Figure (3): Comparison of mean marginal bone loss group I and II

II- Clinical evaluation:

1. Probing depth

Comparison between group I and II regarding mean difference of two successive follow ups revealed significant difference in means with $p < 0.05$ in the period (from 6 to 9 months). It revealed insignificant difference in means with $p > 0.05$ in the periods from (0 to 3, 3 to 6 & 0 to 9). This is presented in table (2) as the probing depth was gradually decreased at those follow up periods.

Bleeding index:

Comparison between group I and II revealed significant difference ($p < 0.05$) at time of insertion, while there was insignificant difference ($P > 0.05$) after 3 months, after 6 months and after 9 months , as presented in table (3) .

Plaque index:

Comparison between group I and II revealed insignificant difference ($P > 0.05$) at time of insertion, after 3 months, 6 months & 9 months , as presented in table (4).

Table (2): *Comparison of mean probing depth between group I and II:*

Follow up periods	Mean difference ± SD		P value
	Group I	Group II	
0 to 3 Months	- 0.21 ±0.14	- 0.12 ±0.12	0.3222
3 to 6 Months	- 0.42 ±0.26	- 0.17 ±0.07	0.0715
6 to 9 Months	0.0 ± 0.0013	- 0.29 ±0.19	0.0226*
0 to 9 Months	- 0.63 ± 0.25	- 0.58 ±0.19	0.731

*M= mean SD=standard deviation. P= probability level * = significant difference (P≤ 0.05)*

Table (3): *Comparison between group I and II regarding bleeding index:*

	Group I				Group II				P value
	No bleeding	**Isolated bleeding**	**red line on margin**	**Heavy bleeding**	**No bleeding**	**Isolated bleeding**	**Red line on margin**	**Heavy bleeding**	
At insertion	100 %	0%	0%	0%	33.3 %	33.3 %	33.3 %	0 %	0.04 *
After 3 months	66.7 %	33.3 %	0%	0%	33.3 %	66.7 %	0%	0 %	0.5
After 6 months	66.7 %	33.3 %	0%	0%	66.7 %	33.3 %	0%	0%	0.9
After 9 months	33.3 %	66.7 %	0%	0%	66.7 %	33.3 %	0%	0%	0.5

*P; probability level * = significant difference (P≤ 0.05)*

Table (4): *Comparison between group I and II regarding plaque index*

	Group I				**Group II**				**P value**
	No plaque	**Plaque recognized by probe**	**Plaque can be seen by the naked eye.**	**Abundance of soft matter**	**No plaque**	**Plaque recognized by probe**	**Plaque can be seen by the naked eye.**	**Abundance of soft matter**	
At insertion	100 %	0 %	0 %	0 %	100 %	0 %	0 %	0 %	0.9
After 3 months	100 %	0 %	0 %	0 %	33.3 %	66.7 %	0 %	0 %	0.6
After 6 months	66.7 %	33.3 %	0 %	0 %	66.7 %	33.3 %	0 %	0 %	0.9
After 9 months	66.7 %	33.3 %	0 %	0 %	33.3 %	66.7 %	0 %	0 %	0.6

DISCUSSION

In this study, ten completely edentulous male patients were selected free from any systemic and neuromuscular diseases to have single symphyseal implant inserted in the midline of the mandible as it is a safe with less challenging surgical procedure [21, 22] .Single implant retained mandibular overdentures have some advantages which was confirmed by several studies which are lower component cost and treatment times, less invasive, has more patient satisfaction, higher improvement in oral comfort, function and no destructive strain concentration in the bone surrounding the implant [23-28] .

An important factor in decision between fixed implant-supported prosthesis and removable implant overdentures is the inter-arch space, inter-jaw relationship, oral hygiene and patient's expectation and preference [29].

Cone beam computed tomography (CBCT) was used preoperatively in this study to reveal the three-dimensional image of the bone which provides enough information about the location, volume, width and degree of mineralization of the bone [23-24] .A radiographic stent with a metallic ball was used during the CT scans to obtain maximal advantage from such radiograph. Also, from this radiographic template a surgical template was obtained after removal of the metallic ball [30].

Flapless surgical technique was used in all cases because it causes less damage to the patient, shortened surgical procedure and less pain, edema and discomfort [31]. To avoid the heat generated at the time of surgery, Copious internal and external irrigations were provided during surgical procedures as it cause necrosis of the surrounding differentiated and undifferentiated cells [32].

Pilot drill was used to start bone drilling, to make the initial osteotomy, for direct approach instead of a punch method before the implant placement. It was found that the healing of both bone and gingival tissue around the implant was hampered with punched flapless technique because it is much wider than the implant diameter, on the outcome of the implantation procedure so it has to be avoided[33,34] .

The ball and socket attachments were selected due to the fact that it is one of the most resilient attachments, their simplicity of application, low-cost, minimal chair side time requirements and ease of handling and effectiveness [35,36]. A periapical radiograph was taken following implant placement to ensure the optimum position, depth, and angulation of implant and to be documents for the analysis of following bone level changes [21] .

Denture was relined with soft liner opposing to the ball attachment on the fitting surface and delivered to the patient [30]. The patient leaves after surgery wearing both the complete maxillary denture opposed by soft –lined mandibular denture at the area opposed to the ball attachment on the fitting surface [22] .The advantages of soft liners include better range of overdenture movement, energy absorption, and equal force distribution to the implants and edentulous ridge, minimizes implant overloading, and prevents the accumulation of plaque around the abutment [37] .

In this study, peri-implant bone height change (bone loss), was evaluated using a standardized intraoral Parallel digital periapical radiograph with a custom-made stent [30] .It should be noted that, the peri-implant bone was analyzed with the aid of digitized radiographies which were reported to be able to facilitate the quantification of bone changes. Recent studies recommend digital method for longitudinal follow up measurements [38] .

Periodontal probing using a light probing force is a dependable tool for assessing the peri-implant health and disease. [39] As reported by several studies destruction to the tissue surrounding the implant will not be caused by probing with a light pressure using a conventional periodontal probe [40] .

In the comparison of mean marginal bone loss between both groups after different periods of follow up revealed significant difference during the first follow up period (0 to 3 months) in both right and left side ($P<0.05$), during the second follow up period (3 to 6 months) significance between two groups revealed in left side only. This was in accordance with previous studies that revealed significantly more amount of vertical bone loss in immediately loaded group than conventionally loaded ones [41, 42].

On the other hand, many other different studies reported insignificant difference between immediate and delayed loading of dental implants [43-48].

This study also revealed that an insignificant difference in mean marginal bone loss between both groups at the 2nd follow up period (3 to 6 months) in the right side and at third follow up period (6 to 9 months) in both sides. This can be explained by the use of the "resilient" configuration of ball and socket attachment which provide wider contact area. This allowed for an increase of the mastication load transiting through denture fitting surface. With implant retained overdentures treatment plans, attachments are passively loaded with the complete denture [49].

Comparing the mean difference of probing depth between both groups after all follow up periods revealed insignificant difference ($P>0.05$). This was in accordance with several studies which revealed insignificant differences between both groups in probing depth aspects [50-55].

Except for the last follow up period (6 to 9 months) which revealed significant difference ($P<0.05$).This was in accordance with a study which revealed significant difference in mean difference of probing depth between both groups in specific period of the follow up periods [41] .

It was noticed that there was a decrease in probing depth with time which decreased significantly with advance of time. That was agreed with other study that revealed that the using of soft liner (especially silicone-resilient liner) resulted in significantly and better soft tissue health around the implant that led to these results [37,56,57].

That was because of several reasons which clarify these results: it conditioned these tissues, diminished swelling and increased blood supply to these tissues. In addition to that, candidal and microbial adhesion and favors plaque removal are significantly minimizes because of the glazing material which seals surface porosity. Moreover, its presence resist the contraction of acrylic resin which can occur during the processing of the denture. This avoids direct contact between the acrylic resin and both of the implants and the attachment, and minimizes implant overloading. Furthermore, Soft liner absorbs and distributes masticatory forces by its cushion effect which reduces stresses around implants and also around peri-implant bone, which in turn reduces bone loss. In addition, it encircle the abutment, this contact between the liner and the abutment decreases peri-implant mucosal inflammation by diminishing plaque accumulation[37, 57-60].

Postoperative swelling or edema not permitted to occur by immediate soft loading of the dentures and caused more patients' comfort compared with immediate hard loading and so did not affect the probing depth adversely[30] .Beside, it reduces plaque and microbial adhesion that cause peri-implant tissue swelling and pocket formation [37].

It was believed that the resilient soft liner had significantly decreased bone loss, plaque formation and gingival score, probing depth in comparison with implant retained overdenture using other attachment [37] .

Regarding bleeding index between both groups after different periods of follow up, it revealed insignificant difference during all follow up period except for at the time of insertion, which was significant, this is obviously due to the loading time in immediately loaded group. Furthermore, when comparing plaque index of both groups revealed

also insignificant difference between both groups during all follow up periods. These results are in agreement with several studies which revealed insignificant differences for both bleeding and plaque indexes aspects [41, 50-55] .

The abutments cleaned continuously by soft liners as the denture placed in or removed from the patient's mouth preventing plaque from being accumulated so, it significantly decreased plaque scores regardless of oral hygiene practice [37].

The presences of the implant anteriorly allow proper accessibility and easily performing of oral hygiene measures which led to to the gradual decrease in plaque and bleeding index which was confirmed by author [56]. So, because of the importance of oral hygiene measures and accurate patient education during the scheduled follow-up visits, the gradual decrease in bleeding and plaque index with advancement of time is revealed [56].

CONCLUSION

More marginal bone resorption immediate loading of single implant supporting a ball-retained mandibular overdenture by comparing it with delayed loading of implant after 9 months follow up. Clinical outcome revealed insignificant difference nearly in all follow up periods.

Also clinically, immediate loading had probing depth and bleeding index higher than delayed loading, while for plaque index for both loading protocols was almost the same.

Immediate loading of single implant supported mandibular overdenture using ball attachment show high success rate, so, it appears to be a technique that can be used in single mandibular retained overdenture. The advantage here is a significant shortening of rehabilitation times.

All results of the study cleared that inspite of the successful results of immediate loading protocol, delayed loading still have better result clinically and radiographically than it.

REFERENCES

1. Cunha-Cruz J, Hujoel PP, Nadanovsky P. Secular trends in socio-economic disparities in edentulism. J Dent Res. 2007; 86:131–36.
2. Mahoorkar S, Bhat S, Kant R. Single implant supported mandibular overdenture: A literature review. J Indian Prosthodont Soc 2016; 16:75-82.
3. Shah FK, Gebreel A, Elshokouki A H, Habib A A , Porwal A. Comparison of immediate complete denture, tooth and implant-supported overdenture on vertical dimension and muscle activity. J Adv Prosthodont. 2012; 4: 61–71.
4. Simon H, Yanase. Terminology for Implant. Int J Oral Maxillofac Implants. 2003; 18: 539–43.
5. Krishnaraj R, Murugan R, Meera NK, LaksmipathyP, Krishnan CS, Packiaraj I. Implant-based overdenture: A review in patient perspective. J Pharm Bioall Sci. 2016; 8: 20–2.
6. Luthra R, Sharma A and Kaur P. Implant Supported Overdenture: A Case Report. Periodon Prosthodon. 2016, 2:2.
7. Al-Harbi FA. Mandibular implant-supported overdentures: Prosthetic overview. Saudi J Med Med Sci.2018; 6: 2-7.
8. Kronstrom M, Davis B, Loney R, Gerrow J, Hollender L. A prospective randomized study on the immediate loading of mandibular overdentures supported by one or two implants; a 3 year follow-up report. Clinical implant dentistry and related research. 2014; 16:323-9.
9. Lee JY, Kim HY, Shin SW, Bryant SR. Number of implants for mandibular implant overdentures: a systematic review. J Adv Prosthodont. 2012; 4: 204–9.
10. Nogueira TE, Esfandiari S, Leles CR. Cost-effectiveness analysis of the single-implant mandibular overdenture versus conventional complete denture: study protocol for a randomized controlled trial. Trials. 2016; 17:533.
11. Trisi P, Perfetti G, Baldoni E, Berardi D, Colagiovanni M, Scogna G. Implant micromotion is related to peak insertion torque and bone density. Clin Oral Implants Res. 2009; 20:467-71.
12. Parithimarkalaignan S, Padmanabhan TV. Osseointegration: an update. J Indian Prosthodont Soc.2013; 13:2-6
13. Meyer U, Joos U, Mythili J, Stamm T, Hohoff A, Fillies T, et al. Ultrastructural characterization of the implant/bone interface of immediately loaded dental implants. Biomaterials 2004, 25:1959-67
14. Gallucci GO, Benic GI, Eckert SE, Papaspyridakos P, Schimmel M, Schrott A, Weber HP. Consensus statements and clinical recommendations for implant loading protocols. Int J Oral Maxillofac Implants .2014; 29:287–90.

15. Chuang SK, Weber HP Papaspyridakos P, Chen CJ. Implant loading protocols for edentulous patients with fixed prostheses: a systematic review and meta-analysis. Int J Oral Maxillofac Implants .2014; 29:256-70.

16. Ghanavati F, Shayegh SS, Rahimi H, Sharifi D, Ghanavati F, Khalesseh N, et al. The effects of loading time on osseointegration and new bone formation around dental implants: a histologic and histomorphometric study in dogs. J Periodontol. 2006; 77:1701-7.

17. Turkyilmaz I, Tozum TF, Fuhrmann DM, Tumer C. Seven-year follow-up results of TiUnite implants supporting mandibular overdentures: early versus delayed loading. Clin Implant Dent Relat Res. 2012; 14: 83-90.

18. Menassa M, de Grandmont P, Audy N, Durand R, Rompré P, Emami E. Patients' expectations, satisfaction, and quality of life with immediate loading protocol. Clin Oral Implants Res. 2016; 27:83-9.

19. Bratu EA, Tandlich M and Shapira L. A rough surface implant neck with microthreads reduces the amount of marginal bone loss: a prospective clinical study. Clin Oral Implants Res. 2009; 20: 827–32.

20. Chiapasco M, Romeo E, Casentini P, Rimondini L. Alveolar distraction osteogenesis vs. vertical guided bone regeneration for the correction of vertically deficient edentulous ridges: a 1–3-year prospective study on humans. Clin Oral Implants Res. 2004; 15:82-95.

21. Hämmerle CH, Glauser R. Clinical evaluation of dental implant treatment. Periodontol 2000. 2004; 34:230-9

22. Alsabeeha N, Payne AG, De Silva RK, Swain MV. Mandibular single-implant overdentures: a review with surgical and prosthodontic perspectives of a novel approach. Clin Oral Implants Res. 2009; 20:356-65.

23. Usman J, Raghavan R, Kumar R, Ramzi M, Balakrishnan S. single implant retained mandibular overdenture–a literature review. Int J Dent Oral Health. 2015;1:76-80.

24. Cordioli G, Majzoub Z, Castagna S. Mandibular overdentures anchored to single implants: a five-year prospective study. J Prosthet Dent 1997;78:159-65.

25. Liu J, Pan S, Dong J, Mo Z, Fan Y, Feng H. Influence of implant number on the biomechanical behaviour of mandibular implant-retained/supported overdentures: a three-dimensional finite element analysis. J Dent. 2013;41:241-9.

26. Walton JN, Glick N, Macentee MI. A randomized clinical trial comparing patient satisfaction and prosthetic outcomes with mandibular overdentures retained by one or two implants. Int J Prosthodont 2009;22:331-9.

27. Grageda E, Rieck B. Metal-reinforced single implant mandibular overdenture retained by an attachment: a clinical report. J Prosthet Dent.2014;111:16-9.

28. Bryant SR, Walton JN, MacEntee MI. A 5-year randomized trial to compare 1 or 2 implants for implant overdentures. J Dent Res. 2015;94:36-43.

29. Kapoor K, Harshakumar K, Lylajam S, et al. Rehabilitation of a Completely Edentulous Patient with a mandibular overdenture supported by two immediately loaded single piece implants. Case report. Int J Oral Implantol 2015; 6: 53-7.

30. Tavakolizadeh S, Vafaee F, Khoshhal M, Ebrahimzadeh Z. Comparison of marginal bone loss and patient satisfaction in single and double-implant assisted mandibular overdenture by immediate loading. J Adv Prosthodont. 2015 1;7:191-8.

31. Hultin, M., Svensson, K. G., & Trulsson, M. Clinical advantages of computer-guided implant placement: a systematic review. Clin Oral Implan Res 2012; 23 : 124–35.

32. Mishra SK, Chowdhary R. Heat generated by dental implant drills during osteotomy—a review. J Indian Prosthodont Soc. 2014; 14:131-43.

33. Lindeboom JA, Van Wijk AJ. A comparison of two implant techniques on patient-based outcome measures: a report of flapless vs. conventional flapped implant placement. Clin Oral Implants Res. 2010; 21:366-70.

34. Bayounis AM, Alzoman HA, Jansen JA, Babay N. Healing of peri-implant tissues after flapless and flapped implant installation. J Clin Periodontol. 2011;38:754-61.

35. Meijer H, Raghoebar G, Van't Hof M, Visser A. A controlled clinical trial of implant- retained mandibular overdentures; 10 years' results of clinical aspect and aftercare of IMZ implants and Branemark implants. Clin Oral Implants Res, 2004; 15; 421-27.

36. Chrcanovic B, Albrektsson T, Wennerberg A. Flapless versus Conventional Flapped Dental Implant Surgery: A Meta-Analysis. PLoS One. 2014; 9:30-40.

37. ELsyad MA. Soft liner/clip attachment for Bar-Retained implant overdentures: A technical note. J Oral Implantol. 2016; 42:442-5.

38. Bilhan H, Geckili O, Bilhan SA , Aycicek F, Albayrak B, Bozbulut P, et al. The comparison of the precision of different dental radiographic methods in mandibular peri-implantary measurements: an in vitro study. J Istanbul Unıv Fac Dent 2015; 49:1-92.

39. Schou, S., Holmstrup, P., Stoltze, K., Hjørting-Hansen, E., Fiehn, N.-E., & Skovgaard, L. T. Probing around implants and teeth with healthy or inflamed peri-implant mucosa/gingiva. A histologic comparison in cynomolgus monkeys (Macaca fascicularis). Clin Oral Implan Res 2002; 13, 113–26.

40. Etter, T. H., Håkanson, I., Lang, N. P., Trejo, P. M., & Caffesse, R. G. Healing after standardized clinical probing of the perlimplant soft tissue seal: a histomorphometric study in dogs. Clin Oral Implan Res 2002; 13, 571–80.

41. Elsyad MA, Al-Mahdy YF, Fouad MM. Marginal bone loss adjacent to conventional and immediate loaded two implants supporting a ball-retained mandibular overdenture: a 3-year randomized clinical trial. Clin Oral Implants Res. 2012; 23: 496-503.

42. Kim SH, Choi BH, Li J, Kim HS, Ko CY, Jeong SM, et al. Peri-implant bone reactions at delayed and immediately loaded implants: an experimental study. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2008 1; 105:144-8.

43. Najafi H, Siadat H, Akbari S, Rokn A. Effects of immediate and delayed loading on the outcomes of all-on-4 treatment: a prospective study. J Dent (Tehran) 2016; 13:415-22.

44. Barewal RM, Stanford C, Weesner TC. A randomized controlled clinical trial comparing the effects of three loading protocols on dental implant stability. Int J Oral Maxillofac Implants. 2012; 27: 945-56.

45. Pae A, Kim JW, Kwon KR. Immediate loading of two implants supporting a magnet attachment-retained overdenture: one-year clinical study. Implant Dent. 2010; 19: 428-36.

46. Boujoual I, Andoh A. Immediate vs delayed implant loading: The current status of the literature. Int J Curr Res. 2017; 9: 58141 – 6.

47. Zhu Y, Zheng X, Zeng G, Xu Y, Qu X, Zhu M, Lu E. Clinical efficacy of early loading versus conventional loading of dental implants. Sci Rep. 2015; 5:15995.

48. Alfadda SA. Early and immediate loading protocols for overdentures in completely edentulous maxillas: a comprehensive review of clinical trials. J Contemp Dent Pract. 2014; 15:797-805.

49. Daas M, Dubois G, Bonnet AS, Lipinski P, Rignon-Bret C. A complete finite element model of a mandibular implant-retained overdenture with two implants: comparison between rigid and resilient attachment configurations. Med Eng Phys. 2008; 30:218-25.

50. Den Hartog L, Huddleston Slater JJ, Vissink A, Meijer HJ, Raghoebar GM. Treatment outcome of immediate, early and conventional single-tooth implants in the aesthetic zone: a systematic review to survival, bone level, soft-tissue, aesthetics and patient satisfaction. J Clin Periodontol. 2008;35:1073-86.

51. Schropp L, Kostopoulos L, Wenzel A, Isidor F. Clinical and radiographic performance of delayed-immediate single-tooth implant placement associated with peri-implant bone defects. A 2-year prospective, controlled, randomized follow-up report. J Clin Periodontol. 2005;32:480-7.

52. Salman A, Thacker S, Rubin S, Dhingra A, Ioannidou E, Schincaglia GP. Immediate vs. Delayed Loading of Mandibular Implant-Retained Overdentures: A 60-month Follow-up of a Randomized Clinical Trial. J Clin Periodontol. 2019; 46: 863–71.

53. Turkyilmaz I. Clinical and radiological results of patients treated with two loading protocols for mandibular overdentures on Brånemark implants. J Clin Periodontol. 2006; 33:233-8.

54. Elsyad MA, Elsaih EA, Khairallah AS. Marginal bone resorption around immediate and delayed loaded implants supporting a locator-retained mandibular overdenture. A 1-year randomised controlled trial. J Oral Rehabil. 2014; 41:608-18.

55. Liao KY, Kan JY, Rungcharassaeng K, Lozada JL, Herford AS, Goodacre CJ. Immediate loading of two freestanding implants retaining a mandibular overdenture: 1-year pilot prospective study. Int J Oral Maxillofac Implants. 2010; 25784-90.

56. Gibreel M, Fouad M, El-Waseef F, El-Amier N, Marzook H. Clips vs Resilient Liners Used With Bilateral Posterior Prefabricated Bars for Retaining Four Implant-Supported Mandibular Overdentures. J Oral Implantol. 2017; 43:273-81.

57. 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; 21:473-80.

58. Fundeanu I, van der Mei HC, Schouten AJ, Busscher HJ. Polyacrylamide brush coatings preventing microbial adhesion to silicone rubber. Colloids Surf B Biointerfaces. 2008; 64:297-301.

59. Olan-Rodriguez L, Minah GE, Driscoll CF. Candida albicans colonization of surface-sealed interim soft liners. J Prosthodont. 2000; 9:184-8.

60. Sesma N, Laganá DC, Morimoto S, Gil C. Effect of denture surface glazing on denture plaque formation. Braz Dent J. 2005; 16:129-34.