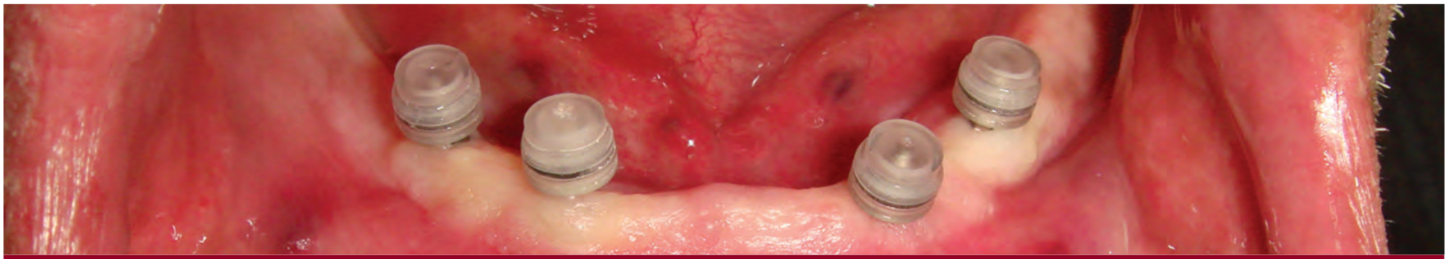

The Effect of Two Loading Protocols on the Supporting Structures of Mini Implants Supporting Mandibular Overdenture

Dr. Khaled Aziz Abd El-wahab; Dr. Essam Adel Aziz; Dr. Mohamed Abd El-Monaem Nada

Introduction

Treatment of the edentulous mandible using conventional complete removable denture is a common clinical treatment option, yet at times it can be a difficult and challenging intervention. Although, patient expectations for such a treatment intervention are understandably high, the predictability of the outcome is generally regarded by most practitioners as variable. Mandibular implant-retained overdentures can provide an effective treatment modality for edentulous patients and, in particular, those who have persistent problems in using conventional mandibular prosthesis (1).

Nowadays, Oral Implantlogy tends to evolve into a less time-consuming, more aesthetic and less invasive techniques to restore lost dentition, in addition to minimize the possibility of postoperative peri-implant tissue loss and to overcome the challenge of soft tissue management during or after surgery. So the concept of flapless implant surgery has been introduced and clinically applied to both delayed and immediate loading cases (2, 3).

With a flapless approach, the time consumed during the surgery is decreased; minimal surgical trauma is

Figure 1

Figure 2

achieved as the circular incision is narrow, usually 1 mm wider than the implant to be placed. Therefore postoperative pain, swelling, and discomfort related to soft tissue trauma are greatly minimized leading to accelerated postsurgical healing (4).This was in accordance with studies which demonstrated that patients who treated with flapless implant placement experienced pain of lower intensity and less duration than patients in whom conventional flaps were reflected (5, 6).

Mini dental implants (MDI) are single piece implants with a diameter ranging from 1.8mm to 3.0mm, there are two types of mini implants according to their head design either ball type or square type. (7).They are originally used for transitional and provisional purposes, but it was observed that these implants appeared to osseointegrate and it is histologically reported that the bone appeared to be integrated to the surface of the mini dental implant at the light microscopic level, and the bone appeared to be relatively mature and healthy (8).

Mini dental implants have the advantage of expanding the bone as they are placed, producing immediate stabilization in most situations with minimal bone removal, as well as they require only a narrow-diameter osteotomy that does not extend to the full depth of the implant, as well as they are usually loaded on the day of placement, reducing the length of the treatment period (9). Additionally flapless placement leads to minimal surgical trauma, and in case of infrequent failure of these small diameter implants, they are merely unscrewed and the osteotomy heals within a few days, additionally their cost is significantly less than conventional implants (10).

Materials and Methods

I. patients Selection and pre-surgical evaluation:
Ten completely edentulous patients were selected from the outpatient clinic of Prosthodontic Department; Faculty of Oral and Dental Medicine, Cairo University. The patients had an average age of 52 years. They should be free from any systemic disease that may interfere with dental implant placement and/or osseointegration. All the patients should have Class I Angel`s classification and the lower arch showing flat to moderate size ridge. Patients showing gagging reflexes, para-functional habits and heavy smokers were excluded from the study. Only cooperative patients following instructions and having proper neuromasculer co-ordination were included in the study. (Fig. 1)

Selection criteria were verified by detailed history and clinical examination, as well as radiographic assessment by 1:1 panoramic radiographs to assess the available bone quantity corresponding to the proposed implant sites.

Complete denture was constructed using the conventional procedures, and was delivered to the patients to get used to it. The finished lower denture was duplicated for each patient and processed in clear acrylic resin in order to construct a surgical guide template, and was finished, polished and checked in the patient's mouth for correct seating.

About 4 mm depth cavity was done in the fitting surface of the surgical template in the site corresponding to the area between the 1st and 2nd premolars and was filled with amalgam filling material as a radioopaque material to help in the proper assessment of the location of the mental foramina relative to the teeth of the template guided by digital panoramic radiograph. Holes were then drilled at the chosen implant sites in order to facilitate implant placement during surgery. (Figs. 2&3)

II. Implant system:
40 implants were placed in this study (4 per case).They were single piece mini implants with diameter 2.8mm and length 13 mm with a ball head (polycarbonate housing were supplied with the implant).

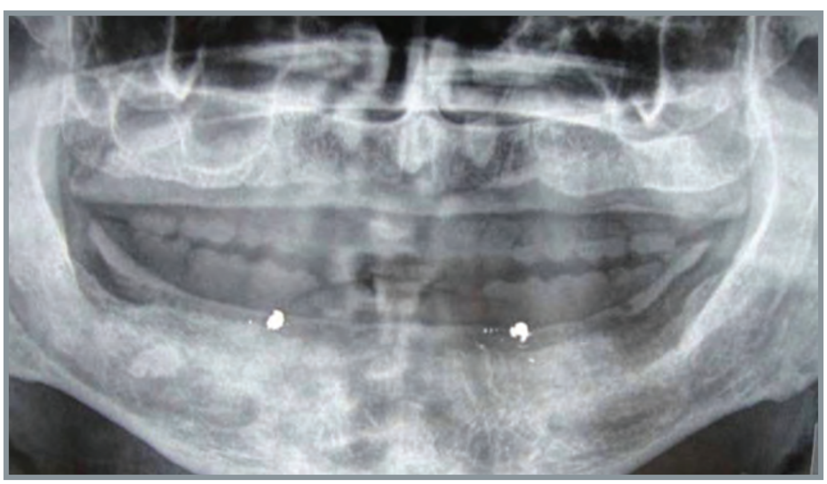

Figure 3

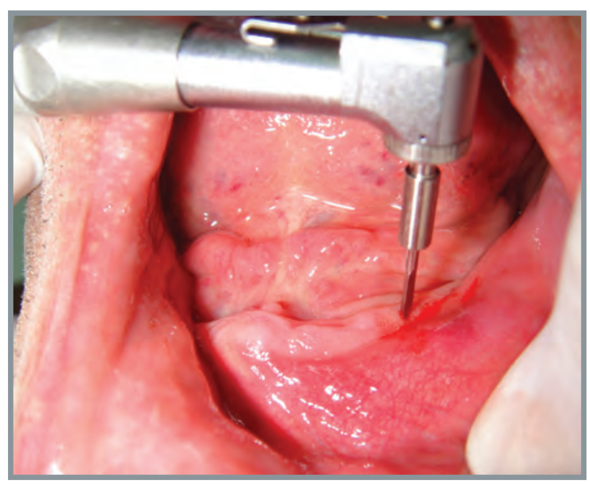

Figure 4

III. Surgical protocol:

The surgical template was seated over the mandibular ridge and a tissue marking probe was inserted through holes in the stent performed corresponding to the proposed implant sites to mark bleeding points at the sites selected for implant placement.

Flapless preparation of the implant site was done by drilling the implant osteotomies through the soft tissue then the bone guided by the surgical template to a depth equal to two third of the implant length using a single perforation profile drill of diameter 1.3mm.

The direction was kept perpendicular to the bone, and midway bucco-lingually till reaching the desired depth, putting in consideration the parallelism between the four implants (Fig. 4). After preparation of each osteotomy site, the implant is installed until the implant was fully seated in place. The procedure is repeated till four implants are placed inter-foraminally. (Figs. 5&6)

Afterward, Primary stability of each implant was checked using an adjustable torque wrench to confirm that initial primary fixation was exceeding 35N/cm (Fig. 7). Additionally a periotest device was also used for the same purpose to confirm that the values were between -8 to +9 to submit to the immediate loading requirements. (Fig. 8)

IV. Prosthetic phase and Patients Grouping:

After implant placement patients were divided into two equal groups

Group I: patients of this group received an immediate loaded mandibular overdentures supported by mini implants

Group II: patients of this group planned to receive mandibular overdenture supported by mini implants with conventional loading (after 3months of placement)

- **Group I (Immediate loading):**

After implant placement the polycarbonate housings were secured firmly over the ball abutments (Fig. 9). The denture was adequately relived, to allow seating of the

Figure 5

Figure 6

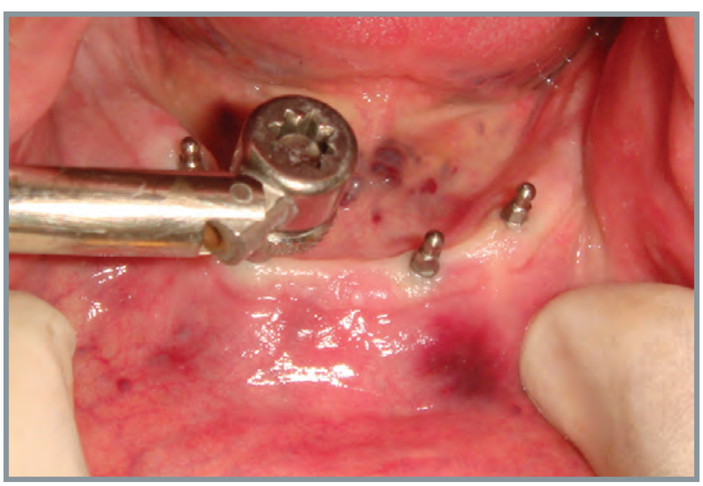

Figure 7

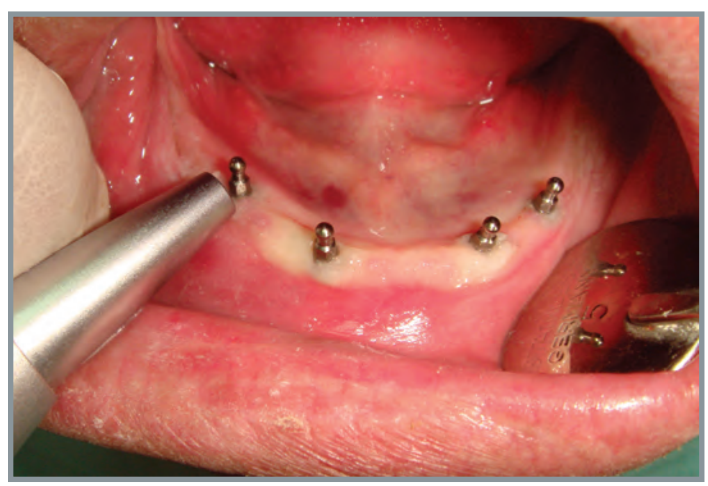

Figure 8

denture without any interference with the polycarbonate housings as proved by absence of rocking, pressure indicating paste and proper occlusion (Fig. 10)

The pickup procedure starts by applying rubber band sheets around the ball abutments to facilitate the pickup procedure and preventing the prosthesis lock in undercuts (Fig. 11). Cold curing resin was placed in the relieved areas of the denture and the denture was seated in the patient mouth. The resin was left to polymerize while the patient was closing in centric jaw relation with gentle pressure. The overdenture was removed, trimmed and polished with the polycarbonate housings picked up in its fitting surface the denture was delivered to the patient. (Fig. 12)

- **Group II (conventional Loading)**

After implant placement the mandibular denture was properly relived to allow for its full seating on the implants without the housings as proved by the use of pressure indicating paste. The patients were recalled every two weeks to recheck that there was no contact between the balls and the denture that might happen due to denture settling. After three months the patients were recalled to attach the polycarbonate housing in the fitting surface using direct pick up technique

V. Patient's instructions

The patients with immediately loaded dentures were instructed to eat soft diet food for one month.

All patients were called every month for regular check up for the overdenture, the implants and the oral hygiene.

VI. Postoperative follow and evaluation:

All patients were evaluated clinically using gingival index, probing depth and periotest values and radiographically using cone beam CT at the time of implant placement and after nine months.

a) Periotest values (PTV):

Periotest M device was used to assess implant stability

Figure 9

Figure 10

Figure 11

Figure 12

at the base line and 9 months after. The entire measuring procedure requires approximately 4 seconds. Loose implants display high Periotest values, while implants with good mechanical or biological stabilities display low Periotest values.

Periotest values (PTV) of (-8 to +9) were considered the ideal values that denote successful primary stability and osseointegration. Three consecutive readings were obtained and the average of these values represented the PTV of the implant.

b) Gingival index (GI):

The gingival tissues around the implants were isolated and gently dried by a piece of gauze and then each surface was individually scored according to the modified Loe gingival index scores and the mean value of the scored surfaces was calculated.

c) Probing Depth (PD):

Probing depth around the implants was measured using a graduated pressure-sensitive probe and the mean value of the scored surfaces for each implant was calculated.

d) Radiographic Evaluation
(Cone Beam Computed Tomography CBCT)

Images were acquired using the I-CAT Imaging system.The patients were exposed in the sitting position and the mandibles were immobilized using a head band to position the head against the head rest and chin cup, with the mid-sagittal plane perpendicular to the horizontal plane using vertical and horizontal alignment beams as recommended by the manufacturer.

The X-ray field size applied in the current study (field of view for mandible only) was 23.2 cm diameter x 17 cm height, and scanning time was 8.9 seconds (fast enough to avoid patient movement, image blurring and haziness). Operating parameters were 120 kVp, and 5 mA with slice thickness of 0.3 mm (the standard resolution for scanning at I-CAT machine).The I-CAT Vision software was used which allows the recording of linear and density measurements of images.

Image reconstruction

All the linear measurements are measured from the MPR screen (Multi-planar reconstruction) (MPR facilitates reconstruction of any projection due to the fact that whole volume is acquired in MPR in coronal, sagittal and axial views) of the I-CAT Vision software.

In order to standardize the cut on which every time the measurement is taken, a set of steps are to be made for each implant in every case. First the axial view is adjusted with slice thickness of 0.3mm (the minimum thickness is mandatory here to accurately view implant cross section at which coronal and sagittal reference lines intersect) and 3mm for both the sagittal and the coronal sections (3mm cut is suitable for taking linear measurement putting relative to the 2.8mm implant diameter, so that error in choosing the measuring cut to measure at is minimized, knowing that measurement is taken at 10 superimposed cut 0.3X10, hence a minimum possibility in taking measurements at different cuts) . The axial view is set to the level where all implants are seen, the coronal and the sagittal reference lines are adjusted to intersect at the center of the implant to be measured. The implant then is adjusted by rotation of the view in order to obtain an image of the implant of its long axis parallel to sagittal and coronal reference lines in coronal and sagittal views respectively. On the coronal image, the level of the axial reference line was set to be 6mm above the apex of the implant (at this level a well defined outline of the cortical plate is best seen), at this axial view the coronal reference line is adjusted to be parallel to the labial or buccal cortex at this level, thus a fixed and reproducible axial, coronal and sagittal views are obtained. Finally the parallelism of the implant is rechecked.

Evaluation of bone height changes

A tangential line was drawn at the apex of the implant perpendicular to the long axis of the implant. The bone height was measured by measuring the distance from the apex of the implant to the crest of the alveolar ridge.

The labial and lingual bone heights were measured on the sagittal view screen, while the mesial and distal bone heights are measured on the coronal view screen. The mean value of readings of both mesial and distal together and buccal and lingual together was taken, tabulated and statistically analyzed. (Figs. 13&14)

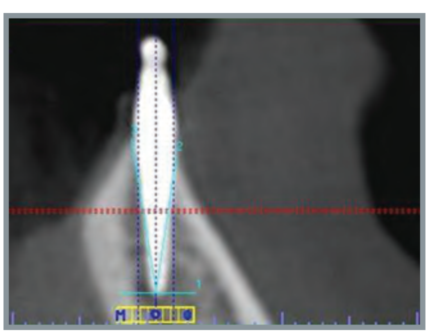

Figure 13

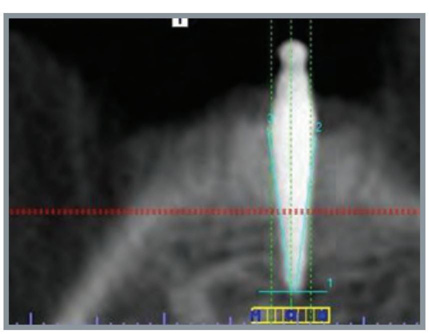

Figure 14

Density measurements

The density measurements are performed by calculating the mean of the Hounsfield units at a square area of 0.4 mm2 located 1mm away from each surface of each implant to reduce the effect of the scattered radiation on the density values so

The bone densities at the labial and lingual bone surfaces are measured on the sagittal view screen. While the bone densities at the mesial and distal surfaces are measured on the coronal view screen. The mean values of readings of both mesial and distal together and buccal and lingual together were taken, tabulated and statistically analyzed. (Figs. 15&16)

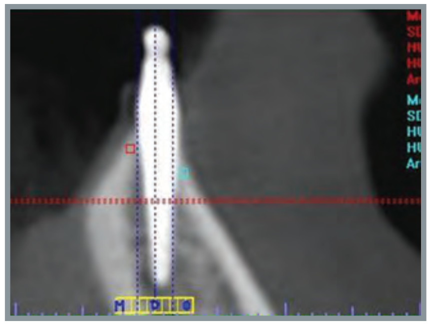

Figure 15

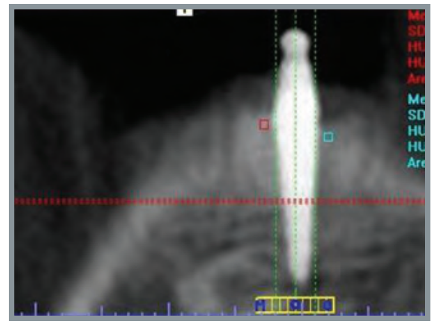

Figure 16

Statistical analysis

Data were presented as mean and standard deviation (SD) values. Paired t-test was used to study the changes along time within each group. Student's t-test was used to compare bone density, bone height, Periotest and probing depth results in the two groups. Mann-Whitney U test was used to compare between Gingival index (GI) in the two groups. This test is a non-parametric test alternative to the Student's t-test. Wilcoxon signed-rank test was used to study the changes along time in the GI within each group. This test is also a non-parametric alternative to paired t-test.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with SPSS 16.0 (Statistical Package for Scientific Studies) for Windows.

Results

Generally all the patients who participated in this study were satisfied with their implant supported overdentures. The prostheses were highly accepted by the patients, the enhanced denture retention and stability allowed easier and convenient adaptation period with less post insertion complaints. They all accommodated well to their dentures and could use it effectively few days after delivery. The only complaint reported by most of the patients was that they became not satisfied with the retention of their upper dentures.

This study was carried out on forty endosseous mini implants inserted into the mandibles of ten completely edentulous patients. During the follow up period, an implant was lost in the immediate loading group after 7 days of loading; this may be attributed to an error during the pick-up procedure which led to an over stressed implant resulting in micromotion and failure of osseointegration. This problem was solved by inserting a new implant 5 mm away of the lost one and the pick- up was meticulously repeated.

I. Radiographic (Cone beam) results

a) Results of marginal bone height

There was a statistically significant decrease in the mean alveolar bone height ($P \leq 0.05$) regarding the two groups along the study period, while a statistically insignificant difference was revealed; when the percentage of bone loss ($P \leq 0.05$) of the two studied groups were compared throughout the study period. (Table 1)

Percentage of bone loss in the two groups along the study period

Group	Immediate Loading		Delayed Loading		P-value
Time	Mean %	SD	Mean %	SD	
Base line – 9 months	6.98	2	7.07	1.96	0.956

*: Significant at $P \leq 0.05$

Table (1): Percentage of change in bone height (percentage of bone loss) in the two groups along the study period

The effect of time on the mean bone density of each group

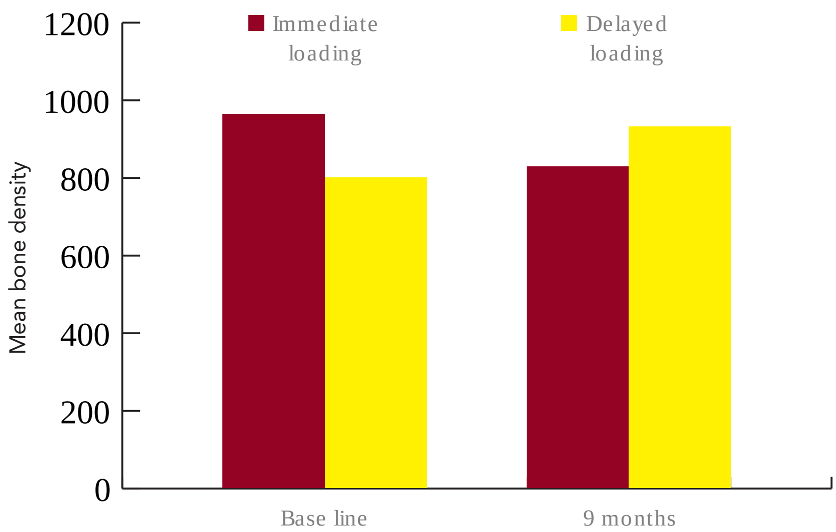

Figure (17): The effect of time on the mean bone density of each group

Comparison between percentages of change in bone density in the two groups along the study period

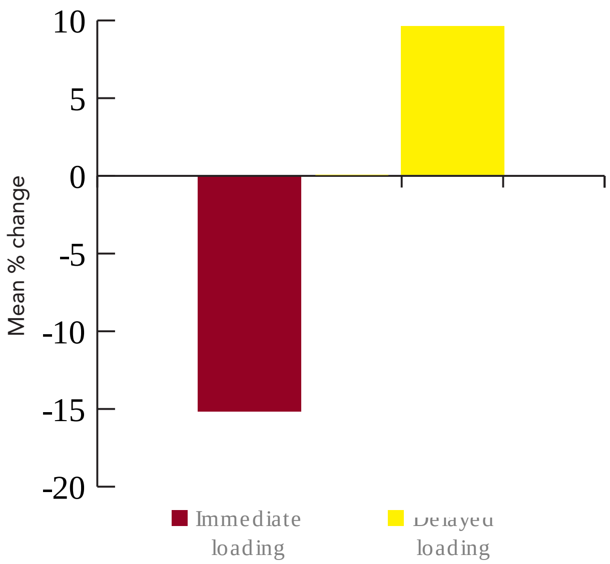

Figure (18): The percentages of change in bone density of the two groups along the study period

b) Results of bone density

There was a statistically insignificant decrease in the mean bone density (P ≤ 0.05) regarding the immediate loading group throughout all the study period. On the other hand a statistically insignificant increase in the mean bone density regarding the delayed loading group was revealed throughout the study period. (Fig. 17)

When the mean of the percentage of change in bone density of the two studied groups was compared throughout the study period, delayed loading group showed a statistically significant higher percentage (P ≤ 0.05) than immediate loading group. (Fig. 18)

II. Results of periotest

There was a statistically significant increase in the mean PTV P (≤ 0.05) regarding the immediate loading group throughout the study period. Regarding the delayed loading group the results showed a statistically insignificant increase in the mean PTV throughout the study period. (Fig. 19)

When the mean of the percentage of change of PTV of the two studied groups was compared throughout the study period, immediate loading group was statistically significantly higher than delayed loading group (≤ 0.05) (Fig. 20)

III. Results of probing depth and gingival index:

There was a statistically insignificant increase (≤ 0.05) in the mean gingival index and the probing depth regarding the two groups throughout the study period.

Discussion

All of the investigated cases in this study showed changes both clinically and radiographically during the whole follow up period, these changes could be logically explained as they could be considered as a biological response to the insertion of mandibular implant supported over denture.

Crestal bone resorption around the implants is a well known phenomenon occurring mostly as an immediate bone response after implant insertion as well as after functional implant loading. The amount of bone resorption occurring after loading may be related to many factors as the amount of load, nature of the prosthesis, bone quantity and quality, implant related factors

In this study the bone height changes, despite of being statistically significant along time; they remain within the clinically permissible range. This may be attributed to many factors. First of all is the flapless approach adopted during implant placement, as it is demonstrated that flap reflection will often result in poor subperiosteal blood supply, thus leaving poorly vascularised cortical bone, promoting bone resorption during the initial healing phase. Second, the type

The effect of time on periotest values (PTV) within each group

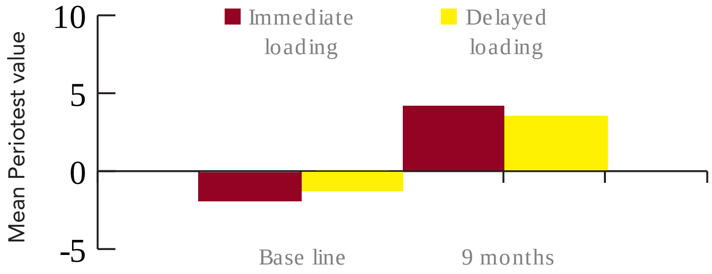

Figure (19): The effect of time on the mean Periotest values of each group

(design, number and dimensions), opposing restoration and crown height space (11, 12). It is well known now in the literature that crestal bone resorption is not only unavoidable but also time related. Many studies confirmed these findings and agreed that most of this resorption occurs within the first year from loading with an average of 1.2mm and it does not contradict implant success (13, 14).

of prosthesis which is an implant-tissues supported prosthesis that shares the load between the ridge and the implant, thus protecting the implants through the stress breaking action of the ball attachments. Third, careful patient selection excluding those with ridge relation discrepancies (Angle's class II and III) and those with previous history of bruxism. This helped to avoid implant overload as much as possible. The selection of the anterior part of the mandible also allows for superior bone quantity and quality which made bone remodeling within the permissible range (2, 15, 16, 17). Finally it should be noticed that the opposing restoration was upper complete denture that exerts less load on opposite arch compared to natural dentition or fixed restorations (18)

The results of this study also revealed a statistical insignificant difference in marginal bone loss next to the immediately and the delayed loaded implants, these results are in accordance with other studies comparing immediate loading and delayed loading. (19, 20)

This could be attributed to the fact that both the surgical and the loading protocols in the two groups were strictly applied in accordance with previous studies and protocols regarding; proper implant site selection with good bone quality (21, 22), proper implants design as well as, primary stability (23), number of implants and prosthetic design (24), in addition to the strict instructions given to the immediately loaded patients to eat soft diet for one month and oral hygiene measures, as well as reduction of occlusal load by adjusting the occlusion, reducing cusp inclines of artificial

Comparison between percentages of change in Periotest

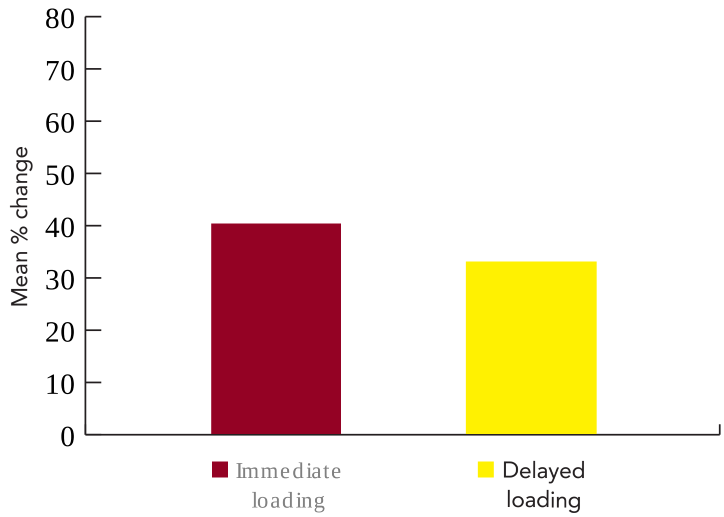

Figure (20): The mean percentage of change in Periotest values in the two groups

teeth as well as maximum coverage of the edentulous alveolar ridge.(25, 26)

Regarding the bone density, results revealed statistically insignificant decrease in immediate loading group and insignificant increase in delayed loading group. This may be explained by the fact that the delayed loading protocol allows sufficient time for adequate bone remodeling before loading of the denture, this remodeled bone was capable to withstand the functional forces of loading in a much better way than immediate loading protocol.

These results were inconsistent with other authors who found a statistically significant increase in the bone density in bone supporting the immediately loaded than the delayed loaded implants.They explained that this may be due to the bone response to stresses within physiologic tolerance as new bone formation and active remodeling may be observed when the bone is mechanically stimulated during the first 6 months to one year of loading (25, 19).

This variation may be attributed to many factors related to the studies as all of these findings were in cases with implants with larger diameter than the mini implants, also the prosthetic design may vary from fixed restoration to over denture supported by different attachment types as bar, or telescopes, as well as the number of implants used in these studies were varying from two to six implants. Finally most of the literature dealing with the bone density assessment was depending on two dimensional radiographic techniques either periapical or panoramic radiography which ignore the bone density at the buccal and lingual surfaces.

In this current study cone beam C.T was used to evaluate the bone density around the implants by calculating of the Hounsfield units at the four surfaces Therefore each implant had four Hounsfield units (B, L, M and D) indicating the density of bone engaged with the threads of the implant. (27, 28)

Regarding the periotest results which reveled significant increase in PTV in immediate loading group and insignificant increase in PTV in delayed loading group throughout the study period, the PTV still remain within the permissible range (-8 to +9) which indicates no discernible movement, this may be attributed to high primary stability achieved in both groups during implant insertion due to the undersized osteotomy together with the self threading design of the implant and finally the dense bone of the anterior area of the mandible which led to adequate initial implant stability. This primary stability changed gradually to biological stability which is affected by the rate and the quality of bone remodeling (29, 30).

In this study the immediate loading group showed significant increase in the PTV than the delayed one; and this could be explained on the basis that the periotest is mostly affected by the bone density around the implant which showed an increase in the delayed loading group.

Two similar studies were performed, where a computerized tomography scan was done for the preoperative evaluation of bone density for each patient before implant placement. Bone quality according to resistance to drilling, insertion torque and primary stability were evaluated. It was concluded that the primary implant stability depends on bone density values, bone quality and implant location (31, 32)

In this study the mean values for the gingival index scores in both groups have been insignificantly changed which may reflect the easiness in oral hygiene maintenance of the ball attachments due to facilitated denture insertion and removal, and the patients compliance to the given oral hygiene instructions.

Consequently, this study agrees with other authors who considered the ball attachments as highly hygienic and reported that ball attachments have superb hygiene maintenance capabilities (33).They attributed this finding to the small size of ball attachments that permit accessibility for implant brushing and cleansing (34).

The two groups, as well showed statistically insignificant increase in probing depth throughout the study period, which may again reflect the ability of the patient to control plaque accumulation which is directly related to peri-implant mucositis and peri-implantitis (35). This increase in probing depth is considered as a common change relative to other similar studies and is considered within the permissible range of the criteria for implant success (36)

Additionally the single piece mini implants provide a gap free connection (bacteria proof) and therefore getting the optimal effect of the barrier and protection functions of the peri-implant soft tissue. This also allows the establishment of a tissue collar overlapping the bone implant interface (37). n

Acknowledgment

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