Implant Stability and Bone Level Assessment around Dental Implants in Response to Laser Treatment in Mandibular Implant Supported Over-Denture: Split Mouth Study

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Abstract

Purpose: The purpose of this study was to see how Laser treatment affected the implant stability and bone height changes of mandibular implant-supported over-dentures. **Subjects and Methods:** Ten entirely edentulous patients were chosen and rehabilitated using mandibular over-dentures supported by two implants in the canine region. Each patient received an upper and lower denture, and after surgery and placement of the two implant, they were divided into two implant groups. Group I: Right dental implant in each patient without Laser treatment. Group II: Left dental implant in each patient was subjected to six Laser treatment session by Semi-conductor diode laser.

Each implant's stability was assessed at the time of surgery, one month, and three months later. Cone-beam Computed Tomography (CBCT) was used to measure bone height at the time of denture placement, six, and twelve months later. **Results:** There was a significant difference in implant stability measurements ($p \leq 0.05$), but a non-significant difference in bone height ($p > 0.05$) between the two studied groups. Where group II showed a higher value in implant stability and bone height measurements than group I. **Conclusion:** The application of laser on dental implants has a great benefit in increasing implant stability and decreasing the crestal bone loss than implants not subjected to laser treatment.

Keywords: Implant, laser, implant stability and bone height.

Introduction

Complete edentulism is a serious condition that happens when all of the teeth are lost. If left untreated for a long period, this disorder can lead to advanced alveolar bone resorption, decreased masticatory function, and physical and psychological incapacity [(1)]. For many years, patients who were entirely edentulous were treated with a conventional complete denture. Complete mandibular dentures have problems with stability and retention. Due to the restricted coverage area, the approach of muscle attachment, saliva overflow, and tongue activity, these issues are prevalent in mandibular dentures [(2)].

Dental implants are now widely used to maintain alveolar bone height in edentulous individuals with progressive bone loss. Because of their great success rate, liability of the surgery, and relatively few complications, the usage of implants to restore lost teeth has expanded significantly over the last 30

years. Research studies have demonstrated that dental implants minimize or entirely avoid vertical and horizontal bone loss in implant-retained overdentures when compared to a conventional denture. [3, 4].

The technique for a successful implant insertion aids in osseointegration and ensures that the implant is positioned correctly for an aesthetic and functional restoration. The most recent innovation in this field is creating an implant placement guide using 3D technology. Computer-guided implant surgery involves the use of a stable surgical stent to steer the placement of the implant to the intended position in accordance with the prosthetically guided surgical plan created in a computerized implant planning programme[5].

This surgical approach has the benefits of being less invasive, accurate implant placement, predictability, less postoperative discomfort, and a reduced recovery period. The correct angulation and location of the implants in the bone are made easier by surgical guides. The surgical guide aids in placing the implant properly In addition, it can retain the restoration in place and support occlusal stresses. [6].

Osteointegration is the process through which organized live bone directly connects structurally and functionally to the surface of a load-bearing implant. As osseointegration refers to the mechanical anchoring of a dental implant in the jaw bone that lasts under all normal oral function conditions. Implant stability is influenced by both mechanical stability, this derives from the implant being firmly held in position by compression bone, and biological stability, which comes from osseointegration and new bone cells growing at the implant site. [7]. Because implant success is dependent on the implants' long-term integration into hard and soft tissues, there is enough confirmation to acknowledge favorable association among initial stability of the implant and successful implant [8].

The preservation of peri implant-bone height is critical because it determines the dental implant's long-term survival rate. The implant runs the risk of failing following osseointegration if there is a disruption in the implant-tissue contact along the crestal region following load. Marginal bone loss during the initial year of use ought to be below 1 to 1.5 mm, and persistent annually bone loss must be no more than 0.2 mm, in accordance with the requirements for effective dental implants. But since then, efforts have been undertaken to speed up osseointegration and prevent marginal bone loss surrounding implants that have successfully osseointegrated. Implant biomaterials, design, surface properties, and the implant-abutment link have all improved [9].

Laser treatment is one such supplemental therapy that has recently been studied to boost bone regeneration capability Near-infrared or red spectrum laser therapy with a wavelength range from 600 to 1100 nm is referred to as laser treatment. Laser treatment stands for low-energy densities and power output. [10]. A number of tissue responses, including vascularity, inflammation, cellular proliferation, and differentiation are affected by Laser treatment's biostimulatory effects on tissues, generating a variety of biological environments that encourage curing both in vivo and in vitro. It promotes faster angiogenesis, accelerates fibroblast migration and proliferation, and enhances mesenchymal cell differentiation into osteoblasts as well as their adherence to the titanium implant surface, which all contribute to bone repair. [11].

Resonance frequency analysis (RFA), a harmless assessment technique, can be utilized to evaluate lateral micro-mobility during different phases of the implant procedure. A tiny transducer that is attached to an implant or abutment is used to measure the initial resonance frequency.. For use with the RFA method of implant stability testing, Osstell created a scale of measurement known as the Implant Stability Quotient (ISQ). The ISQ, which is ascended from 1 to 100, is displayed on the instrument. The higher the number, the more stable the situation. A number of less than 45 implies implant failure, whereas a value of 60-70 indicates implant success [12].

True volumetric data processing and development of a three-dimensional picture volume can be reformatted using special software for changed visualization of the anatomy with lesser radiation exposure in CBCT. In comparison to traditional CT, CBCT has better resolution due to smaller single

voxels. During the treatment plane of an implant, a CBCT is used to precisely measure the bone height and width to avoid implant placement in important structures. It's also utilized to assess supporting structures and bone height around implants since it appears to be one of the most advanced and promising resources in the field [(13)].

Thus, the purpose of the present research was to assess how laser treatment affected implant stability and crestal bone loss surrounding dental implants that were supporting a mandibular overdenture.

SUBJECTIVE AND METHODS:

Ten fully edentulous male patients between the ages of 50 and 60 were chosen from the Out-Patient Clinic of the Removable Prosthodontic Department; Faculty of Dental Medicine for Girls, Al Azhar University. All of the patients in this study had a Class I Angel ridge association and were free of any systemic disease, TMJ, or neuromuscular condition. This study excluded smokers, alcoholics, individuals with poor dental hygiene, and those who had chemotherapy. All surgical and prosthetic treatments were explained to each patient and carried out with the agreement of the Research Ethics Committee (REC) of the Faculty of Dental Medicine, Al-Azhar University displaying the advantages, dangers, and implant treatment options.

Each patient's medical and dental histories were obtained, followed by an oral examination (extraoral and intraoral), and radiographic evaluation. Before selecting patients that can be treated with implants using an implant surgical guide, all patients are first evaluated by CBCT and the image was saved as DICOM (digital imaging and communications in medicine), which was then loaded into specialist software for virtual planning. A CBCT scan was used to assess the height, width, and quality of the bone at the implant site.

Complete denture construction:

After the upper and lower special tray was done over the diagnostic cast, a secondary impression was taken by zinc oxide and eugenol impression material or by using rubber base impression material if the patients had undercuts. Upper and lower record blocks were constructed over the master cast using bases made of auto-polymerizing acrylic resin and rims made of wax. The correct vertical dimension of the centric relation in the patient's mouth was noted. With a maxillary face bow record for the upper cast and a centric jaw relation record created using the wax wafer technique for the lower cast, the upper and lower casts were positioned on a semi-adjustable articulator (Bio-Art articulator).

Over the temporary denture base, artificial teeth were fitted. The patient was then given the waxed denture to try in their mouth. The acrylic upper and lower dentures were examined in the patient's mouth for retention, stability, extension, and harmonic occlusion after the waxed-up denture was processed. Any modifications that were required were made. After giving the patient the instructions and home-care instructions, the dentures were handed to him. Planning of implant prospective sites and construction of Stereolithographic stent

For the purpose of making an acrylic resin radiography template, the new mandibular denture was duplicated. In order to precisely determine the amount of bone needed for prosthetically driven implant placement, patients received CT scans. To gauge the average thickness of the mucosa covering the remaining alveolar ridge, gutta-percha radiopaque indicators were fastened to perforations drilled in the duplicated denture's fitting surface opposed implant potential locations. CBCT was used to perform a dual scan regimen on the patients. The first scan was performed using a radiographic stent alone. Then, the patient was occluded on the radiographic stent during the second scan. A special implant analysis software imports the raw Dicom scan files. Both scans are superimposed together by the software. Virtually, two implants were positioned in the canine area perpendicular to the occlusal plane and parallel to each other. Finally, Rapid prototyping technology was employed to create a mucosal-supported stereolithographic surgical template with two sleeves placed over the sites of the prospective implant sites.

Surgical procedure:

The patient was directed to take a mouth wash (0.12 % chlorhexidine) every eight hours three days prior to surgery. Oral broad-spectrum antibiotics were taken twice a day starting one day before surgery and ending on the fourth postoperative day.

In addition to infiltration anaesthesia injected into the buccal and lingual mucoperiosteum, all patients underwent surgery while under local anaesthesia utilising 2% lidocaine and a bilateral inferior alveolar nerve-blocking approach. After making sure the surgical template was precisely positioned on the underlying mucosa, anchor pins were used to secure the template to the underlying bone on both sides. Then, the implant location was exposed by performing a circular tissue puncture with a tissue puncher. The pilot drill was utilized initially at the implant site under copious normal saline irrigation, followed by sequential implant drills to prepare the osteotomy site. To get rid of any bone shards, perfuse saline was injected onto the osteotomy site. (Fig 1)

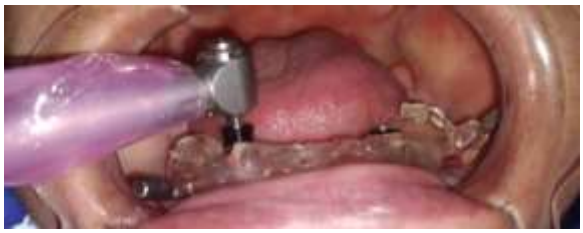


Figure (1): Surgical stent that allows implants insertion through a flapless approach

Following the final preparation of the implant site, the implant was manually placed into the bone and then ratchet wrenched into place until the implant platform was level with the bone. Finally, the implant fixture was connected to the smart peg, and the Osstell device was used to hold the probe close to the smart peg without touching it. ISQ is displayed on the device's screen when it beeps. Figure (2)

-The implant was then covered with a 2 mm healing cap.

After each patient received two implants, the right implants were not subjected to laser, and the left implants were subjected to the laser so, the implants were grouped into two groups.

Fig. (2): Implant stability measurement after implant insertion

Implant grouping: Ten implants in each group after surgery according to laser treatment application.

Group I: Right dental implant in each patient in the canine area without Laser treatment.

Group II: Left dental implant in each patient in the canine area was subjected to six sessions of laser treatment. Intra orally, a semiconductor diode laser with a wavelength of 810 nm and a power of 0.5W was used. In two weeks, there were six sessions.

The first session began the day after the implant was placed. In each session, the total energy dose provided in one minute is around 20 J/cm3 (30 seconds buccally and 30 seconds lingually).

Prosthetic phase:

At the end of the third month after implant placement, patients were contacted to get a ball and socket attachment. After removing the healing abutment, ball attachments were put into the fixture and the ball housing covered the ball attachment. The portion on the denture's fitting surface opposite the housing was relieved to make room for the ball housing in the denture's fitting surface. The pick-up procedure began after testing for occlusion and the lack of rocking. The relieved portion of the denture was filled with cold cure acrylic resin, and the denture was seated in the patient's mouth. Until the acrylic resin polymerized, the patient was in centric occlusion. Ball housing was picked up in the fitting surface of a lower denture. Then, the lower denture has been finished, polished, and delivered to the patient.

Implant stability evaluation:

Both groups had their assessments done using Osstell for use with RFA at one-month and three-month intervals. The healing abutments on the right and left were both removed, and the electronic peg was fastened to the implant fixture in their place. The probe was then held in close proximity to the electronic peg using the Osstell equipment without actually touching it. ISQ is displayed on the device's screen when it beeps. After one month and three months, this procedure was performed.

Radiographic evaluation:

All patients were scheduled for follow-up visits utilizing CBCT to assess marginal bone changes at four axial surfaces (Mesial (M), Distal (D), Buccal (B), and Lingual (L)) of each implant at the time of denture insertion (baseline), six months later, and twelve months later. The linear measurement equipment provided by the manufacturer of CBCT was used to evaluate peri-implant bone height changes on each axial surface of the implant. As a reference point, a horizontal line tangential to the implant's apex and perpendicular to its long axis was chosen. Using the measurement tool in the software, the bone height was calculated from the implant's apex to the crestal bone in contact with it. Figure (3)

All of the data are gathered, tabulated, and statistically analyzed.

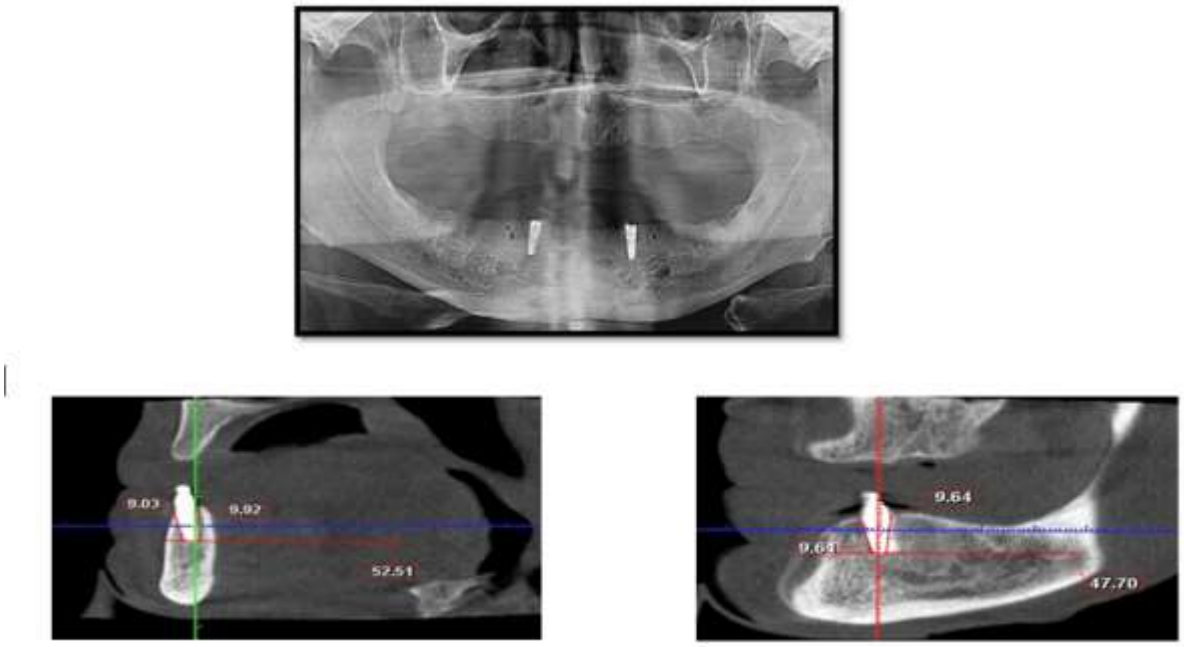


Figure (3): CBCT used to asses marginal bone changes

Statistical analysis:

The mean and median values were determined, the data distribution was examined, and the Kolmogorov-Smirnov and Shapiro-Wilk tests were performed to determine the normality of the data. The paired t-test and repeated measures ANOVA were employed for intergroup comparisons, followed by the Bonferroni post hoc test. Non-parametric data were assessed for intergroup comparisons using the signed-rank test, Freidman's test, and then the Nemenyi hoc test. The significance level was set at p0.05 for all tests. The statistical study was performed using R statistical analysis software for Windows, version 4.1.3.

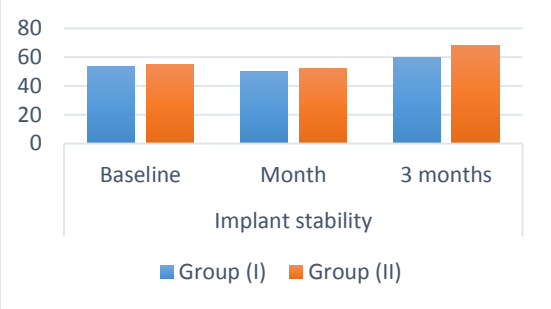
RESULTS:

Implant stability

There was no significant difference between the two groups at baseline (during implant installation) and after one month ($p>0.05$). There was a significant difference between the two groups after three months ($p<0.001$). The mean value of group II was greater than it in of group I.

Table (1): Mean and standard deviation (SD) values of implant stability for both groups at different intervals

Time	Implant stability (Mean± SD)		P-value
	Group (I)	Group (II)	
Baseline	53.47±8.21	54.53±7.22	0.594ns
Month	50.11±6.80	52.22±6.42	0.296ns
3 months	59.36±5.28	67.69±5.85	<0.001*



Graph (1): Bar chart showing mean value of implant stability for both group

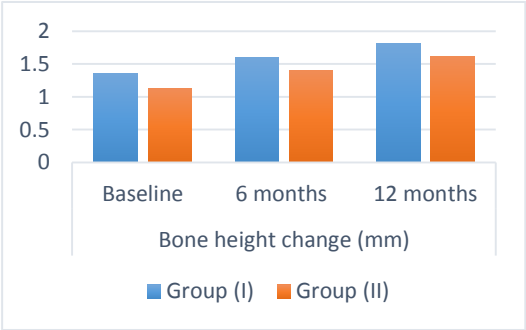
Peri implant-bone height change (crestal bone loss):

At baseline (denture insertion), six months later, and twelve months later, group II (implants with Laser treatment) had a lower mean value of crestal bone loss than group I (implants without Laser treatment). However, there was no significant difference in crestal bone loss between the two groups ($p>0.05$).

Table (2): Mean and standard deviation (SD) values of bone height change (mm) for both groups at different intervals

Time	Bone height change (mm) (Mean ± SD)		p-value
	Group (I)	Group (II)	
Base line	1.36±0.75	1.13±0.62	0.123ns
6 months	1.60±0.67	1.40±0.57	0.125ns
12 months	1.82±0.57	1.62±0.47	0.118ns

ns; non-significant (p>0.05)



Graph (2) : Bar chart showing mean value of bone height change (mm) for both groups

DISCUSSION

The introduction of implants and their use in implant-retained mandibular overdentures has resulted in massive improvements in denture retention, stability, and masticatory efficiency. The mandible was chosen for implant insertion in this study to assist solve several problems with the mandibular arch prosthesis, such as ill-fitting dentures, retention limitations, and reduced denture stability because the mandible exhibit more bone resorption than the maxilla [(14)].

The age range the patient was chosen according to was between 50 and 60. Patients above the age of 65 were excluded because age has an impact on how the residual ridge resorption, muscle control, oral mucosa, and TMJ behaves. In addition, only male patients were chosen for the current study to prevent the hormonal changes related to the sex, which can lead to mucosal alterations, and bone resorption [(15)].

Generally, all of the patients were healthy and devoid of any systemic illnesses that could impair the oral cavity's state, increase bone resorption, or modify the healing process, and therefore affect the study's outcome. Moreover, Patients with abnormal ridge relationships and para-functional habits such as bruxism and clenching were excluded from this study to prevent applying too much force to the implants [(16)].

The canine region bilaterally (interforaminal regions) was chosen for implant implantation in the current investigation because good bone quality and quantity are commonly observed to demonstrate more early stability and so predictable positive results when Laser treatment is used. Furthermore, there are no substantial anatomical structures in these locations [(17)].

In the treatment plan of this study, an implant surgical guide was used as using it made it easy to place the dental implant in the intended location and allowed for the use of a guided flapless procedure. Dental implants placed without a flap have been shown to have high success rates when compared to those of conventional implant placement techniques due to the absence of features including incisions, flap

reflection, implant placement determination, drill depth control, and suturing techniques. In addition, flapless computer-assisted surgery seems to have other advantages, including reduced operating times, preservation of the Peri-implant tissue, less postoperative complications as pain and bleeding which will result in quicker healing, and enhanced comfort of the patient [(18)].

Two implant-supported over denture designs were used in this study to decrease the length of a probable cantilever. Ball and socket attachments were used as they provide a wide range of motion of the prosthesis, avoid overloading of the implants, handling them and changing attachments are easy, they are less technique sensitive and of low cost. [(19)].In this study the dental implants were standardized (10mm long and 3.5mm wide),[(20)].In this investigation, each patient received two implants, on each side, but only the left implant was treated with laser treatment, to standardize all factors that might affect the outcome.

In this study laser treatment was used on the implant as it is a non-invasive technique that produces an increase in ATP production, the release of growth factors and other cytokines, macrophage, lymphocyte, and fibroblast proliferation, and synthesis of collagen. It also improves microcirculation, which reduces discomfort and edema, resulting in decreasing the postoperative recovery period [(21, 22)].

The Osstell ISQ device for RFA has been recommended for providing objective measurements of implant primary stability and nondestructive monitoring of implant stability during the healing process. When compared to prior electronic versions, it is said to be more accurate, reliable, and has improved recording accuracy [(23)].

Cone-beam Computed Tomography (CBCT) gives a quantitative measurement of the implant site's bone height, so it was used in pre-operative planning and postoperative radiographic assessment of Peri-implant bone height. It is considered as a true volumetric data analysis, production of a 3D image volume that can be reformatted using special software, high resolution, and lower radiation dose [(24)].

Regarding the results of implant stability, group II (implants with Laser treatment) demonstrated an insignificant increase in ISQ measures when compared to group I (implants without Laser treatment) during implant installation and one month later, but group Ⅱ was higher than group Ⅰ. This could be because laser treatment stimulates the conversion of non-differentiated mesenchymal cells into osteoblasts, which then changes into osteocytes more quickly, improving vascularization, anti-inflammatory effects, and increased collagen synthesis, all of which help with bone healing [(25)]. These results agrees with those of the current study, which found that laser treatment promotes bone repair around dental implants [(26)].

The results of this study stated that, After three months, the ISQ measures of group II (Implants with laser treatment) were considerably greater than those of group I (Implants without laser treatment). These findings matches Fahmy et al. [(27)] who suggested that the mechanism of laser treatments' participation in early bone healing is based primarily on the osteoblast stimulation, cell proliferation and multiplication of osteoblastic cells, which leads to an increase in bone production.

Moreover, a significant difference was displayed in implant stability for group Ⅰ and group Ⅱ throughout the study periods and showed bio stimulatory effects of laser treatment that is proven to enhance the bone healing process and modulate inflammation. These results agree with the studies that found that the laser treatment enhance the osseo-integration around dental implants [(27)].

Regarding the peri-implant-bone height, the result of the present study showed no statistically significant difference between group Ⅰ (implants without laser treatment) and group Ⅱ (implants with laser treatment) at different time periods. However, there is a decrease in peri-implant bone height in group Ⅱ than in group Ⅰ. This finding was in accordance with studies [(28)] that thought that the implant success rate might be improved by the laser treatment. As it improves bone healing around the dental implants and might result in increased osseo-integration, however, there was still no significance

detected.

Furthermore, the findings of this study revealed that during the follow-up period, both groups showed a statistically negligible rise in crestal bone loss. This may be due to surgical trauma, and the healing process. Also, it may be seen as an initial bone reaction following the the prosthesis wearing, which is ascribed to the healing and rearrangement of the bone and periosteum following trauma, as well as remodeling due to implant installation . Forces applied to implants may be centered, causing crestal bone loss. [(29)]

CONCLUSION

Within the parameters of this study and the limitations of the follow-up time, it can be concluded that applying Laser treatment to dental implants enhances bone reactivity and increases implant stability.

RECOMMENDATION

For future research, it is recommended to increase the number of the sample and the follow-up period. And to investigate the effect of laser treatment on other parameters or outcomes.

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