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The Effect of Ridge Splitting with Laser Bio-Stimulation on Bone Loss Around Four-Implant Supported Mandibular Overdentures (Within- Patient Study)

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ABSTRACT

Purpose: This study aimed at assessing the radiographic consequences of implants supporting mandibular overdenture. Two implants located in expanded anterior–knife-edge ridges with crest ridge-splitting, bone graft, membrane placement followed by laser application. The anterior implants were compared to posterior ones implanted in unexpanded ridges with no modifications. **Materials and methods**: Twenty completely-edentate patients had anterior -knife-edge mandibles, two implants were received in the 1st premolar areas without ridge-expansion or further alterations (Group I; control group). Another two implants (lateral-incisor areas) were placed. Ridge-expansion, bone graft, low-level laser therapy LLLT and membrane placement were all accomplished (Group II; test group). 6 months following placement of implants, Locator attachments were used to connect the mandibular overdentures to implants. Radiographic (Vertical bone loss; VBL and Horizontal bone loss; HBL) parameters were then respectively recorded at: overdentures delivery (baseline, T0), 6 months (T6), and 12 months (T12). **Results:** For each group, insignificant differences in HBL between observations were noted. Whereas, For Group I, VBL significantly increased (T6 to T12). Howbeit, insignificant differences in VBL and HBL among groups were revealed. **Conclusion:** Within this study limitation, mandibular knife-edge ridge expansion along with concurrent implants placement exhibited comparable radiographic outcomes to those implanted in unexpanded ridges. Yet, ridge-expansion together with LLLT seems advantageous respecting VBL.

INTRODUCTION:

Obviously, osseointegrated dental implants supporting overdentures are being rendered a successful therapy respecting patients uttering denture problems related to mandibular alveolar ridge atrophy. Such treatment confers improved retention and stability, masticatory performance, quality of life, patient satisfaction coupled with the cost compared to conventional dentures [1, 2] .

Attachments are authentically used to retain implant overdentures. Interestingly, various systems are readily gettable. Of these, Locator which becomes an increasingly popular attachment system can be used on free-standing, non-splinted implants. This system is categorized as universal hinge resilient overdenture attachment for endosseous implants. Locator attachments are common place low-profile attachment, besides, it can offset for angle corrections up to 40◦[3] .

Plainly, ridge splitting technique results in lateral ridge expansion combined with creating a new implant bed via longitudinal osteotomy. This will allow the buccal (labial) cortex to be positioned laterally, eventually, form a space between the buccal and lingual cortical plates. This space is being filled with endosseous implant accompanied by graft material if needed. This technique is beneficial for enabling the simultaneous implant placement immediately, having minimal technical complications ,averting morbidity of the donor site, and having significant reduced treatment times [4].

The validity of Low Level Laser Therapy (LLLT) upon regeneration of the bone has been currently spotlighted as it improves vascularization and enhances collagen synthesis [5-7]. It modulates the inflammation, accelerates fibroblast proliferation and enhances wound healing [8]. Additionally, it was demonstrated that LLLT stimulates the bone stem cells and accelerates their repair process. Apparently, immediate implant loading has become more popular and is better accepted by many patients. It obviates the need for second surgery where provisionalization is simplified by the immediate loading of the implant after surgery [9].

The present study aimed to evaluate and compare radiographic outcomes of implants supporting mandibular overdentures; two placed in expanded knife-edge ridge of the mandible with conducting of ridge splitting, bone graft in addition to membrane placement followed by laser application, and those implants placed in unexpanded ridges. The null hypothesis was that no significant difference would be found in radiographic outcomes of implants positioned in expanded and unexpanded ridges throughout all time intervals.

MATERIALS AND METHODS

Patient Selection:

Twenty eligible patients were recruited from the Outpatient Clinic at Faculty of Dentistry, Mansoura University in Egypt. They were entirely edentulous and unable to masticate with their former worn dentures as well as poor retention. Following a complete thorough clinical and radiological evaluation, the selected patients had appropriate bone height but insufficient bucco-lingual bone breadth (nonetheless it is not less than 3 mm in the mandibular lateral incisor region). In the missing first premolar region of the arch, the patients also exhibited appropriate length and bucco-lingual bone breadth. Cone beam computed tomography (CBCT) was utilized to confirm the quality and quantity of alveolar bone. All the patients were classified according to Lekholm and Zarb[10], having Class 2 to 3 bone quantities.

The exclusion criteria implied; systemic diseases that may encounter obstacles in osseointegration, such as osteoporosis and diabetes, history of parafunctional habits, bruxism, history of radiotherapy in the head and neck region as well as heavy smoking .Exclusion criteria also dictated that the patients had no sever undercuts on labial or lingual side of the ridge. The current study has been accepted by the committee of ethics, Faculty of Dentistry, Mansoura University.

All the participants have been informed about the treatment plan in detail besides, the follow-up recalls needed, after then, they signed written consents. All cases matched respecting age and gender, type of implant, number and position of implants, type of attachment and loading protocol. Power analysis was not carried out and the groups had not been randomized.

The patients had their old conventional complete denture. The mandibular dentures were duplicated into autopolymerizing clear acrylic resin. At the site of each missing lateral incisor and 1st premolar area, four radiopaque gutta-percha markers were put into holes in the intaglio surface of the clear acrylic denture (at crest of the ridge). These markers were utilized to locate the missing lateral incisor and 1st premolar positions of the alveolar ridge and to assess bone height and width in these sites. The patients were scanned using CBCT while wearing their duplicated dentures (with gutta percha markers) as a radiographic template.

For ridge expansion ,the width can be increased by an average of 3.35 mm(11). To determine the amount of ridge splitting and expansion required, the proper dimensions of missing lateral incisor areas were measured. The proper implant dimension (3.5mm×11mm), position and angulation were planned, using the software, for the missing lateral incisor areas after ridge splitting and expansion in addition to the missing 1st premolar regions.

All surgeries were carried out under local anesthesia by the same oral and maxillofacial surgeon**.** Implants were placed in the missing lateral incisor area after ridge splitting and expansion. Whilst, the implants in the premolar areas were placed without ridge splitting **Figure (1)**. Cover Screws were connected to the implants.

Following implant insertion, a xenogeneic hydroxyapatite particles bone graft was inserted in the expanded space**.** Also, a low level intensity laser was performed around the implant bone with a gigaa laser dentistry diode laser system **Figure (2).** Each side of the implant received 4 J of energy both buccally and lingually (a total of 8 J per session). The last dose was 56 J of all seven sessions since the Laser irradiation was repeated at (2, 4, 6, 8, 10, and 12 days) postoperatively. Protective glasses were worn by both the patient and clinician (the clinician should be in a separate room)(7).

After implant placement, a resorbable collagen membrane was placed on the xenogeneic hydroxyapatite particles bone graft in the expanded space.

Subsequent to fixation of the resorbable collagen membrane, the mucoperiosteal flap was closed with interrupted sutures. Postoperative medications were prescribed for three days. After ten days, the sutures were removed. A soft lining substance was utilized to reline the old mandibular dentures after being relieved. Postoperative panorama radiography of the patients was taken shortly after surgery. After a minimum of six months of healing time from surgery, the healing abutments were placed, and new complete dentures with new impressions were made for all patients.

All submerged implants had been left to heal for 6 months prior to uncovering and prosthetic loading[12]. All implants were delayed loaded by the final overdentures via Locator attachments [13]. The Locator abutments were chosen based on the tissue height and the prosthetic platform. A periapical radiograph was performed along the long axis of the implants after the locator attachments were placed to ensure that the abutments were completely seated onto the implants. Over the head of each Locator abutment, a white block-out spacer was placed. A Locator cap with a black processing insert was placed on each Locator abutment. The denture had no contact with the titanium caps, which were checked. The extra material got out through lingual vents. The denture caps were bonded to the denture with a self-cure acrylic resin.

Dentures were polished just before changing the metal denture cap to the final male retentive insert **Figure (3)**. The occlusion was checked and corrected and all patients were educated how to remove and seat the denture properly.

Radiographic Examination:

A periapical standardized radiograph was made for each implant using the long cone paralleling approach[14].To standardize the film-implant distance and cone-implant distance during film exposures, a hole was drilled precisely above the implant hex in the film holder (XCP Instrument, Dentsply Rinn, USA). The holder was secured to the locator's abutment. By employing direct digital imaging system (DigoraVR Optime, Orion Corp./Soredex, Helsinki, Finland), radiographs were taken. The dental x-ray unit (XgenusVR , de GotzenVR S.r.l., Roma, Italy) operated at 70 kVp and 8 mA. Using the software of the imaging system (Scanora light Version. 3.2.6), the digital images were displayed on a computer screen with the following characteristics: 40 mm pixel size, 9003641 pixels, and 8 bits. The brightness and contrast of all images were standardized.

On each image, using the software's measurement tool, the distance from the implant shoulder (point A) to the first bone-to-implant contact (point B) was measured (in mm). This distance is named (DIB) and denotes the vertical bone level in mm (AB line). For determination of magnification errors, DIB measurements were calibrated based on the known implant length. DIB at T6 and T12 were subtracted from DIB at T0 to calculate vertical bone loss (VBL). For the horizontal loss of alveolar bone (HBL): the distance between the marginal bone levels (C point) [which represents the intersection point of a tangent to the horizontal bone crest (CD line) and another tangent to the crater-shaped defect (CB line)] and the implant perpendicularly indicates horizontal bone level (mm) **Figure (4).**

The VBL of each implant was measured on the distal and mesial surfaces, and the mean was statistically analyzed. For testing the reliability of the data recorded, evaluations of the radiographs and clinical parameters were carried out on the same day for three times.

Statistical analysis

SPSS® software version 25 was used to analyze the data (SPSS Inc., Chicago, IL, USA). Ascribed to the small sample size, Shapiro-Wilk tests were employed to diagnose the normality of distribution of data for all variables. The data were non-parametric, and the normal distribution was violated. The information was given as a median (minimum- maximum). Whitney-test was used to perform between-group comparisons of all parameters. Friedman-test was used followed by Wilcoxon signed ranks test for comparing between two times in the same group. P-values <0.05 were considered to be significant.

RESULTS:

Table (1) demonstrated descriptive data of bone loss vertically and horizontally at various observation times for both groups. Only group I experienced a significant increase in vertical bone loss from T6 to T12 (0.026). For group II, no significant change in vertical bone loss was recorded. There wasn't significant difference in vertical bone loss between the two groups.

DISCUSSION:

In the current study, ridge splitting technique was implied for increasing the width of the anterior ridge to accommodate proper placement of implant simultaneously with augmentation. This was in accordance to Moro and colleagues[15] . They stated that treatment of horizontal deficiencies of alveolar bone with alveolar split osteotomy was more dependable and trustworthy than onlay bone grafting and guided bone regeneration.

Verily, LLLT is a noninvasive procedure that can boost a variety of cellular processes such as, DNA and RNA synthesis and ATP synthesization [16, 17] . And on top of that ,LLLT certified its aptness for both osteoblasts differentiation and proliferation , production of collagen, induction of cultured cells mitosis , [22] revitalization and healing of bone [18-22], or even regeneration of nerves [23]. In this study the LLLT was used on implant to enhance density of bone and peri-implant soft tissue after being irradiated with a high power 980-mm diode laser [24] . That was to decrease the rapid bone remodeling which occurs after the ridge splitting due to the separation of the periosteum from the surface of bone throughout surgical procedures. Additionally, the strain on cortical plates (due to expansion and spreading of the bone) might cut off the supply of blood to the peri-implant bone during the critical phase of healing following expansion[25].

Patients were eligible having atrophic ridges width not ≤ 3mm. That was attributed to carrying out the procedures on atrophic ridges ≤ 3 mm wide could result in undesirable bone fractures and bone resorption. Moreover, this procedure involving separating the longitudinal alveolar ridge could eventually result in greenstick fracture with small chisels .Thence, all patients were selected had bone quality of types 3 or 4 [26].

According to the results declared in this study, the observed VBL in both groups, met Albrektsson and Isidor's [27] success criteria. These criteria involved loss of peri-implant crestal bone of less than 1.5 mm within the first year of loading. The average VBL in the control group (group I) after one year (0.10-0.60mm) was conforming to another study of mandibular knife-edge ridge expansion along with simultaneous placement of implants for overdentures retaining [13].

Despite using a bone grafting material following ridge growth in two previous studies[25, 28], the mean VBL after 1 year of loading in the study group of the current study was (0.03-0.50mm) while overdentures were employed, and locator attachments were utilized to connect them to the implants. Notwithstanding, in Bassetti et al trial[25], implants were employed to support a fixed prosthesis. The forces operating on implants that support overdentures tend to increase the amplitude of the bending moment in comparison to those acting on implants supporting fixed prostheses ascribable to movement of the prosthesis. As a result, micromotion of the implant has a deleterious influence on bone-to-implant contact, potentially leading to increased bone turnover [29, 30]. Whilst, in our study, VBL was less than the other two studies[13, 25] . The presumed explanation could be owing to LLLT action by photobiomodulation and biostimulation that had been advocated as a way of enhancing the bone quality around dental implant besides, accelerating the healing process of bone tissue [24].

Another finding in the current study is that no significant difference in VBL was notable among groups at T6 and T12. This was contrasted to the conclusion of a previous study[13] .That previous claimed that at 6 and 12 months, implants installed using the ridge expansion approach had significantly higher VBL than conventionally placed implants. In this context, El-Kholey and El-Shenaway [31] elaborated a statistically significant difference in vertical bone loss between the two groups, as well as a statistically significant difference in the marginal bone level in favor of the laser group.

Only group I experienced a significant increase in vertical bone loss from T6 to T12 (0.026). This could be related to LLLT's effect on bone growth at the implant interface (group II), which reduces bacterial count around the implants[32].Besides, at the time of titanium implant attachment, LLLT produces increased bone-to-implant contact due to high content of calcium and phosphorus. This is compliant with the study of Khadra et al [33].

Similarly, this result concurred with the findings of a study conducted in 2015[34]. The authors investigated the impact of postoperative low-level laser therapy on the self-tapping implants osseointegration being placed in the posterior maxilla. They assured that LLLT stimulates repairing of bone, affects differentiation, adhesion and cellular proliferation. Also, it has displayed a potentiality to lessen the time of healing following placement of implant.

In like manner, this result was in line with a previous study which examined the influence of LLLT on crestal bone levels around dental implants[24]. The research involved twenty participants who had been randomly enrolled into two groups. Patients of group I didn't receive adjunctive treatment, whereas group II patients were given LLLT following implant placement. Their results demonstrated statistically significant less crestal bone loss in group II that were administered LLLT. The authors interpreted their results as LLLT-irradiated bone has stronger apparent maturation of bone and an increase in bone-implant contact than control group. This was also assured by other studies [22, 35-37].

Contrariwise, this result was incompatible to a research investigated the effect of LLLT on marginal bone of narrow implants retaining overdenture and their stability in moderately controlled diabetic patients[38]. The investigators affirmed that LLLI had no influence on bone loss surrounding small-diameter implants (immediately loaded) bearing overdentures in moderately controlled diabetics.

Overall, the minimal number of patients in the current could explain why there was no discernible difference in VBL across groups. Consequently, randomized controlled trials of long-term with a high sample size are deemed required to confirm the current study's findings.

The null hypothesis was partially rejected in this study.

CONCLUSION:

Within the limitations of the current study, after one year, mandibular knife-edge ridge expansion along with low level laser therapy and simultaneous implants placement exhibited comparable radiographic outcomes to those implanted in unexpanded ridges. Yet, as regards VBL ridge expansion and low level laser therapy seems advantageous. Long -term randomized controlled trials having sufficient sample size are thus required to validate the results of this study.

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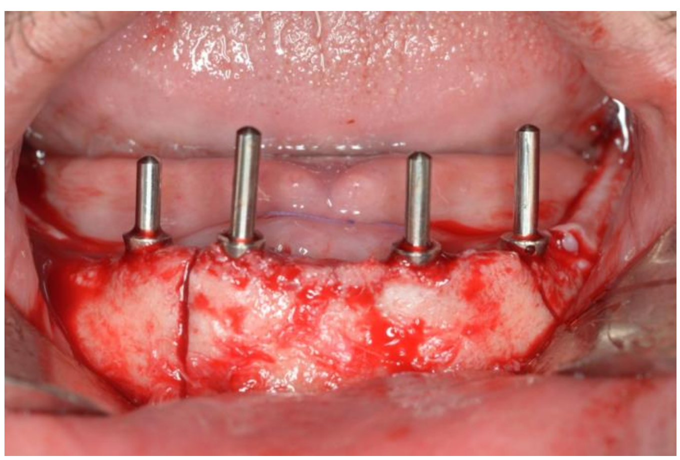

Figure 1: parallel pins for the four implants.

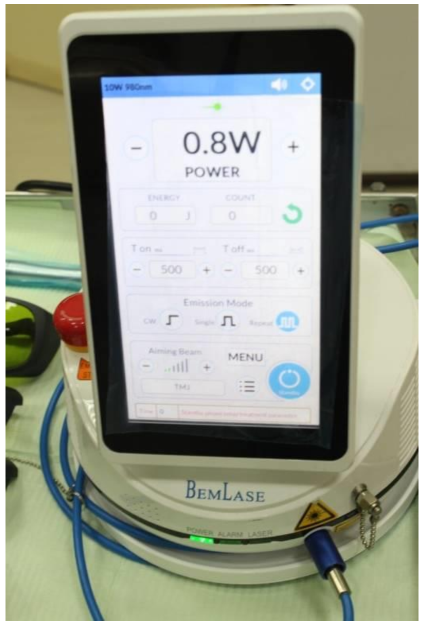

Figure 2: Diode laser system

Figure 3: The denture was finished and polished.

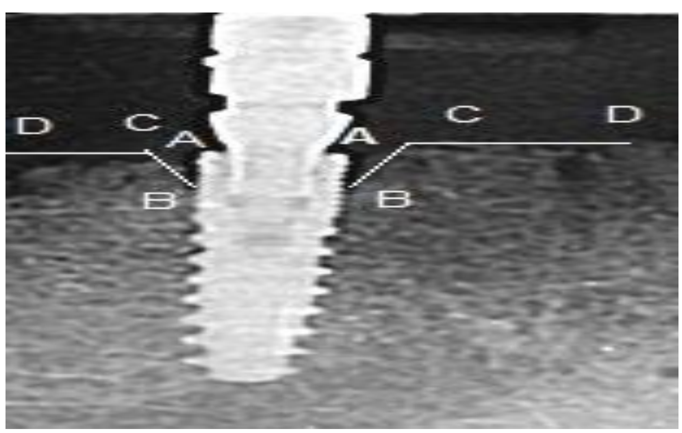

Figure 4: Reference points on the peri-apical radiograph.

Table 1: Median values of Vertical bone loss and horizontal for both groups at different time intervals.

Vertical bone loss	T0 M(min-max)	T6 M(min-max)	T12 M(min-max)	Freidman test (P value)
Group I (control)	-	.30a (.05-.38)	.37b (.10-.60)	.026*
Group II (test)	-	.17a (.05-.33)	.27a (.03-.50)	.11
Mann-Whitney test (P value)	-	.31	.52	
Horizontal bone loss	**T0 M(min-max)**	**T6 M(min-max)**	**T12 M(min-max)**	**Freidman test (P value)**
Group I (control)	-	.10a (.05-.80)	.37a (.10-.55)	.17
Group II (test)	-	.06a (.00-.35)	.40a (.00-.50)	.066
Mann-Whitney test (P value)	-	.48	.58	

M; median, min; minimum, max; maximum, * p is significant at 5% level. Different letters in the same raw indicates a significant difference between each 2-observation time (Wilcoxon signed ranks test, p<.05).