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Original Article

Effect of Different Implant Surface Treatments on Bony Changes around Mandibular Implants for Completely Edentulous Patients: A Split-Mouth Comparative Study

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Abstract

Aim: This study was done to evaluate the bony changes around laser surface treated implants and sandblasted acid-etched surface treated implants installed in the mandible of completely edentulous patients. **Subjects and methods:** Evaluation of the marginal bone loss around implants was performed using image analysis software (Digora Optime, Soredex), bone resorption was measured as the distance between implant-abutment junction and the first implant-bone contact. Implant dimensions, width and length, were used for software calibration to compensate for radiographic magnification. Marginal bone loss was determined in millimeters after 6, 9, 12 months from values at base line and averaged from mesial and distal aspect of each implant. After finishing the assessment phase, the collected data was collected and statistically analyzed. **Results:** Results of this study showed that SLA group showed significant higher bone loss than Laser group at all observation times. **Conclusion:** According to the discussion, and considering the limitations of the present study, it can be concluded that laser treated implant surfaces have significant marginal bone stability compared to SLA treated implant surfaces.

Keywords: Implant, Laser surface treatment, Marginal bone loss, Overdenture, Stud attachment

I. INTRODUCTION

Complete edentulism (CE) is increasing among subjects worldwide, yet it has been considered a multifactorial problem impairing speech, mastication and appearance. This may affect patient's satisfaction and quality of life which made most of the clinicians present different treatment modalities to decrease this phenomenon.[1]

Conventional complete dentures have the advantage of being cheaper and easily constructed and maintained providing sufficient retention and stability. However, the biomechanics for a successful denture mainly depends on favorable arch form, size and shape. Yet, the compressibility of the soft tissue and gingival biotype thickness can be an important factor offering a keratinized protection over the bone and reduces pain and discomfort for most patients.[2]

Various prosthetic approaches had been introduced to enhance the quality of life for the completely edentulous patients ranging from conventional complete denture (CD) to implant retained overdentures. The use of dental implants can be a mechanical means for retaining CDs improving the stability and retention for the prosthesis, in compromised arches especially the mandible.[3]

Implant retained prosthesis had made great breakthrough in the last decades, retaining overdentures. However, patient's financial consideration is a major factor in selecting this prosthetic option and the choice of implants with a desired surface topography that aids in better osseointegration and increased bone to implant contact can be quite challenging.[4] Osseointegration of dental implants is a significant key of success which resembles the direct structural and functional contact between bone and implant's surface by developing stable and asymptomatic fixation with the bone and maintain such fixation during function.[5]

In order to improve or accelerate such process, especially in edentulous areas with poor bone quality, various modifications to surface treatment of dental implants had been innovated in the last few decades.[6]

One of the main advantages of the dental implant surface treatment is modifying implant surface topography and surface energy, which results in improved wettability, cell proliferation and growth and accelerated osseointegration process. It has been claimed that coating of titanium implants with hydroxyapatite (HA) improves bone rigidity and implant/bone interface.[7]

Various types of dental implant surface treatments are used including titanium and hydroxyapatite (HA) plasma spray, different types of blasting particles (sand, glass, aluminum oxide), acid etching, anodization and irradiation with high- intensity laser.[8]

Several objective methods for the in-vivo assessment of bony changes around the implants are required at baseline of implant installation and after osseointegration especially at the crestal module of the implant bed. Radiographic assessment using long paralleling technique periapical x-ray, Digital sensors or digital imaging using CBCT can be a valid and reliable tool for bone assessment around the implants.[9]

II. SUBJECTS AND METHODS

Thirteen Completely edentulous patients (7 males and 6 females) aged from 45-60 years old were selected from the out-patients clinic of the prosthodontics' department, faculty of dentistry, Cairo university according to the following:

Inclusion Criteria:

- Normal skeletal relationship
- Normal facial Symmetry
- Last extracted canine not less than 6 months
- Sufficient intra-foraminal bone quality and quantity
- Minimal inter-arch space of 12mm
- Width of keratinized mucosa more than 6 mm
- Free from any Temporomandibular disorders

The following patients were excluded from the study:

- General contraindications for surgical procedures such as chemotherapy and radiotherapy

- Patients with metabolic disorders that affect osseointegration such as uncontrolled diabetes mellitus and osteoporosis.
- Long term immunosuppressive and corticosteroid drug therapy
- Patients with bleeding disorders and under anticoagulant therapy
- Flabby tissues or knife edge mandibular residual ridge.
- Patients with neuromuscular disorders
- Heavy smokers

Maxillary and mandibular complete dentures were made. Mandibular denture has been utilized in the role of radiographic stent for diagnosis and evaluation of bone dimensions on canine regions as well as a surgical stent for accurately and prosthetically positioning the proposed implants (Figure 1,2 and 3).

Figure (1): Radio-graphic stent

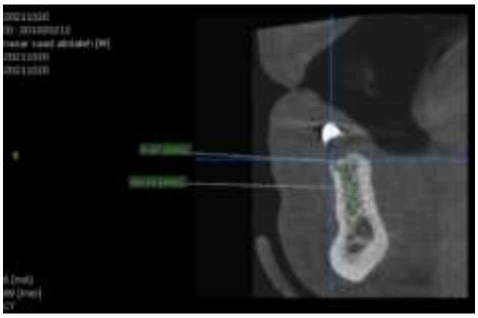

Figure (2): Radio-opaque marker on CBCT right side

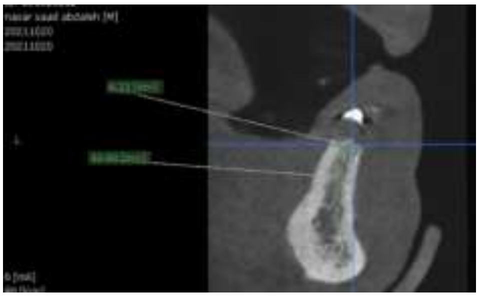

Figure (3): Radio-opaque marker on CBCT left side.

Two days before the surgery the patients were instructed to rinse with 0.12% chlorhexidine mouth wash (Antiseptol) three times daily, oral antibiotic was prescribed 875 mg amoxicillin and 125 mg clavulanic acid as potassium clavulanate (Augmentin 1 gm) twice daily.

Canines were bilaterally removed from the stent then it was seated in the patient's mouth, one stage flapless surgical protocol was done by tissue punch for bone exposure with speed 1100 rpm and 50 N /cm using a 1/20 contra angle. Initial osteotomy site preparation was made through the surgical stent using the pilot drill of both surgical kits BIOMATE and IMPLURA implant systems with a copious external irrigation (Figure 4).

Figure (4): Parallel osteotomy sites

All patients received BIOMATE implant laser surface treatment in the right-side size 4.1x10mm and IMPLURA implant sandblasted acid-etched surface treatment in the left-side size 4.2x10.

Implants were manually driven in the mandibular osteotomy sites with a torque ratchet until the implant platform flushed with the bone surface with torque of 35N. Healing collars were screwed in place over both implants.

The definitive complete dentures were early-loaded after 6 weeks of surgery. Healing abutments were removed and ball abutments were torqued over the implants at 20 N (Figure 5).

Figure (5): Torqued ball abutments

The denture was sufficiently relieved over the metal housing of the attachment till complete seating guided by the proper occlusion with the opposing arch. Small lingual hole was made in the relieved area to allow escape of the acrylic resin used in the pick-up impression. Small piece of rubber dam was placed underneath the ball abutments to prevent flow of the acrylic underneath the abutments (Figure 6).

Figure (6): Preparation for pick-up procedures

After setting of the acrylic resin, the denture was removed from the patient's mouth for finishing and polishing.

Patients were scanned at day of delivery and recalled at 6,9 and 12 months for assessment.

Bone height was measured from both the mesial and distal aspects of installed implants radio-graphically by digital x-ray system (SOREDEX™ DIGORA™ Optime) using a long cone paralleling technique.

Evaluation of the marginal bone loss around implants was performed using image analysis software (Digora Optime, Soredex), bone resorption was measured as the distance between implant-abutment junction and the first implant-bone contact. Implant dimensions, width and length, were used for software calibration to compensate for radiographic magnification (Figure 7).

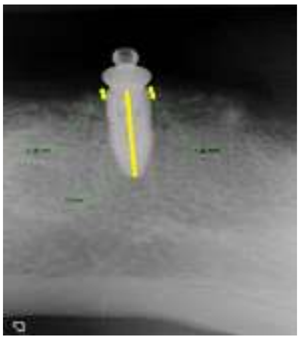

Figure (7): Marginal bone loss evaluation

Marginal bone loss was determined by subtracting bone level values in millimeters after 6, 9, 12 months from values at base line and averaged from mesial and distal aspect of each implant. After finishing the assessment phase, the collected data was tabulated and statistically analyzed.

III. RESULTS

The SPSS statistical package for social science version 25 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Shapiro-Wilk test was used to test the normality of the bone loss values. The data was parametric and normally distributed. Descriptive statistics were performed in terms of mean, median, standard deviation, range, minimum, maximum.

Repeated measures ANOVA was used to test significant difference in bone loss between time intervals followed by Bonferroni post hoc test for multiple comparison between each 2-time intervals. Independent samples t-test was used to compare bone loss between groups. P is significant if < 0.05 at confidence interval 95%.

The study was carried out for 12 months after early loading of mandibular overdentures. Descriptive statistics of bone loss for both SLA and Laser groups at different observation times [6 months (T6), 9 months (T9) and 12 months (T12)] after overdenture insertion.

Significant difference was observed in bone loss between T6 and T9 and also between T6 and T12 in both SLA and Laser groups separately. However, no significant difference was found between T9 and T12 (Figure 8).

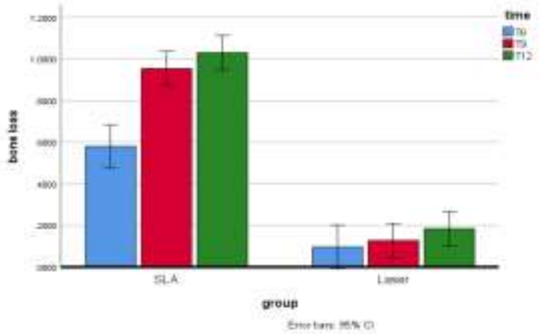

Figure (8): Comparison of bone loss between same group at different observation time

At T6, there was a significant difference in bone loss between groups (independent samples t-test, p<.001). SLA group showed significant higher bone loss than Laser group.

At T9, there was a significant difference in bone loss between groups (independent samples t-test, p<.001). SLA group showed significant higher bone loss than Laser group.

At T12, there was a significant difference in bone loss between groups (independent samples t-test, p<.001). SLA group showed significant higher bone loss than Laser group (Table 1) (Figure 9).

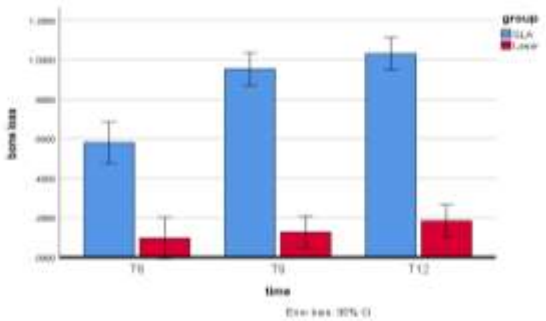

Figure (9): Comparison of bone loss between both groups at different observation time

(Table 1) Comparison of bone loss between groups at different observation times

	6 months after overdenture insertion (T6)	9 months after overdenture insertion (T9)	12 months after overdenture insertion (T12)
SLA (X±SD)	.580±.243	.954±.192	1.031±.161
Laser (X±SD)	.096±.047	.127±.029	.183±.113
Independent samples t-test (p value)	<.001*	<.001*	<.001*

P value is significant at 5% level

VI. DISCUSSION

The mandible was the area of interest, for its rapid bone reduction and more patient complain of the mandibular dentures. The implant retained mandibular overdenture is a successful treatment modality for edentulous patients encountering problems wearing a conventional mandibular denture as Romeo et al stated.[10]

Treatment of the completely edentulous mandible with two implant-retained overdenture is a well-accepted treatment option. It was reported by Doundoulakis et al that 94.5% cumulative success rate for implants and 100% for over-dentures.[11]

Implants were placed in the intra-foraminal region of the mandible as Ge recommended where there are no vital structures in addition to the presence of good bone quality and quantity which is not frequently available in the posterior region. The canine seemed to carry heavy occlusal loads, especially, during lateral excursions. Therefore, these regions were chosen for implant installment.[12]

Flapless surgery protocol was performed to maintain the supra-periosteal plexus intact and its osteogenic activity and blood supply to the underlying bone. Naeini et al stated, flap elevation increases osteoclastic potential in addition, flapless surgery is less traumatic and time-consuming, consequently decreasing post-operative swelling and pain.[13]

Acid etched-sand blasted implants were used to increase surface area of the implant allowing better osseointegration as Cervino et al mentioned.[14]

Laser treated implants were used for their advanced, precise and accurate surface modifications without altering implant material's biomechanical properties, consistent with Abdal-hay et al.[15]

Simões et al analyzed the influence of high-power laser irradiation surface treatment on the surface properties of titanium implants and concluded that laser treatment improves surface wettability with greater amounts of surface oxygen on titanium implants increasing their ability to form and adhere surface coatings.[16]

Allegrini et al studied the biologic response of titanium implants with laser treated surfaces concluding that increased surface roughness and bone-implant contact were observed in laser treated surfaces rather than machined ones.[17]

Azzawi et al evaluated osseointegration of laser treated dental implants and mentioned that bond strength at bone-implant interface increased significantly in laser treated samples and considered laser as an alternative for coating titanium implants.[18]

The implants were early loaded (after 6 weeks) to allow the stimuli at the bone-implant interface and thus leading to better differentiation of bone structure around implant, resulting in higher marginal bone level in accordance with Helmy et al.[19]

Stud attachments were used in this study for its outstanding performance in mandibular overdenture's retention and stability as agreed with Kanathila et al.[20]

Misch considered stud attachments the simplest among all retentive systems. They provide additional retention which is extremely needed in mandibular dentures. Support and stability can also be improved in addition to easy maintenance.[21]

Long cone paralleling technique was advised by Raes et al as it allows the production of accurate reproducible image with sharp details without overlapping and elongation. All radiographs were taken with the same voltage, intensity, film type and speed to allow standardization.[22]

Dave et al compared both CBCT and periapical radiography at detecting peri-implant bone defects and reported the reliability and validity of periapical radiography with better performance than CBCT.[23]

Results of this study revealed that SLA group showed higher bone loss than Laser group at all observation times with significant difference between them. This finding was augmented by the clinical study of osseointegration in implant dentistry in which Pellegrini et al mentioned that more stable radiographic marginal bone level was reported around laser microtextured implants than machined implants.[24]

These results were also assured by Hohlweg et al through his study of morphometric CBCT to predict bone quality and quantity. He found that the majority of marginal bone loss arises within the first year after loading especially the first six months as a consequence of the natural biological process of bone remodeling which occurs after the placement of implant and immediate bone reaction to healing in conjunction with function stresses.[25]

Furthermore, this was augmented by Ali et al who studied PEEK hybrid prosthesis used for "All on Four" rehabilitation of edentulous maxilla and pointed out that bone loss after 6 months could be explained by the natural biological bone remodeling activity that occurs after implant insertion as an immediate bone response in conjunction with functional stresses. Therefore, the amount of marginal bone loss diminishes after 6 months.[26]

Correspondingly, Kang et al compared removal torques between laser-treated and SLA-treated implant surfaces in rabbit tibiae and data confirmed that laser treated implants have higher removal torque than SLA treated implants.[27]

However, Çehreli et al concluded that there is no difference in marginal bone loss around dental implants retaining mandibular overdenture relative to implant type or attachment design and this could be contributed to the fact that this study evaluated bone loss around implant according to implant macro-design and attachment type.[28]

V. CONCLUSION

According to the discussion and considering the limitations of the present study, it can be concluded that laser treated implant surfaces have significant marginal bone stability compared to SLA treated implant surfaces.

Conflict of Interest:

The authors declare no conflict of interest.

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Ethics:

This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo university on: 18-2-2020 approval number: 20-2-34

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