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Evaluation of Two Types of Surface Treatment of Implants Supported Mandibular Complete Overdentures

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ORIGINAL STUDY

Evaluation of Two Types of Surface Treatment of Implants Supported Mandibular Complete Overdentures

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Abstract

Purpose: The present study was performed to compare the effect of two types of implant surface treatment (Laser Treatment versus Resorbable Blast Media (RBM)) on marginal bone height and bone density in two implant-supported mandibular complete dentures. **Patients and methods:** Mandibular complete dentures were supported by two implants in nine patients who are qualified for treatment with two implants: laser-Lok implants and RBM implants. At baseline, 6 months, and 12 months follow-up, radiographic examination utilizing cone beam computed tomography (CBCT) was performed to evaluate marginal bone height and bone density. The ANOVA test was used to collect and analyze the data in order to compare the groups and examine the changes over time within each group. The significance level was set at $P \leq 0.05$. **Results:** This study revealed a statistically significant increase in marginal bone loss in the RBM group compared with the laser group after 6 as well as 12 months. Regarding bone density, the laser group showed a statistically significant higher mean value compared with the RBM after 12 months. **Conclusion:** Laser-surface-treated implants show superior results compared with the use of RBM-surface-treated implants.

Keywords: Implant, Laser surface treatment, Resorbable blast media (RBM) surface treatment

1. Introduction

Rehabilitation of edentulous patients is attainable with implant-retained prostheses. It increases retention, stability, function, and aesthetics, particularly in the mandible. An important factor for the success of any implant treatment is osseointegration [1].

Numerous variables influence the osseointegration process. These variables include the biocompatibility of the implant material, the nature of the osteotomy site, the surgical procedure, the disrupted healing period, the loading circumstances, and the macroscopic and microscopic design of the implant surface [2].

Various surface treatments are utilized to improve implant surface wettability, implant-to-bone contact, cell adhesions, and osseointegration. Implant surface treatment can be categorized as mechanical (including sandblasting and resorbable blast media RBM) and chemical (including acid etching, electrochemical, vacuum, thermal, and laser) [3].

The resorbable blast media surface (RBM) is produced by projecting bioceramic particles (which are resorbable, coarse, and made of calcium phosphate) onto a titanium metal substrate. After that, a passivation process is done to raise the degree of roughness and improve the osseointegration capabilities of the implant. The use of calcium phosphate particles abolishes the possibility of desert contaminating material after blasting, which is one of the benefits of this method. The RBM surface is characterized by a roughness of around 1.5 μ on average [4].

Lately, laser surface modification for implant surfaces has been developed. The laser offers effective surface treatment without making direct interaction with the implant and enables full influence over the implant's micro-topography. Contemporary laser

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technologies have enabled the creation of a predetermined, micro-manufactured, and constant superficial implant geometry [5]. There are few studies comparing laser surface-treated implants with RBM implants regarding radiographic findings so the present study was performed to assess the radiographic findings comparing the use of two types of implant surface treatment (Laser Treatment versus Resorbable Blast Media) on marginal bone height, and bone density in two implant-supported mandibular complete dentures.

The null hypothesis was that there is no difference between laser surface treated and RBM implants regarding bone height and bone density.

2. Material and methods

The study included nine completely edentulous patients. The patients were selected from the Out-Patient clinic of the Removable Prosthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University. Participants in this study were informed about the treatment steps, methodology, and written consent was granted accordingly. Ethical committee approval was obtained with code (REC-PR-22-06). The targeted age ranged from 55 to 65 years (males), besides being free from any oral or systemic disease affecting bone metabolism. The mandibular residual alveolar ridge exhibited adequate height and width for all patients whose covering mucosa was healthy, firm, and free from ulcerations. All the patients had sufficient inter-arch space. On the other hand, patients who suffered from oral or systemic disease, xerostomia or excessive salivation, parafunctional habits (bruxism or clenching), heavy smokers, or alcoholic patients were excluded. A split-mouth-designed clinical trial was performed for each patient in which the right side received implants with laser surface treatment at the collar (laser-Lok implants) while the left side received implants with resorbable blast media (RBM) surface treatment.

Patients' medical and dental history was recorded in their diagnostic sheets in addition to data records obtained upon intra-oral clinical examination. A complete denture was constructed following conventional procedures. The mandibular denture was later on used to construct a radiographic stent by adding radio-opaque reference marks (metal balls) at the canine-premolar region. A CBCT image was produced for the lower jaws as a DICOM (Digital Imaging and Communications in Medicine) on a compact disc. Thereafter, the mandibular complete denture was converted to a surgical stent by removing the radio-opaque markers from the denture and two holes were performed instead.

Two root forms of tapered threaded dental implants of 3.8 mm in diameter and 10.5 mm in length were selected for each patient.

The implant installation procedure started by using the surgical stent to determine the surgical sites. Then, a surgical flap was performed bilaterally using a lancet and reflected to expose the bone, and the surgical stent was inserted in the patient's mouth, followed by the preparation of the osteotomy site using the surgical implant drills according to the manufacturer's instructions. Then implant placement was carried out. The right side received a laser-surface-treated implant at the collar, while the left side received an RBM-surface-treated implant (Biohoriozons). After the installation of all implants, the covering screws were inserted and screwed over the implant fixtures. Intermittent sutures were performed, and the patients were instructed not to wear their dentures for the next 48 h.

After 3 months, the second surgical stage was performed, in which fixture positions (implant screws) were detected by palpation, and the surgical stent was used as a guide for implant positioning. A minor crystal incision was made to expose the implant screws. The cover screws were unthreaded, and saline was used to irrigate the implant from the inside. Ball abutments with 3.8 mm in diameter and 2 mm in collar height were screwed to the top of the implants using a screwdriver.

A direct pick-up technique was performed to stabilize and attach the female part to the mandibular denture. The undercuts in the cervical half of the implants were blocked where the O-ball half of the attachment protruded uncovered. The stainless-steel housing with the elastic retentive caps was placed and accurately fitted to the ball heads of the two implants. Relief of the denture's fitting surface was followed by intraoral testing to check the seating while the patient was at maximum intercuspation. The relieved areas were filled with pink, fast cold-cure acrylic resin mixed in the dough stage, and the denture was placed in the patient's mouth under biting at maximum intercuspation until complete curing of the resin. The denture was removed, cleaned, and the flash trimmed. The stainless-steel housings were checked to be firmly and properly attached to the fitting surface of the denture. The denture with the housing was inserted inside the patient's mouth to check that the pick-up stage was done properly and the denture was seated properly and retentive, as represented by Fig. 1.

2.1. Evaluation of bone height and bone density

The measurements of bone height (mm) and bone density were carried out using CBCT radiography at

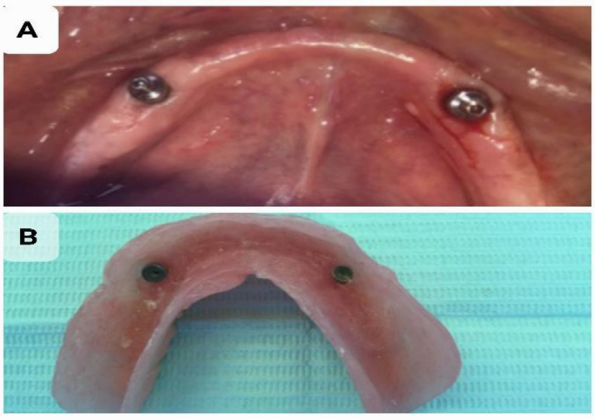

Fig. 1. A-ball and socket attachments in the patient's mouth. B-metal housing inserted in the fitting surface of mandibular complete denture.

baseline (loading day), 6 months, and 12 months of follow-up. Crestal bone height changes were evaluated by measuring the distance from the alveolar crest to the implant apex in the coronal plane. Bone height was measured buccally, lingually, mesially, and distally, and the average was taken for the four sides as shown in Fig. 2. The viewer software (In vivo dental viewer, anatomage) was supplied with the CBCT radiographs and used for linear measurements for evaluating the crystal bone height changes around the implants to assess the marginal bone loss. The bone density was measured at selected areas around the dental implants mesially and distally, and the average was taken for both sides.

2.2. Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov–Smirnov and Shapiro–Wilk tests). Numerical data were presented as mean, standard deviation (SD), median, and range values. For parametric data (bone dentistry); two-way repeated measures ANOVA test was used to compare the groups as well as to study the changes by time within each group. Bonferroni's post-hoc test was used for pairwise comparisons when the ANOVA test is significant. For nonparametric data (bone height); the Mann–Whitney *U* test was used to compare the groups. The significance level was set at *P* less than or equal to 0.05. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

3. Results

3.1. Overall bone height (mean of the four sides)

Comparing both groups, there was a statistically significant decrease in overall bone height ($P < 0.05$), with the laser group experiencing statistically significantly lower mean values of bone loss than the RBM group after six and 12 months. In both groups, there was a statistically significant change in overall bone height over different time periods. Pair-wise comparisons between the periods revealed that there was a statistically significant

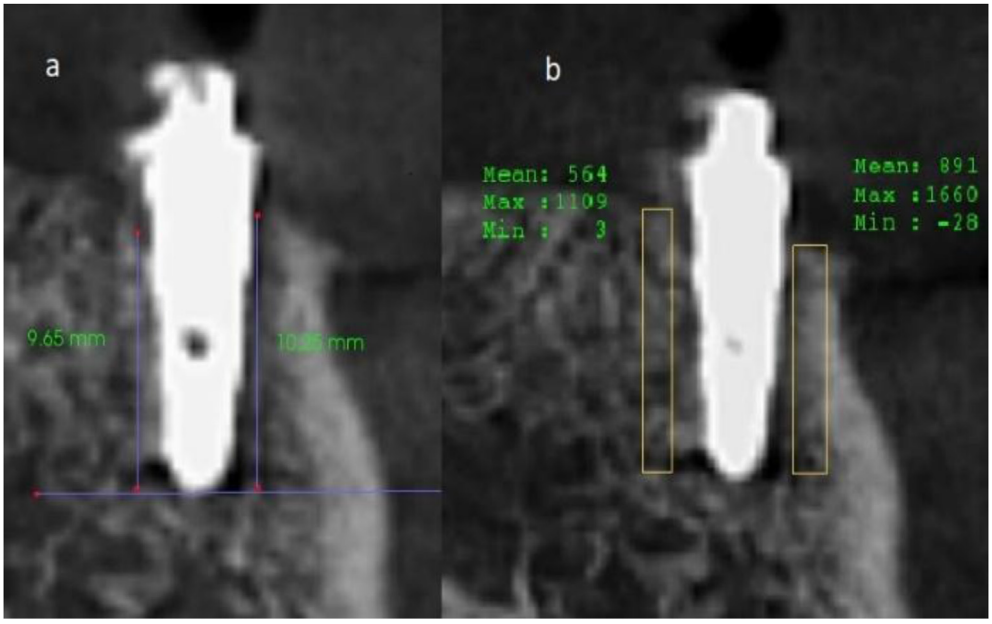

Fig. 2. Measuring bone height.

Table 1. Descriptive statistics and results of two-way repeated measures ANOVA test for comparison between overall bone height (mm) in the two groups and changes by time within each group.

Time	Laser ($n = 9$)	RBM ($n = 9$)	*P*-value	Effect size (Partial Eta squared)
	Mean (SD)	Mean (SD)		
Base line	9.32^{A}(1.37)	9.66^{A}(1.73)	0.347	0.025
6 months	8.99^{B}(1.26)	9.17^{B}(1.69)	0.586	0.009
12 months	8.73^{C}(1.24)	8.84^{C}(1.7)	0.746	0.003
P-value	<0.001*	<0.001*		
Effect size (Partial Eta squared)	0.866	0.908		

*Significant at *P* less than or equal to 0.05, different superscripts in the same column indicate statistically significant change by time.

decrease in overall bone height measurements after 6 months as well as from 6 to 12 months, as shown in Table 1.

3.2. Bone density (HU)

Comparing the bone density between groups at the baseline, and after 6 months, the laser groups overall showed no statistically significant difference at the baseline, and after 6 months ($P = 0.067$), ($P = 0.056$) respectively. However, after 12 months, the Laser group showed a statistically significantly higher mean value than the RBM group ($P < 0.05$). In both groups, there was a statistically significant change in bone density over different time periods. Pair-wise comparisons between the periods revealed that there was no statistically significant change in bone density measurements after 6 months, followed by a statistically significant increase in bone density from 6 to 12 months, as shown in Table 2.

4. Discussion

The null hypothesis that there is no difference between laser and RBM-surface-treated implants regarding bone height and density was rejected. In this study, a split-mouth design was conducted to determine the degree of bone loss and bone density throughout multiple periods of time and up to a one-year follow-up to demonstrate the difference between the two implant types. It was selected so that each patient could serve as his or her own control, limiting the interindividual heterogeneity in periodontal immunoinflammatory reactions Pera and colleagues [6].

The patients were recruited based on a set of inclusion and exclusion criteria in order to control the study and maximize its efficacy without being influenced by differences between study groups or other variables. Individuals were recruited between the ages of 55 and 65, as current demographic trends show that tooth loss occurs at this age, and to prevent elderly patients with systemic disorders that could negatively impact bone health Schimmel and colleagues [7].

All of the patients had an appropriate bone in the mandible to be able to place implants with precise dimensions of 3.8 mm in width and 10.5 mm in length into the jaw. In addition, patients with a sufficient interarch gap were selected, where the minimum vertical and horizontal distances are established to prevent restorative placement errors Yuqiang and Haiyang [8].

Additionally, this study's participants were selected to be free of any systemic or oral mucosal disorders to prevent interference with implant placement stability and functionality, as these conditions have traditionally been regarded as limitations or risk factors for implant installation Ghinassi and colleagues [9].

A high-risk factor affecting implant failure is heavy smoking, which causes local absorption of nicotine into the circulation and promotes

Table 2. Descriptive statistics and results of two-way repeated measures ANOVA test for comparison between bone density (HU) in the two groups and the changes by time within each group.

Time	Laser ($n = 9$)	RBM ($n = 9$)	*P* value	Effect size (Partial Eta squared)
	Mean (SD)	Mean (SD)		
Baseline	533.8 ^{B} (158.2)	468.9 ^{B} (167.8)	0.067	0.36
6 months	620.8 ^{B} (103.3)	497.6 ^{B} (134.8)	0.056	0.403
12 months	742.4^{A} (89.5)	577.7^{A} (141.1)	<0.001*	0.819
P-value	0.008*	0.009*		
Effect size (Partial Eta squared)	0.748	0.739		

* Significant at P less than or equal to 0.05; different superscripts in the same column indicate statistically significant change over time.

vasoconstriction. In addition, patients who suffer from parafunctional habits, such as bruxism and clenching, in which the increase in occlusion force magnitude causes mechanical issues and implant failure Mourya and colleagues [10]. Additionally, either a rise or reduction in salivary flow can negatively impact the implant Kunrath and colleagues [11]. Similarly, alcohol consumption is one of the primary causes of peri-implantitis, and marginal bone loss correlates with alcohol consumption Hemani and colleagues [12].

Implants from the same manufacturer were utilized in this study to assure the use of two geometrically identical implant groups with different surface treatments Demetoglu and colleagues [4]. Surgical stents were required for implant placement, particularly when the implant location was near an anatomical structure such as the inferior alveolar nerve, mental foramen, or adjacent tooth roots Sun and colleagues [13]. The choice to perform a flap enables the doctor to identify anatomic landmarks, reduce bone loss due to poor irrigation during osteotomy, and contour the osseous ridge in order to assist restorative operations Divaker and colleagues [14].

This study examined two outcomes: bone density and marginal bone loss. Progressive marginal bone loss can lead to implant failure by interrupting their osseointegration with the bone, making the marginal bone loss a key clinical index of implant effectiveness Pera and colleagues, Koodaryan and Hafezeqoran [6,15]. Moreover, it is considered a factor of esthetic success and survival due to the fact that peri-implant bone loss might lead to the formation of pockets, which may be essential for the everlasting health of peri-implant tissues Koodaryan and Hafezeqoran [15].

The assessment of bone density was performed as the clinical efficacy of dental implants depends on bone quality and quantity. This study employed computed tomography (CT), an effective method for measuring bone quality and determining bone density in Hounsfield units (HU). There is a solid correlation linking grey values in CBCT and Hounsfield units (HU) in CT with many slices. CBCT's advantages include high resolution, less radiation exposure, and lower costs Ivanova and colleagues [16]. Commercially accessible interactive CT applications permit the simulation of implants on the CT picture. This enables dentists to determine the ideal implant location, trajectory, and size. In addition, they provide an examination of bone density, volume, distance to vital structures, and the identification of areas that may need bone augmentation Lim and colleagues [17].

The success of osseointegration was determined for both types of dental implants (laser and RBM) using radiographic evaluations conducted throughout the follow-up period. The success factors for implants are the absence of radiolucency, movement, and suppuration or discomfort Beschnidt and colleagues [18]. Constant bone level on all sides of dental implants is vital for implant longevity and influences aesthetic results. The success during the first year of treatment is characterized by a marginal bone level shift of 1−1.5 mm, followed by a yearly bone loss of 0.2 mm Koodaryan and Hafezeqoran [15].

Assessing the mean values for crystal bone level (CBL) between the laser-surface-treated and RBM groups, RBM implants demonstrated more peri-implant bone loss. This difference was found to be statistically significant, which gives credibility to the theory that laser surface treatment of implants causes varying roughness in an effort to enhance osseointegration, resulting in increased bone contact and bone conductivity. Microtexturing with a laser on the collar area of the implant resulted in stronger and greater crystal bone attachment adjacent to the implant. This may be related to the fact that the mechanical substrate adjacent to the tissues has a significant impact on cell growth and development. In addition, solid connective tissue CT attachment to LMS implants reduces apical migration of epithelial tissues and limits bacterial toxin takeover, hence inhibiting alveolar bone resorption and promoting bone formation Mongardini and colleagues [19].

These results concurred with those of a study that compared radiographic marginal bone loss surrounding implants with laser micro-grooved collar surfaces to those without. This study found that implants with laser micro-grooved collars had statistically significantly less marginal bone loss than those without laser micro-grooved collars Guarnieri and colleagues [20]. In addition, this result was consistent with the findings of another study that compared preimplant marginal bone loss surrounding a single implant with and without laser micro-grooved collars placed and loaded according to nonidentical protocols. According to this study, laser micro-grooved collar implants demonstrated a statistically significant reduction in marginal bone loss Guarnieri and colleagues [21].

Furthermore, the results of this study agreed with a study that analyzed radiographic marginal bone loss around certain laser-treated dental implants and determined that the implants maintained marginal bone levels over time and, in many instances, the laser-modified implant surface could encourage

bone formation; the bone loss that occurred in both studies were still within the clinically accepted level Mongardini and colleagues [19]. In addition, a retrospective study compared clinical and radiographic findings of implants with and without a laser micro-grooved collar after 10 years of follow-up and found a statistically significant difference in marginal bone loss, with implants with a laser micro-grooved collar exhibiting less bone resorption than implants without a laser micro-grooved collar Iorio-Siciliano and colleagues [22].

In contrast, this result contradicted a study that compared the clinical and radiographic outcomes of implants with similar body design but distinct collar surfaces (laser microtextured versus non-laser microtextured) after functional loading and found no statistically significant difference between the clinical and radiographic outcomes of implants with microtextured collar designs. This may be attributable to the impact of various variables, such as type of connection, type of restoration, implant placement depth, soft tissue thickness, and patient features, on crystal bone remodeling Kadkhodazadeh and colleagues [23].

Concerning bone density, it was evaluated in specific regions adjacent to RBM and laser-treated surface implants, and it improved throughout the course of the follow-up periods. This is due to the fact that surface treatments enhance biological surface characteristics, which stimulate mineralization and promote the osseointegration mechanism Alghamdi, Lim and colleagues [2,17].

Comparing the mean bone density values around laser-treated versus RBM-treated collar implants, implants with a laser-treated surface had significantly higher mean values than those with an RBM surface, indicating a small performance advantage for the laser-treated surface group. This result concurred with a study performed and designed to assess the radiographic bone density around a non-submerged dental implant with a laser microtextured collar after 5 years of functional loading and demonstrated an increase in bone density up to 5 years of loading, which demonstrated an increase in bone density around laser microtextured collar implants Guarnieri and colleagues [24]. However, a study was conducted evaluating bone density around RBM implants and concluded that there was a statistically significant increase in bone density after 6 months as well as from 6 to 12 months around RBM implants Khalil and colleagues [25].

The process of controlled laser ablation forms microchannels on the implant and abutment surfaces, which may promote direct connective tissue attachment. Multiple clinical and histological studies have demonstrated that laser-ablated retentive properties positively influence bone stability throughout the early period of implant therapy, and minimize marginal bone loss Koodaryan and Hafezeqoran [15]. Laser-micro-grooved implants and abutments may have maintained a functional alignment of collagen fibers that restricted the apical migration of the epithelium, thereby accounting for the lower peri-implant sulcus depth and minimizing crystal bone loss Ahamed and colleagues [26]. Solid connective tissue CT attachment to laser-microtextured surface implants can inhibit apical migration of epithelial tissue and limit bacterial toxin infiltration, hence giving resistance to alveolar bone resorption Ghinassi and colleagues [9].

5. Conclusion

Within the time frame and limitations of the current study, it could be concluded that Laser-surface-treated implants show superior results compared with the use of RBM-surface-treated implants as regards bone height and bone density.

5.1. Recommendations

Further studies with larger sample sizes and longer follow-up periods need to be conducted for a better evaluation of the effect of laser-surface-treated implants on bone height and density.

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Conflicts of interest

The research team avails no conflict of interest.

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