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Comparison of Osseointegration in Novel Laser-Textured and SLA Implants

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ABSTRACT

Background: Osseointegration is defined as the direct structural and functional connection between neo-formed bone and dental implants. Among the parameters suggested to predominantly influencing the establishment of a successful osseointegration is the quality of the implant surface, which may enhance the strength and speed of this biomechanical process. **Objective:** The purpose of this study was to evaluate the ability of a novel laser-treated surface, compared to sandblasted, large-grit, acid-etched (SLA) surfaces, to enhance and accelerate implant integration in delayed implant placement. **Methods:** Thirty patients with two missing posterior teeth were enrolled in this study. Each patient received, at a randomly allocated site, an implant with a conventional SLA surface, and at a second site, an implant with laser-textured surface. A total of 60 tissue-level implants were subsequently placed. Implant stability (ISQ) was measured using resonance frequency analysis (RFA). ISQ was assessed at baseline (T0), 8 weeks (T1), and 12 weeks (T2) following implant placement. **Results:** There was a statistical difference in implant stability between laser-textured and SLA group at 12 weeks postoperatively. Implant stabilization showed a successful osseointegration with both surface types. **Conclusion:** Both laser and SLA surface treatments had positive impacts on implant stabilization following delayed placement. Laser-treated surfaces presented higher values of osseointegration at 3 months postoperatively.

Keywords: implant stability, implant surface, resonance frequency analysis, dental implant, laser-textured implants.

1. BACKGROUND

Osseointegration is defined as the direct structural and functional connection between neo-formed bone and dental implants without interposition of fibrous tissue (1). Several parameters have been suggested to predominantly influence the establishment of a successful osseointegration (2). Among these factors is the quality of the implant surface, which may enhance the strength and speed of this biomechanical process (3). Wennerberg et al. proposed a classification for surface roughness going from smooth (≤ 0,4 μm), to minimally rough or machined (0,5–1,0 μm), intermediately or moderately rough (1,0–2,0 μm), and rough (> 2,0 μm) (4). Implant roughness can be created by different treatment modalities such as sandblasting, acid etching, titanium plasma spraying, and hydroxyapatite coating (5). Sandblasted, large-grit, acid-etched (SLA) implants have demonstrated one of the most increased rates and degrees of osseointegration during the early phases of healing (6, 7).

Recently, a novel technology of surface treatment via robotic tools for laser ablation is being introduced. Laser-treated surfaces (LZ) have been suggested to enhance the biological properties of implants. This method consists of creating a mesh of well-defined, identical (in size and shape), symmetrically distributed, hemispherical micrometric pores. The resulting topography may increase cell attachment and bone differentiation, thus promoting more stable osseointegration (1). Implants treated with laser have also been proposed to significantly reduce bacterial adhesion and peri-implantitis risk (8, 9).

2. OBJECTIVE

The aim of this study is to compare the implant stability of LZ to SLA surfaces during osseointegration.

3. MATERIAL AND METHODS

Patient selection

This randomized controlled clinical trial was conducted between March 2021 and July 2022. Patients requiring the placement of two adjacent / contralateral implants in the same mandible (either superior or inferior) were selected. All participants signed an informed consent prior to any intervention.

The study population included thirty patients with two missing posterior teeth in the mandible or maxilla requiring implant-supported restorations. Patients who fulfilled the following inclusion criteria were enrolled in this study:

- Adult patients (above 21 years of age)
- Light or non-smokers (<10 cigarettes per day)
- Absence of systemic diseases (ASA 1 patients)
- Absence of osseous diseases that may affect peri-implant healing
- Absence of periodontal diseases and oral hygiene problems
- Sufficient bone width and length without previous ridge preservation nor bone augmentation procedures
- Adjacent or symmetrical contra-lateral implant sites.

Surgical procedure

All patients were asked to rinse with chlorhexidine 0.12% for one minute prior to surgery. Under local anesthesia infiltration (Articaine with adrenaline 1/100 000), a linear mid-crestal incision was made and a full-thickness flap was raised. Sites were prepared following the manufacturer's drilling sequence.

Implants from BIOMED® (Manufacturer: Dr. Ihde Dental AG, St. Gallen, SWITZERLAND) with grade 5 titanium alloy were used in the current study. Sites were randomly allocated to receive either a traditional implant from BIOMED®; double-sandblasted/acid-etched (SLA) or a laser-textured LZ implant (No-Itis® surface) from the same manufacturer. Each patient received two implants, both placed by the same surgeon. A total of sixty Tissue Level standard size, diameter, and length (4.1 x 9 mm) implants were placed. Implants were covered with transgingival healing caps and flaps were sutured.

Implant stability quotient (ISQ) was then measured by a single masked examiner with a resonance frequency analysis (RFA) device (Osstell ISQ; Integration Diagnostics AB, Gothenburg, SWEDEN). ISQ values were determined in duplicate and a third reading was taken in case of a difference greater than 2 ISQ between readings. Independent measurements were assessed at the buccal, palatal/lingual, occlusal, and proximal sides of each implant.

Postoperatively, patients were prescribed antibiotics (Amoxicillin 2g/day/7 days or, in case of allergies, Clindamycin 600mg/day/7 days), anti-inflammatories (Brufen 400mg/8h/3 days), and chlorhexidine mouth rinses (CHX 0.12%/twice a day/10days).

ISQ measurements were performed immediately after surgery (T0), at 8 weeks (T1) and 12 weeks (T2) postoperatively.

Statistical analysis

A descriptive analysis was first carried out. Quantitative variables are described by their minimum, maximum, mean, and standard deviation (SD). The paired-samples t-test was used to assess whether the mean ISQ values at Day 1 and week 12 of the SLA and LZ implants are significantly different. A P value of less than 0.05 was considered statistically significant. IBM SPSS Statistics 25 software was used for data analysis.

4. RESULTS

Twenty-seven participants (n = 27) were included in the study (3 patients were taken out of the study because of reasons related to implant failure or postoperative infection). ISQ values decrease between the day of insertion and the eighth week for both types of implants, then increase at the twelfth week. The ISQ values for SLA and LZ implants are presented in Table 1 and Figure 1.

Type of implant	Variable	Minimum	Maximum	Mean	SD
SLA	Mean D1	50.0	82.8	68.70	6.76
	Mean W8	56.4	73.0	67.71	4.26
	Mean W12	61.6	82.8	71.28	4.96
LZ	Mean D1	54.8	80.0	69.59	5.79
	Mean W8	56.6	76.2	67.37	4.79
	Mean W12	58.8	82.4	73.53	6.21

Table 1. ISQ values for LZ and SLA implants (n=27)

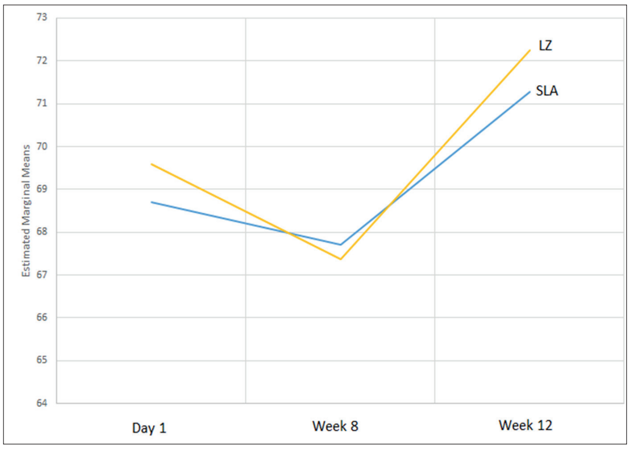

Figure 1. Mean ISQ at day 1, week 8, and week 12 for LZ and SLA implants (n=27)

Bivariate analyses showed that:

There was no statistically significant difference between the mean ISQ values of SLA and LZ implants on the day of placement (p-value = 0.479).

There was a statistically significant difference between the mean ISQ values of SLA and LZ implants at week 12 (p-value=0.003), with LZ implants having a significantly higher ISQ at week 12 (with a mean of 73.53 and a standard deviation of 6.21) than SLA implants (with a mean of 71.28 and a standard deviation of 4.96).

5. DISCUSSION

This randomized clinical study aimed to evaluate the potential of laser-treated surfaces to enhance implant healing and osseointegration when compared to standard SLA surfaces.

Several studies underlined the critical role of titanium implants' macro- and microtopography during the initial osseointegration phase (10, 11). Healing of dental implants is a complex course that begins after insertion and continues during implant integration into the bone (11, 12). Surface treatment and roughness are considered as a main factor influencing the quality of dental implant integration (1, 13, 14). Several surface treatments have been evaluated in terms of neo formation and integration of bone around dental implants in early healing phases (15, 17).

Among these treatment modalities, micro-rough SLA implants are commonly presented to reduce osseointegration duration (1(). SLA surface is formed by a 0.25-0.5 mm corundum of coarse grit blasting followed by acid etching with hydrochloric and sulphuric acid (19). Preclinical studies showed higher bone-to-implant (BIC) and torque removal values with SLA implants compared to minimally rough surfaces (15, 20). Histological findings indicated that SLA surface can promote initial contact osteogenesis (at the implant surface) but also distance osteogenesis (at the exposed bone wall) (7). A comparative study between implant surfaces showed an increase in stability values after 4 weeks for SLA implants (21). In the current study, SLA implants exhibited a mean ISQ value of 68.70 at day one that kept slightly decreasing until the 8^{th} week with an ISQ of 67.71, then started increasing to reach 71.28 at 12 weeks.

Innovative LZ implants display high biocompatibility with osteoblast cultures. Thus, this surface treatment may influence the osteogenic process, increase cell proliferation and differentiation, contribute to bone matrix synthesis, and enhance bone deposition at early osseointegration phases (22). On the other hand, LZ implants are characterized by a smooth surface, which was found to reduce the adsorption of bacterial adhesion proteins and the risk of peri-implantitis (8). In the current study, the stability of LZ implants over time was similar to that of SLA implants. LZ group showed a mean stability value of 69.59 at surgery day, 67.37 at 8 weeks, and 73.53 at 12 weeks.

There was no statistical difference in primary stability between both SLA and LZ implants. Thus, the implant micro-geometry and surface treatment did not have any influence on the primary stability. Implant stability continued to decrease up to the 8^{th} week in both groups with a lower mean ISQ value in the LZ group. LZ were not able to promote faster osseointegration. However, the difference at 8 weeks was not statistically significant and the two groups were able to maintain relatively high ISQ values for loading at 8 weeks. Afterwards, ISQ values progressively increased in the SLA and LZ groups. At 12 weeks postoperatively, ISQ of the LZ implants showed significantly higher values than the SLA implants with a mean of 73.53 compared to a mean of 71.28. The difference between the two groups is a preliminary proof that this innovative laser treatment of implant surfaces may enhance osseointegration and achieve higher values of secondary stability. Further studies with larger samples are required to validate these results on the long-term.

6. CONCLUSION

LZ and SLA implants surfaces can both achieve successful osseointegration. Nevertheless, a higher secondary stability may be obtained with LZ implants.

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