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Assessment of primary and secondary stability using the implant stability quotient (ISQ) of dental implants after using Low-Level Diode Laser Therapy 940 nm and Platelet Rich Fibrin

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Abstract

Dental implants are increasingly used to replace lost teeth. Based on the preliminary protocols, the healing time following the placement of screw-type implants is 3 to 4 months. This time increases in the maxilla and posterior mandible due to a more cancellous bone structure and may take 5–6 months. To assess Primary and Secondary Stability using the implant stability quotient (ISQ) in Dental implants after using Low-Level Diode Laser Therapy 940 nm and platelet-rich fibrin. There are 4 groups: group A (control group), group B (laser group), group C (PRF group), and group D (laser + PRF). A total of 40 implants (Dentium, Korea) with 4- or 4.5-mm diameter and 10- or 11.5-mm length were placed in the upper jaw of 20 patients. The patients included ten females with an average age of 43 years and ten males with an average age of 40.8 years. The sample size was calculated to be 10 in each group using R software, assuming 80% power of the study, 95% confidence interval, level of significance 0.05 and d = 0.65. Similar superscripted letters denote significant differences between groups within the same row by the Post Hoc Tukey test. Using the implant stability quotient (ISQ) has a significant role in the assessment of Primary and Secondary Stability) in Dental Implant after using Low-Level Diode Laser Therapy 940 nm and Platelet Rich Fibrin.

Keywords: Implant stability quotient, Dental Implant, Platelet Rich Fibrin.

Full length article **Corresponding Author*, e-mail: elmaghrabyyousef@gmail.com

1. Introduction

Dental implants are increasingly used to replace lost teeth [1]. Based on the preliminary protocols, the healing time following the placement of screw-type implants is 3 to 4 months. This time increases in the maxilla and posterior mandible due to a more cancellous bone structure and may take 5–6 months. Several factors affect the primary stability of dental implants, including bone quality and quantity, implant morphology, implant surface roughness, surface topography, and surgical technique [2,3]. The properties of dental implants and surgical techniques influence secondary stability. On the other hand, primary stability directly affects secondary stability as well. Secondary stability determines the time of implant loading and the time it can resist masticatory forces. Thus, assessment of implant stability at different time points is mandatory to determine the ideal loading time [4]. Increasing the stability of dental implants improves prognosis and prolongs clinical service. One suggested surgical technique to improve the primary stability of dental implants in low-density bone is to follow an under-drilling protocol [5]. The resonance frequency was used to measure the implant–bone interface through a reaction in which oscillations were extended to the implant, and the implant stability quotient (ISQ) was used to express the results [6]. Using a torque application device, OsseoCare, the implant was positioned through an initial torque (in Ncm) [7]. This non-subjective procedure assessed the primary stability in most clinical practices [8]. Therefore, an advanced version of devices would apply, such as Penguin, which appeared as a rod-like structure that simplifies the device usage but without any significant difference in the obtained ISQ values using Osstell's device. Effect of Volume and Bone Density on the Primary Stability Bone density was used to predict dental implants' outcomes and their role in the stability of the primary implants [7]. Implant stability was impacted by the quantity and quality of the bone, maturity, and mineral density [8]. Hence, the mandible was found to have higher survival rates for dental implants than the maxilla due to the differentiation in the quality of the bone [9].

2. Patients and methods

There are 4 groups: group A (control group), group B (laser group), group C (PRF group), and group D(laser+PRF). A total of 40 implants (Dentium, Korea) with 4- or 4.5-mm diameter and 10- or 11.5-mm length were placed in the upper jaw of 20 patients. The patients included ten females with an average age of 43 years and ten males with an average age of 40.8 years. The sample size was calculated to be 10 in each group using R software assuming 80% power of the study, 95% confidence interval, level of significance of 0.05 and d = 0.65. All patients signed informed consent forms. To standardize the implant placement sites, the bone density of implant sites was determined on preoperative cone beam computed tomographic scans of patients using On-Demand software (504, SJ Technoville, Seoul, Korea). Surgical areas with almost similar bone density based on the Hounsfield units in the range of 310–517 (D3 and D4 bone types) were chosen for inserting implants. The means of Hounsfield unit values of surgical sits in the test and control groups were 402.14 and 401.94, respectively.

2.1. Inclusion criteria

Partially edentulous, immediate replacement, implant-supported prostheses and patients with high aesthetic and/or functional demands.

2.2. Exclusion criteria

Patients with bad oral hygiene, Severly ridge resorption**,** Recent myocardial infarction and cerebrovascular accident, valvular prosthesis surgery**,** Immunosuppression, bleeding issues**,** Active treatment of malignancy**,** Drug abuse, Psychiatric illness **and** Intravenous bisphosphonate use Pre-operative evaluations were made according to a standard form of examination. The evaluations were uniform for all patients. The examination program included the following. **The chief complaint was registered for each patient, as well as the history of the chief complaint, personal history, and past medical history. Examination** which included ridge examination.

2.3. Preoperative procedure

Before treatment, each patient signed a written consent form with all the details about the surgical procedure. Preoperative medication, including broad-spectrum antibiotic 2g Augmentin, was administrated orally one hour before surgery.

2.3.1. Anesthesia

The surgery was performed under local anesthesia**.**

2.3.2. Armamentarium

Surgical kit **(Fig: 2),** diode laser **(Fig: 3),** Centrifuge. **(Fig: 4) and** OSTELL **(Fig: 5).**

2.3.3. Surgical steps

1-Incision 2-drills sequence 3-Fixture insertion4-PRF insertion in drilling sites. 5-suturing 7- Laser irradiation.

2.4. Postoperative procedures

2.4.1. Postoperative medication

Megamox 1 gram capsule 1cap (every 12 hour)/3days, and Brufen 600mg tablet 1 tab.(every 12 hour)/3 days.

2.5. Methods of evaluation

Implants stability measurements to assess the primary stability of implants after surgery in each group, the healing caps were removed, and the smart peg of the RFA device (Osstell mentor, Integration Diagnostics AB, Göteborg, Sweden) was placed inside the fixture. The head of the transducer was vertically placed on the smart peg, and ISQ was determined (Fig. 1). The smart pegs were then removed, and healing caps were placed again. Stability assessment was done immediately after surgery and after 10 days, 3, 6, and 12 weeks.

2.6. Data Analysis

Data analysis was performed by SPSS software, version 25 (SPSS Inc., PASW statistics for windows version 25. Chicago: SPSS Inc.). Qualitative data mean± Standard deviation for normally distributed data after testing normality using Shapiro Wilk test. The significance of the obtained results was judged at the (≤0.05) level. Monte Carlo tests were used to compare qualitative data between groups as appropriate. One Way ANOVA test compared more than 2 independent groups with the Post Hoc Tukey test to detect pair-wise comparison. Repeated Measures ANOVA test was used to compare more than 2 studied periods.

3. Results

Similar superscripted letters denote significant difference between groups within same row by Post Hoc Tukey test as shown in **Table** 1. Similar superscripted letters denote significant difference between groups within same row by Post Hoc Tukey test as shown in **Table** 2.

4. Discussion

Osseointegration is a prerequisite for dental implant success, and many studies have assessed the efficacy of biological and biophysical adjuncts to enhance healing at the bone-implant interface. Previous studies have reported the positive effects of LLLT on bone healing [10]. However, clinical studies on its effect on osseointegration and implant stability are limited [11]. In our study, the change process in the mean ISQ was almost the same in both the test and control groups and indicated changes due to bone healing. After the surgical insertion of implants, the mean ISQ was higher, and its magnitude gradually decreased over time. Such a reduction in implant stability may be due to bone remodeling around dental implants. From the third week, the mean ISQ increased due to bone formation around implants and almost reached the baseline value over time. The same trend of change in ISQ has been reported by previous studies; however, the magnitude of change in the mean ISQ was greater in our study [12]. The greatest reduction in ISQ occurred in the first 10 days; however, the rate and magnitude of this reduction were lower in the laser group compared to the control group (fig 6).

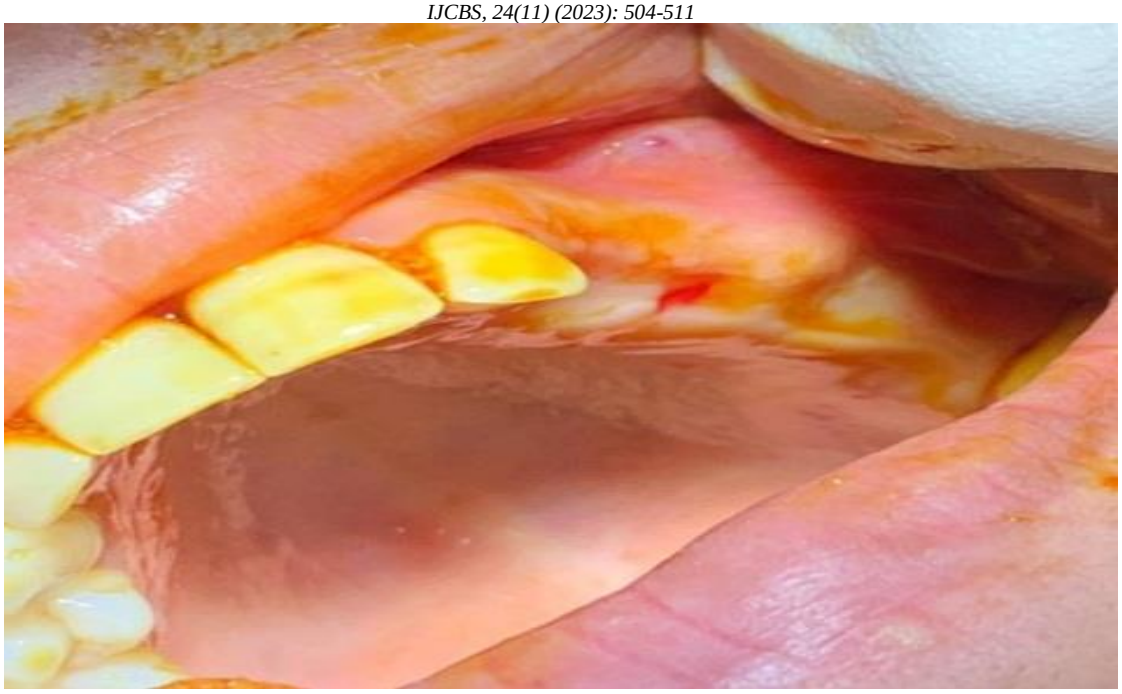

Figure 1: showing ridge examination

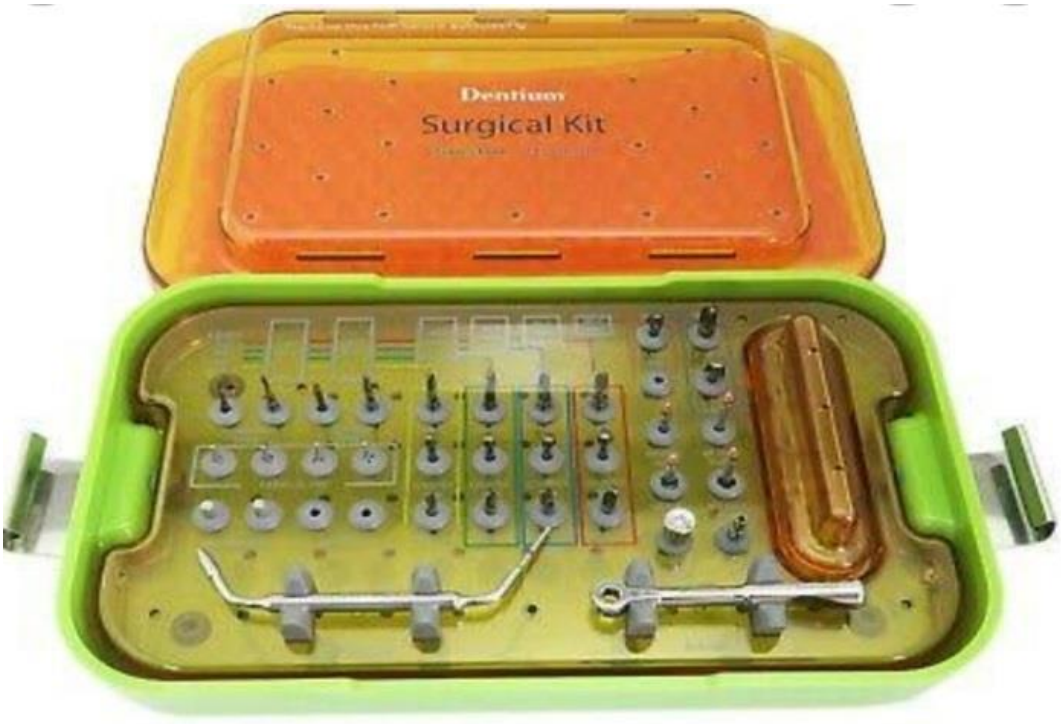

Figure 2: showing surgical implant kit

Figure 3 :showing diode laser

Figure 4 :showing Centrifuge.

Figure 5 :showing ostell

Figure 6: showing ISQ for measuring primary stability

Table 1: Comparison of ISQ measurements between studied groups during different follow-up

ISQ measurements (Ncm)	Group A (control group)	Group B (laser group)	Group C (PRF group)	Group D (laser+PRF)	Test of significance
Baseline	30.0±3.39	30.10±2.73	30.70±4.08	30.60±4.14	F=0.093 P=0.963
10 days	26.30±2.98^{ABC}	31.20±3.82^{AE}	30.10±2.56^{BD}	34.40±4.17^{CDE}	F=9.42 P<0.001*
3 weeks	30.70±2.41 ^{ABC}	33.60±3.41 ^{AD}	35.50±2.84^{BE}	39.10±3.93^{CDE}	F=12.14 P<0.001*
6 weeks	42.0±6.79	44.60±3.92	42.20±14.05	47.30±5.08	F=0.865 P=0.468
12 weeks	55.0±6.34^{AB}	58.90±5.26	60.40±5.13^{A}	61.70±5.06^{B}	F=2.81 P=0.053
24 weeks	79.44±5.05	79.50±3.98	80.0±4.29	81.10±4.09	F=0.305 P=0.822
48 weeks	83.33±7.83	88.50±2.95	86.90±6.37	86.00±6.32	F=1.19 P=0.327

F: One Way ANOVA test, parameters described as mean±SD

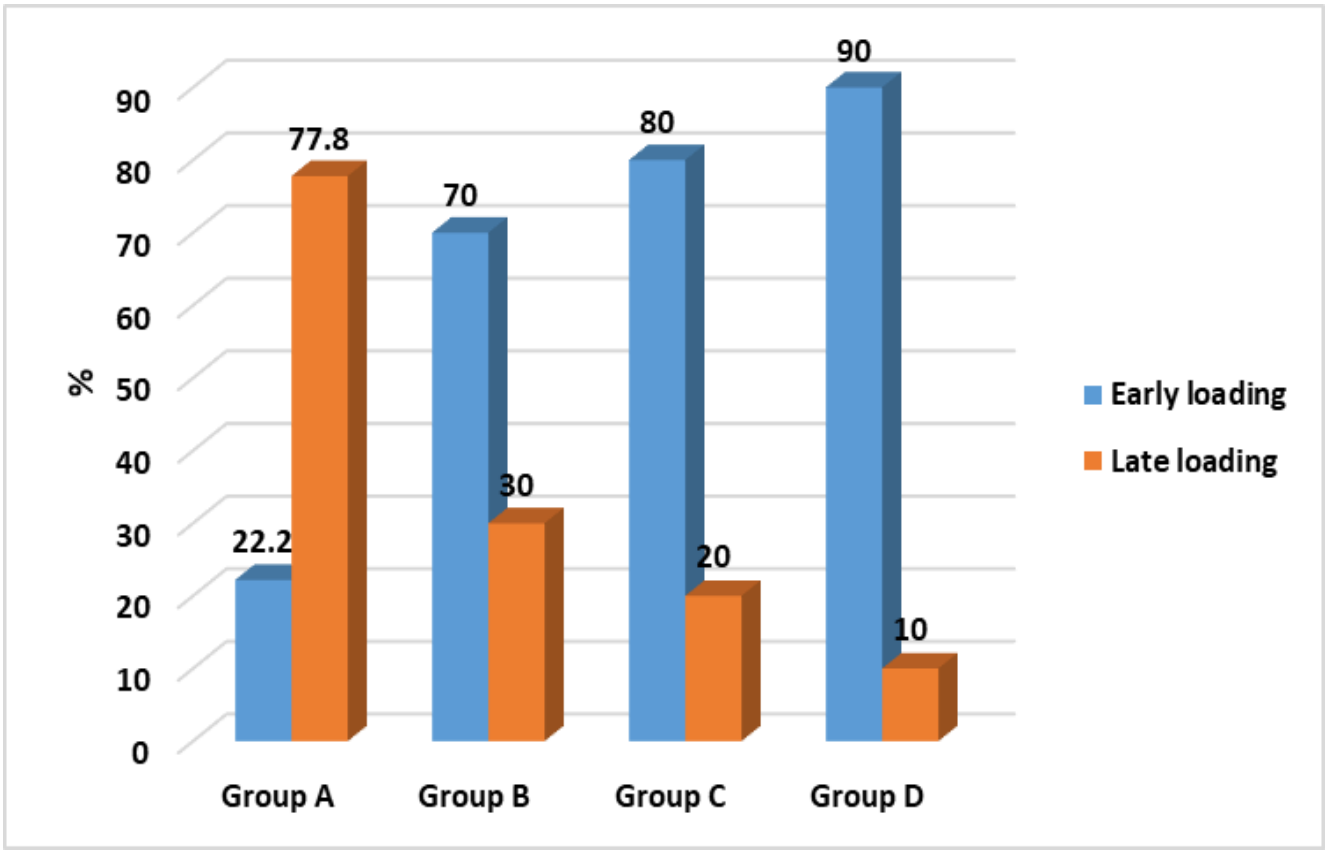

Figure 7: Showing comparison of loading between studied groups

Table 2: Comparison of ISQ measurements between different follow up within each of studied groups

	Baseline	10 days	3 weeks	6 weeks	12 weeks	24 weeks	48 weeks	p
Group A (control group)	30.0±3.39[a]	26.30±2.98	30.70±2.41[a]	42.0±6.79	55.0±6.34	79.44±5.05[b]	83.33±7.83[b]	<0.001*
Group B (laser group)	30.10±2.73[a]	31.20±3.82[ab]	33.60±3.41[b]	44.60±3.92	58.90±5.26	79.50±3.98	88.50±2.95	<0.001*
Group C (PRF group)	30.70±4.08[a]	30.10±2.56[a]	35.50±2.84[b]	42.20±14.05[b]	60.40±5.13	80.0±4.29	86.90±6.37	<0.001*
Group D (Laser+PRF)	30.60±4.14	34.40±4.17	39.10±3.93	47.30±5.08	61.70±5.06	81.10±4.09[a]	86.00±6.32[a]	<0.001*

Used test: Repeated Measures ANOVA test, parameters described as mean±SD

From week 6 to 12, the increase in ISQ was greater in laser group compared to the control group; although the difference between the two groups did not reach statistical significance. Higher ISQ in laser group may be due to increased cell proliferation, cell differentiation, and production of bone matrix around dental implants. The efficacy of laser light depends on the physiological status of cells at the time of irradiation as well as the stimulatory effect of laser light in the primary phase of cell proliferation and differentiation from undifferentiated cells [13]. It should be noted that although no significant difference was noted between the laser and control groups in terms of the mean ISQ, the trend of increase in ISQ and implant stability over time was faster in LLLT group. This is a promising finding because faster healing after implant placement and sooner delivery of restoration are among the main patient demands. Huertas et al., in their histological study, used 940 nm diode laser and reported that laser therapy can have bioactive effects on osteoblasts and can clinically enhance bone regeneration [14]. Jawad et al. showed the optimal efficacy of 940 nm diode laser in different powers and time durations for stimulation of osteoblasts and bone formation (fig 7). They assessed alkaline phosphatase activity and OST protein expression for assessment of cell differentiation and formation of extracellular calcified matrix and reported that 6-minute irradiation of LLL caused greater cell proliferation and differentiation compared to shorter durations of irradiation. In other words, short duration of laser irradiation results in lower energy density, which is not enough for cell stimulation. On the other hand, laser irradiation for longer than optimal time increases the energy density and results in cell injury [15]. In our study, diode laser with 940 nm wavelength and 14.18 J/ cm^2 energy density was used to stimulate cell proliferation and differentiation. In primary phases of bone healing, cell components are dominant and therefore are less susceptible to LLLT [16]. During the primary cell-rich phase, number of osteoblasts increases and in this phase, higher cycles of laser therapy can effectively increase cell proliferation. Higher number of cells results in greater deposition of bone matrix and its calcification and maturation of bone. Accordingly, in our study, laser was irradiated in the first 14 days every other day, which seemed to be an appropriate protocol in terms of duration and interval according to a study by Gomes et al. in 2015 [17]. The direct and positive effects of LLLT on osteoblasts and bone regeneration seem to be well established on in vitro studies [18]; thus, clinical trials are required to assess the efficacy of LLLT in vivo. One reason may be the general effect of laser since in order to standardize the testing conditions in many cases; test and control implants were placed in the same patient. It has been reported that LLLT with combined wavelengths of red and infrared laser in rats can have systemic effects on distant areas similar to the local effects on the treatment site [13].

5. Conclusion

Using the implant stability quotient (ISQ) has a significant role in the assessment of Primary and Secondary Stability) in Dental Implant after using Low-Level Diode Laser Therapy 940 nm and Platelet Rich Fibrin.

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