COMPARATIVE EVALUATION OF EFFECT OF IRRADIATION USING LOW- LEVEL LASER THERAPY WITH TWO DIFFERENT WAVELENGTHS ON STABILITY OF DENTAL IMPLANTS

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Abstract:

Aim: This study aimed to compare the effect of low-level laser therapy irradiation with two different wavelengths after osteotomy site preparation on the stability of dental implants.

Materials and Methods: The current study is a double-masked, randomized clinical trial. A total of seven patients of age 25 to 55 years were assigned randomly into two groups. Group I: Osteotomy site irradiated with low-level laser therapy of wavelength 940nm. GROUP II: Osteotomy site irradiated with low-level laser therapy of wavelength 660nm.

Implant stability was measured after implant placement using the Penguin RFA device. Bone formation was assessed with Cone Beam Computed Tomography.

Results: The current trial results showed that low-level laser therapy aided in bone formation around the implants, but there is no significant difference between the two different wavelengths.

Conclusion: Implant stability increased in both groups, but no difference is observed among the groups. Hounsfield units indicating bone formation improved in both the groups with no pronounced difference between the groups. All 14 implants were stable, thus indicating that low-level laser therapy aids bone formation, but the wavelength difference had no significant impact.

Keywords: Low level laser therapy, Implant Stability, Resonance frequency analysis

Introduction:

Dental implantology is a rapidly advancing field of science that deals with tooth loss and focuses on providing esthetically pleasing, functionally adequate, and biologically compatible replacement choices for missing teeth.

Cone-beam computed tomography (CBCT) is an essential tool for treatment planning and post-procedure monitoring. By providing accurate 3-dimensional images of the patient's anatomy from low-radiation scan, CBCT technology delivers a comprehensive understanding of the patient's jaw and the anatomical structures that aid in treatment planning^[1]. Before implantation, an investigation of the planned implant site is must to visualize the available bone and surrounding anatomical structures and augmented areas that could be affected. For this process, CBCT data is critically important in planning for the insertion implants in dentistry.

Dental implant: An artificial root that is surgically inserted into the jawbone to support a single tooth

replacement (crown), fixed partial or complete denture, or maxillofacial prosthesis^[2]. Based on the preliminary protocols, the healing time following placement of implants is 3 to 4 months. This time increases in the maxilla and posterior mandible due to more cancellous structure of bone and may take 5-6 months. Considering the advances in dental implant materials and designs, most patients demand treatment protocols with shorter recovery time and fewer surgical procedures^[3].

Adequate primary stability of implant at the time of placement is the main prerequisite for implant loading. Implant stability is defined as no mobility after placement and depends on the mechanical involvement of implant in fresh bone socket. Implant stability increases by new bone formation at the bone implant interface and gradual remodeling over time. Several factors affect dental implant's primary stability, including bone quality and quantity, implant morphology, implant surface roughness, surface topography, and surgical technique.

The **Resonance Frequency Analysis (RFA)** technique has extensively been used in experimental and clinical research for the last ten years for assessing primary stability, determining the adequate period of osseointegration before loading the implant, verifying whether sufficient stability has been attained in second stage surgery, following-up the stability during the osseointegration process, as well as monitoring high-risk implants ^[4]. The RFA device measures the resonance frequency of a transducer attached to the implant body, stimulated by different frequencies.

Branemark coined the term 'osseointegration,' which denotes the success and failure of dental implants. Osseointegration was initially defined at the light microscopic level as "a direct structural and functional union between bone and the surface of load-carrying implant" ^[5]. To achieve osseointegration, an adequate interaction between the implant surface and bone is necessary. A variety of treatments have been proposed to improve and accelerate bone formation onto the implant surface, low-level laser therapy (LLLT).

During recent decades, **Low-Level Laser Therapy (LLLT)** has become a clinically well-accepted tool in regenerative medicine and dentistry. It is used to enhance healing processes and treat functional disorders. The low-level laser is a red light whose wavelength has a low absorption power in water and can penetrate soft and hard tissues in a depth of 3mm-15mm. LLLT has been shown to accelerate wound healing by acting on the inflammatory and other cells and improving microcirculation ^[6]. The biostimulatory effect of laser irradiation represents a set of structural, biochemical, and functional changes in living microorganisms.

Laser light irradiation has been utilized in the medical field and proved to have stimulatory effects on wound healing. Laser light appears to promote mitochondrial respiration and adenosine triphosphate (ATP) synthesis ^[7]. For clinical success, the vascular supply can be improved with the use of LLLT. It uses low powered laser light to restore a biological response. They don't emit heat, sound, or vibration. Rather than generating a thermal effect, LLLT acts by producing a photochemical reaction in the cell, a process referred to as photobiomodulation. Concerning bone tissue, LLLT has been applied in several clinical situations, such as orthodontic treatment, alveolar repair after tooth extraction, bone fracture healing, and osseointegration of dental implants adjuvant therapy. Many studies indicate that bone irradiated, mostly with infrared wavelengths shows increased

osteoblastic proliferation, collagen deposition, and bone neo-formation compared to non-irradiated bone. Specific wavelength and dose combination may influence different responses for each cell line.

Thus the purpose of this clinical trial is to compare the effect of low-level laser therapy irradiation with two different wavelengths after osteotomy site preparation on the stability of dental implants using resonance frequency values.

Materials and Methods:

Study Design:

The purpose of the present randomized control study is to compare the effect of low-level laser therapy irradiation with two different wavelengths after osteotomy site preparation on the stability of dental implants.

GROUP A: Osteotomy site irradiated with low-level laser therapy of wavelength 940nm

GROUP B: Osteotomy site irradiated with low-level laser therapy of wavelength 660nm.

Implant stability was measured using the Penguin RFA device in ISQ values.

Radiographic parameters using Cone-beam computed tomography were utilized to assess bone formation.

Clinical parameters will be evaluated at baseline and 6months. Approval of the study was obtained from the ethical committee of St. Joseph dental college, and informed consent was explained and obtained from all patients before the commencement of the study.

Study Population:

Patients aged between 25 - 55 years requiring dental implants were selected from the outpatient department (OPD) of Periodontology, St. Joseph Dental College and Hospital, between April 2019- March 2020.

Inclusion Criteria:

- Patients with age range 25 to 55 years.
- At least two edentulous sites in maxilla or mandible.
- Good systemic health

Exclusion Criteria:

- Any systemic disease that affects the periodontium is contraindicated for implant placement.
- Inability or unwillingness of the patient to complete the trial.

- Patients on any medication that could affect or alter the course of periodontal treatment.
- Poor oral hygiene.
- Pregnant, Lactating mothers.
- History of smoking and alcohol abuse.

Clinical Parameters:

The clinical parameters recorded at baseline and six months are PES/WES INDEX, modified sulcular bleeding index, crestal bone loss, implant stability, and Hounsfield units in CBCT.

Presurgical Procedure:

Before commencement, the study design was discussed with every selected patient, and his/her written consent was taken. Following initial examination and treatment planning, the selected patients underwent phase 1 therapy. Detailed instructions and plaque control measures were given. Two weeks after phase 1 therapy, only those maintaining optimum oral hygiene were subjected to the surgical procedure. All the selected patients underwent routine blood investigations, and CBCT of the area of interest was taken. On completion of baseline examination and thorough initial therapy, dental implants were placed at the edentulous sites.

Implant Materials:

- ✓ Self-tapered threaded implants were used.
- ✓ Minimum dimensions- 3.3mm in diameter and 9.5mm long. Maximum dimensions- 4.5mm in diameter and 13mm long.
- ✓ Crown placed- metal-ceramic.

Surgical Procedure:

Before surgery, all the patients rinsed their oral cavity with a 0.2% chlorhexidine digluconate solution. Local anesthesia (1:200000 lignocaine) is administered at the site where the implant is to be placed. A mid crestal incision was then given at the implant placement area, and a full-thickness mucoperiosteal flap was raised to expose the osteotomy site. First, the pilot drill was used to establish the depth and axis of drilling. The next drill in the sequence is used to drill up to the same depth as specified by the pilot drill. The final drill is then placed at the required depth to complete the osteotomy site. The site is flushed with normal saline and isolated before the placement of the implant.

Application of LOW-LEVEL LASER (Site A):

In Site A, the laser application was performed using a 940nm InGaAsP semiconductor diode laser (BIOLASE EPIC 10 Inc, CROMWELL, USA) with a flexible fiber-optic E3 tip of 9mm length and a diameter of 300 μ m. The osteotomy site was radiated by a laser beam of peak power of 1W, pulse interval- 1 millisecond time on/ 1 millisecond time off, 20 seconds per application, and frequency of 50/60Hz with a sweeping motion. Two 20-second applications were made in each direction, for a total irradiation time of 40 seconds for each site. An interval of 20 seconds between irradiations and continuous saline irrigation was used for thermal relaxation of the tissues. Before activating the laser, the fiber-optic tip was placed at the base of the osteotomy site. Then, the laser was activated, and the tip was moved horizontally and coronally. When the lasers were in use, protective eyewear of appropriate optical density was worn by the investigator and patients.

Application of LOW-LEVEL LASER (Site B):

Immediately after osteotomy site preparation, the Hi-power LED red light source (APOZA Lit-600 PAD system, APOZA Enterprise Co., Ltd, Taiwan) with 660 nm wavelength and 0.5 W of power output, equipped with a probe tip, was activated and placed at a depth of the osteotomy site and moved circumferentially for 40 seconds.

The implant is removed from the vial and placed in the osteotomy site using the implant carrier. The implant driver engages the internal hexagon of the implant while the other end is inserted into the ratchet to screw the implant to its final seating position progressively. Smart peg was then placed over, and implant stability was measured with Penguin RFA device. The cover screw is positioned so that a tight seal of the implant is obtained, and 3-0 silk sutures were placed, and the periodontal dressing was given.

Postoperative care:

All patients were prescribed systemic Amoxicillin 500 mg thrice daily for five days and a combination of Ibuprofen 400mg and Paracetamol 325mg thrice daily 3days. They were also instructed to rinse with 10ml of Chlorhexidine gluconate (0.2%) mouthwash twice daily for two weeks.

Postoperative instructions were given to the patients as follows:

- Avoid taking hot liquids for the first 24 hours.

- Do not brush over the surgical site.
- During the first day, apply an ice pack intermittently on the face over the operated area.
- If you have unusual pain or bleeding from the operated sites, please come to the hospital immediately.

Postsurgical protocol:

Patients were recalled 24 hours after the surgery to evaluate signs of postoperative complications (if any) like swelling, hematoma, hemorrhage, and symptoms like pain, discomfort, and sensitivity. After seven days following surgery, the sutures were removed, and the area was irrigated thoroughly with saline. Any signs of swelling, infection, particle migration, flap displacement, hematoma, and necrosis were noted, and the dressing was again replaced for another one week. The patients were advised to use extra-soft brushes for mechanical plaque control to maintain good oral hygiene. The patients were also instructed to rinse with Chlorhexidine mouthwash twice daily for another week. All seven patients were kept under a recall program for loading after six months.

Prosthetic phase:

In both the groups, delayed loading was done. Cover screws were removed, and a test for osseointegration was done using the reverse torque technique by applying a 20 Ncm force using a torque wrench. Healing abutments were then placed (after three months in the mandibular implants and six months in the maxillary implants). Secondary implant stability was then evaluated in ISQ values. After 15 days of placement of the abutments, abutment level closed tray putty impressions were taken and given for crown fabrication. Each implant was then functionally loaded with metal, ceramic crowns.

Fig 1: APOZA Lit-600 PAD laser system (660 nm)

Fig 2: BIOLASE EPIC 10 laser system (940 nm)

Fig 3: Penguin RFA device with smart pegs

Fig 4: Edentulous site irt 16 (Group A)

Fig 5: Preoperative Hounsfield units (HU) value irt 16

Fig 6: Osteotomy site preparation irt 16

Fig 7: Osteotomy site irradiated with a low-level laser of 940nm

Fig 8: ISQ measurement irt 16

Fig 9: Implant and a cover screw placed irt 16

Fig 10: Edentulous site irt 26 (Group B)

Fig 11: Preoperative Hounsfield units (HU) Value

Fig 12: Osteotomy site prepared irt 26

Fig 13: Osteotomy site irradiated with a low-level laser of 660nm

Fig 14: ISQ measurement irt 26

Fig 15: Implant and a cover screw placed irt 26

Fig 16: Immediate postoperative Hounsfield units (HU) Value

Fig 17: ISQ measurement after six months irt 16

Fig 18: ISQ measurement after six months irt 26

Fig 19: Postoperative Hounsfield units (HU) value after 6 months irt 16

Fig 20: Postoperative Hounsfield units (HU) value after 6 months irt 26

Fig 21: Abutment placed irt 16 and 26

Fig 22: Prosthesis placed irt 16 and 26

Results:

This study is a randomized controlled clinical trial performed to compare the effect of low-level laser therapy irradiation with two different wavelengths after osteotomy site preparation on stability of dental implants. A total of 7 patients were randomly selected from out patient department of periodontics, St. Joseph dental College. The parameters that were studied were Pink Esthetic Score, White Esthetic Score, Bleeding Index, Crestal bone loss, Hounsfield units and resonance frequency values.

Statistical analysis:

Data as entered in MS-Excel and analyzed in SPSS V21. Descriptive statistics were represented with percentages; Mean with SD. Independent t-test,

Paired t-test, Repeated ANOVA, Post hoc test and Fisher Exact test were applied to find significance. P value < 0.05 was considered as statistically significant.

Table 1: Mean, standard deviation of pink esthetic scores (PES)

PES		A		B		P-Value (A vs. B)
		Mean	SD	Mean	SD	
At 6 MONTHS		4.70	0.67	4.70	0.67	1

Statistical Analysis: Independent t-test. Statistically significant if p-value is < 0.05

Inference:

The pink esthetic scores at 6 months showed means of 4.70 and 4.70 respectively for group A and group B and when they were compared, it showed insignificance with a P-value of 1.

Graph 1: Comparison of mean values of pink esthetic scores (PES) in between groups

Table 2: Mean, standard deviation of white esthetic scores (WES)

WES	A		B		P-Value (A vs. B)
	Mean	SD	Mean	SD	
At 6 MONTHS	5.10	0.99	5.20	0.79	0.81

Statistical Analysis: Independent t-test. Statistically significant if p-value is < 0.05

Inference:

The white esthetic scores at 6 months showed means of 5.10 and 5.20 respectively for group A and group B and when the means were compared it showed insignificance with a P-value of 0.81.

Graph 2: Comparison of mean values of white esthetic scores (WES) in between groups

Table 3: Mean, standard deviation of crestal bone loss of group a and group b

Variable	Group	Minimum	Maximum	Mean	SD	P-value
CRESTAL BONE LOSS	A	1.0	2.0	1.40	0.46	0.64
	B	1.0	2.0	1.50	0.47	

Statistical Analysis: Independent t-test. Statistically significant if p-value is < 0.05

Inference:

Crestal bone loss at 6 months showed means of 1.40 and 1.50 in group A and group B, respectively. When the means were compared, it was insignificant with a P value of 0.64.

Graph 3: Comparison of mean values of Crestal bone loss between groups

Table 4: Mean, standard deviation of modified sulcular bleeding index of group and group b

Variable	Group	Minimum	Maximum	Mean	SD	P-value
Sulcular Bleeding Index Baseline	A	3.0	4.0	3.40	0.52	0.39
	B	3.0	4.0	3.60	0.52	
Sulcular Bleeding Index 6 Months	A	0.0	1.0	0.60	0.52	0.39
	B	0.0	1.0	0.40	0.52	

Statistical Analysis: Independent t-test. Statistically significant if p-value is < 0.05

Inference:

The results showed a preoperative mean of 3.40 and 3.60 for groups A and B respectively at baseline which revealed insignificance with p-value 0.39.

The means at 6 months for groups A and B are 0.60 and 0.40 for respectively which revealed insignificance with a P-value of 0.39.

The mean of sulcular bleeding index at baseline and 6 months were 3.40 and 0.60 for group A and 3.60 and 0.40 for group B, which were insignificant with a P-value of 0.39.

Graph 4: Comparison of mean values of sulcular bleeding index among the groups

Table 5: mean, standard deviation of resonance frequency (ISQ values) of group A and group B

	GROUP	MEAN	SD	P-VALUE
ISQ VALUES AT BASELINE	Group A	66.14	6.77	0.096
	Group B	72.57	6.53	
ISQ VALUES at 6 MONTHS	Group A	72.00	4.20	0.154
	Group B	75.57	4.58	

Statistical Analysis: Independent t-test. Statistically significant if p-value is < 0.05

Inference:

The mean ISQ values at baseline for group A and group B are 66.14 and 72.57, respectively, with a P-value of 0.096 which was statistically insignificant.

The mean ISQ values at 6 months for group A and group B are 72.0 and 75.57, respectively, with a P-value of 0.154 which is statistically insignificant.

Graph 5: Comparison of mean values of Resonance Frequency Values among the groups

Table 6: Mean, standard deviation of hounsfield units (HU) of group A and group B

	GROUP	MEAN	SD	P-VALUE
HOUSFIELD UNITS at BASE LINE	Group A	420.43	58.14	0.065
	Group B	474.29	39.52	
HOUSFIELD UNITS at 6M	Group A	555.14	106.63	0.117
	Group B	628.57	43.75	

Statistical Analysis: Independent t-test. Statistically significant if p-value is < 0.05

Inference:

The mean HU at baseline for group A and group B are 420.43 and , 474.29 respectively, with a P-value of 0.065 which revealed insignificance.

The mean HU at 6 months for group A and group B are 555.14 and , 628.57 respectively, with a P-value of 0.117 which is insignificant.

Graph 6: Comparison of mean values of Hounsfield units for among the groups

Discussion:

Laser therapy has begun to show great promising results in dentistry. There is evidence that laser therapy is a useful supplement to conventional routine dental care and is rising in popularity in recent times. Lasers are devices that generate electromagnetic radiation that is uniform in wavelength, phase, and polarization. They are classified as high-powered, low powered, surgical, or therapeutic. Laser technology has the distinctive advantage of improving treatment efficacy as well as aiding in the healing process. There is evidence that low-powered or therapeutic lasers have analgesic, anti-inflammatory, and bio stimulatory properties on live tissue by **Natalia Elson, Denise Foran et al. 2015** ^[8].

Low-Level Laser Therapy (LLLT), or laser photo biostimulation, is a form of phototherapy that involves applying monochromatic and coherent light to stimulate healing. LLLT can be regarded as a valuable adjunct to promote early healing. Concerning bone, LLLT has been shown to modulate inflammation, accelerate cell proliferation, and enhance healing.

This study was endeavored to evaluate and compare Low-Level Laser Therapy's efficacy on the stability of dental implants. A total of seven patients were selected for the study. Two sites in each patient were randomly divided into Group A and Group B by the shuffled deck of cards method.

Group A's treatment comprised low-level laser irradiation of 940nm after osteotomy site preparation and measuring implant stability in Implant Stability Quotient (ISQ) values. Group B comprises irradiation of 660nm low-level laser after osteotomy site preparation and measuring implant stability in Implant Stability Quotient (ISQ) values.

The PES provides a rating of seven soft tissue parameters: the mesial and distal papilla, contour and margin level, alveolar process deficiency, and mucosal color and texture. The WES index was used for evaluating the parameters of the clinical crown-like form, color, texture, volume, translucency, and characterization. The PES/WES index indicated a successful esthetic outcome after the implant placement in the present study. This could be because of the oral prophylaxis protocol performed during the maintenance period and the oral hygiene instructions followed by the patients given after implant placement and proper crown placement. This is in accordance with the studies conducted by **Furhauser et al. (2005)** ^[10], **Belser et al. (2009)** ^[11], **Guaracilei Maciel Vidigal et al. (2017)** ^[12].

The modified Sulcular Bleeding Index (SBI) Mombelli et al. 1987 scores showed a statistically significant reduction in all the groups, which could be attributed to very minimum bleeding on probing due to decreased inflammation after scaling and root planing. This is in accordance with the studies conducted by **Charles M Cobb (2008)** ^[13] and **Anjani Kumar Pathak et al. (2016)** ^[14].

The Resonance Frequency Analysis (RFA) has been extensively used to assess the primary stability of dental implants in the past ten years to determine the best loading time and evaluate implant stability in the process of osseointegration of implants. This method is superior to other methods for the assessment of implant stability since it is non-invasive. This study showed that LLLT with 940 nm and 660nm did improve implant stability based on the mean Implant Stability Quotient values obtained by RFA. This could be ascribed to the rise in the number of osteogenic cells in the primary phase of healing around implants⁵⁷. This is in line with studies done by **Mayer et al** ^[15], **Stein et al. 2005** ^[23], **Deise A.A. Pires Oliveira et al.** ^[24] **2008** and **Keiko Fujimoto et al. 2010** ^[22] in which that LLLT stimulated bone nodule formation via the acceleration of cellular proliferation and differentiation, which was accompanied by increased alkaline phosphatase (ALP) activity and

osteocalcin expression, suggesting direct stimulatory effects on bone formation by laser irradiation.

This study did not show any difference in the implant stability between both the groups, which may be due to better oral hygiene maintenance of the patient and no significant crestal bone loss, which were in accordance with studies done by **Kerem Turgut Atosoy et al.** ^[26] **2017**, **Paulo Sergio Bossini, Ana Claudia Muniz Renno et al.** ^[25] **2011** in which similar response of osteoblasts to different wavelengths and dosages of low-level laser therapy was seen.

The mean crestal bone loss by the end of 6 months follow-up period was not significant, indicating peri-implant health. The non-significant bone loss that occurred in both the groups was also invariable, as mentioned by **Yuko ujiie et al.** **2019** ^[20]. The results of the present study are likewise with **Mohammad d et al., 2016** ^[21], which showed a non-significant bone loss.

Bone mineral density, an essential parameter, can be measured using Hounsfield units(HU). The units are based on a linear scale defined only by two points: the attenuation of dry air, set at 1000 HU, and the attenuation of pure water, set at 0 HU. This study revealed the mean bone mineral density (HU) at baseline to 6 months had increased in both the groups with no difference between group A and group B. The bone mineral density increased considerably after implant placement, which states the physiological changes that have occurred in the bone to be healthy. As stated by **Fujimoto et al.** **2010**, LLLT may increase the expression of BMPs and Runx2 significantly, as it may also considerably increase the calcium content in cell cultures, thus stimulating the mineralization process through the increased expression of BMPs and transcription factors related to osteoblastic differentiation which together contributes to increase in bone mineral density around implants aiding in osseointegration. It was also stated by **Farre-Pages et al.** **2010** ^[18] that HU could be used as a diagnostic parameter to predict possible implant stability. The present study results are in correlation with the studies performed by **Kyou Hiasa et al.** in **2016**, **Stoppie et al.** **2011**, **Farre-Pages et al.** **2010** and **LJ Fuh 2010** ^[19].

However, more extensive clinical trials of longer duration with larger samples are necessary to study Low-Level Laser Therapy's efficiency to obtain a predictable outcome in the stability of dental implants.

Conclusion:

This study was designed to compare the effect of low-level laser therapy irradiation with two different wavelengths on the stability of dental implants. Seven patients, two sites in each patient, were assessed. The parameters evaluated were PES/WES INDEX, modified sulcular bleeding index, crestal bone loss, Hounsfield units, implant stability, and crestal bone loss.

The bleeding index improved from baseline and was maintained throughout the follow-up period suggesting that all implants were successful without any complications.

All the implants osseointegrated with any uneventful healing. The patient's esthetic satisfaction via the PES/WES score was also found to be good. The oral hygiene measures followed correctly showed successful implants. The crestal bone loss found was minimal and found to be non-significant in both groups.

Hounsfield units indicating bone formation improved in both the groups with no pronounced difference between the groups. All implants were stable, thus indicating that low-level laser therapy aids bone formation, but the difference in wavelength had no appreciable impact.

The relationship between the wavelength of the low-level laser and implant stability is multifactorial, and its complexity has not been adequately studied. A lack of scientific knowledge regarding this issue still exists. Further studies with a larger sample size should be conducted to determine the various factors which influence the implant stability, and concerning measures have to be taken to achieve promising results.

References:

1. Edward J. Mills CBCT and implants: Improving patient care, one implant at a time, Part I. Dental economics. Com/ volume 101/issue - 4/features/cbct- and implants
2. Rajiv Saini. Research And Reviews: Journal Of Dental Science Dental Implants: A Review. 2013
3. Becker W (2005) Immediate implant placement: diagnosis, treatment planning, and treatment steps/or successful outcomes. J Calif Dent Assoc 33:303–310 Review
4. Karl M, Graef F, Heckmann S, Krafft T (2008) Parameters of resonance frequency measurement values: a retrospective study of 385 ITI dental

- implants. *Clin Oral Implants Res* 19(2):214–218.
5. Brånemark Pi Hansson BO AdellR *et al*. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand. J. Plast. Reconstr. Surg. Suppl.* 16, 1–132 (1977).
6. Elisabeth Stein, Jadranka Koehn, Walter Sutter, Gabriele Wendtlandt, Felix Wanschitz, Mehrdad Baghestanian. Effects of Low-Level Laser Therapy On Growth And Differentiation Of Human osteoblast-like Cells.
7. Lalitha T. Arunachalam, Uma Sudhakar, Akila Sivaranjani Janarthan. Effect Of Low-Level Laser Therapy On Revascularization Of Free Gingival Graft Using Ultrasound Doppler Flowmetry.
8. Low-Level Laser Therapy in Modern Dentistry Natalia Elson and Denise Foran College of Dentistry, New York University, New York, USA. November 23, 2015.
9. Khadra M, Ronold HJ, Lyngstadaas SP, Ellingsen JE, Haanes HR. Low-level laser therapy stimulates bone-implant interaction: an experimental study in rabbits. *Clin Oral Impl Res* 2004;15: 325–32.
10. Rudolf Furhauser, Dionisie Florescu, Thomas Benesch, Robert Haas, Georg Mailath, Georg Watzek. Evaluation of soft tissue around single-tooth implant crowns: the pink esthetic score. *Clin. Oral Impl. Res.* 16, 2005; 639–644.
11. Belser UC, Grutter L, Vailati F, Bornstein MM, Weber HP, Buser D; outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria. A cross-sectional retrospective study in 45 patients with a 2 to 4-year follow-up using pink and white esthetic scores. *J Periodontol* 2009; 80:140–151.
12. Guaracilei Maciel Vidigal, Jr, DDS, MSc, Ph.D./Mario Groisman, DDS, MSc/Victor Grover Rene Clavijo, DDS, MS, Ph.D./Igor Guimaraes Barros Paulinelli Santos, DDS, MSc/Ricardo Guimaraes Fischer, DDS, MSc, Ph.D. Evaluation of Pink and White Esthetic Scores for Immediately Placed and Provisionally Restored Implants in the Anterior Maxilla. *Int J Oral Maxillofac Implants* 2017;32:625–632.
13. Charles M. Cobb, DDS, MS, Ph.D. Microbes, Inflammation, Scaling and Root Planing, and the Periodontal Condition. *The Journal of Dental Hygiene*. Special supplement.
14. Pathak AK, Goel K, Shakya V, Tiwari AK, Periodontal parameters around implants and natural teeth. *Nat J Maxillofac Surg* 2016;7:52-5.
15. Mayer L, Gomes FV, de Oliveira MG, de Moraes JF, Carlsson L (2016) Peri-implant osseointegration after low-level laser therapy: micro-computed tomography and resonance frequency analysis in an animal model. *Lasers Med Sci* 31:1789–1795.
16. Garcia-Morales JM, Tortamano-Neto P, Todescan FF, de Andrade JC Jr, Marotti J, Zezell DM(2012) Stability of dental implants irradiation with an 830-nm low-level laser: a double-blind, randomized clinical study. *Lasers Med Sci* 27:703–711.
17. Mandić B, Lazić Z, Marković A, Mandić B, Mandić M, Djinić A, Miličić B (2015) Influence of postoperative low-level laser therapy on the osseointegration of self-tapping implants in the posterior maxilla: a 6-week split-mouth clinical study. *Vojnosanit Pregl* 72: 233–240.
18. Nuria Farre-Pages, M Luisa Auge-Castro, Fernando Alaejos-Algarra, Javier Mareque Eduard Ferres-Padro, Federico Hernandez-Alfaro. Bone density and implant stability. *Med Oral Patol Oral Cir Bucal.* 2011 Jan 1;16 (1): e62-7.
19. l.-j. fuh, h.-l. Huang, c.-s. Chen, k.-l. Fu, y.-w. Shen, m.-g. tu, w.-c. shen & j.-t. Hsu. Variations in bone density at dental implant sites in different regions of the jaw bone. *Journal of Oral Rehabilitation* 2010 37; 346–35.
20. Yuko Ujiie, Reynaldo Todescan, and John E. Davies. Peri-Implant Crestal Bone Loss: A Putative Mechanism. *International Journal of Dentistry* Volume 2012.
21. Mohammad D. Al Amri, Crestal bone loss around submerged and non-submerged dental implants: A systematic review. *J Prosthet Dent* 2016;115:564-570.
22. Fujimoto K, Kiyosaki T, Mitsui N, Mayahara K, Omasa S, Suzuki N, Shimizu N (2010) Low-intensity laser irradiation stimulates mineralization via increased BMPs in MC3T3-E1 cells. *Lasers Surg Med* 42(6):519–526
23. Stein, A., Benayahu, D., Maltz, L., Oron, U., 2005. Low-level laser irradiation promotes proliferation and differentiation of human osteoblasts in vitro. *Photomed. Laser Surg.* 23, 161–166.
24. Pires Oliveira DA, de Oliveira RF, Zangaro RA, Soares CP (2008) Evaluation of low-level laser

- therapy of osteoblastic cells. *Photomed Laser Surg* 26(4):401–404.
25. Bossini PS, Rennó AC, Ribeiro DA, Fangel R, Ribeiro AC, Lahoz Mde A, Parizotto NA. Low-level laser therapy (830nm) improves bone repair in osteoporotic rats: similar outcomes at two different dosages. *Exp Gerontol.* 2012 Feb;47(2):136-42
26. Atasoy KT, Korkmaz YT, Odaci E, Hanci H. The efficacy of low-level 940 nm laser therapy with different energy intensities on bone healing. *Braz Oral Res.* 2017 January 5;31:e7.
- 27.