Official Dental Journal of Suez Canal University
DENTAL SCIENCE Updates
Print ISSN 2636-3836
Online ISSN 2636-3844
www.dsujournals.ekb.eg
DSU
DSU — Vol. 5, No. 2, September (2024) — PP. 239:248

EFFECT OF LOW-LEVEL LASER THERAPY ON OSSEOINTEGRATION OF IMMEDIATE DENTAL IMPLANTS IN ANTERIOR AND PREMOLAR REGION OF THE MANDIBLE: A PILOT CLINICAL STUDY

Aliaa El-hossiny Ebrahim[1], Ahmad El-Rawdy [2], Mohammed Ahmed ElSholkamy[3], Mohamed Said Hamed [4]

DOI: 10.21608/dsu.2024.218727.1204
Manuscript ID: DSU-2309-1204 (R3)

KEYWORDS

Immediate, Implant, Laser

• E-mail address: alyaaelhossiny@gmail.com

1. Demonstrator in the department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Suez Canal University
2. Associate Professor of Oral Radiology, Faculty of Dentistry, Suez Canal University
3. Professor of Oral and Maxillofacial Surgery, Faculty of Dentistry, Suez Canal University
4. Professor of Oral and Maxillofacial Surgery, Faculty of Dentistry, Suez Canal University

ABSTRACT

Introduction: The success of endosseous dental implants largely depends on the successful osseointegration of the implant and bone, and many attempts have been made to improve this process, one of which is the use of low-level laser therapy**.** **Aim:** to evaluate the role of low-level laser therapy on osseointegration of immediate implant in mandible in the anterior and premolar region. **Patients and Methods:** This study was conducted on 8 badly decayed lower anterior and premolar teeth in patients selected from those who were referred to the department of oral and maxillofacial surgery Faculty of Dentistry, Suez Canal University.All selected patients were informed about the details of the study and signed an informed consent. Approval of the Research Ethical Committee was obtained before starting the study. Patients were divided into two equal groups randomly using a research randomizer software (https://www.randomizer.org/). Group 1: 4 implants will be inserted in 4 fresh extraction sockets (act as control group), Group 2: 4 implants will be inserted in 4 fresh extraction sockets followed by low level lase therapy session (act as study group). Both groups had received frontier implant from GMI ilerimplant group. All patients were evaluated Clinicaly using OSTELL device and Radiographically by CBCT preoperatively and by digital radiograph immediately after implant placement and 6 months postoperatively. **Results:** Clinical and Radiographic evaluation showed significant higher implant stability and higher bone density around the inserted implants laser group than control group and also, the values were high after 6 months than immediate. **Conclusion:** The use of Low Level Laser Therapy following immediate dental implants enhances osseointegration and implant stability.

INTRODUCTION

The history of dental implants goes back many centuries, when people tried to replace lost teeth with various methods to restore full chewing function and comfort as well as aesthetics on the face. face. Before the era of bone integration, there were different implant and frame designs used to support dentures and partial dentures with varying success rates. The different materials used in the implants are porcelain, chromium-cobalt and iridio-platinum. However, the discovery of titanium changed the course of implant history[(1)].

The original concept of osseointegration arose from intravital microscopy of rabbit fibular bone marrow exposed following a very gentle surgical preparation technique for visual examination on a modified high-resolution intravital microscope. After abrading the covering bone to a thickness of only 10–20 μm using special instruments, the bone marrow could be examined in vivo and in situ by fluoroscopy. Blood flow was maintained in this thin bone layer and there was little evidence of microvascular injury, the earliest and most sensitive sign of tissue damage. These intravascular studies of bone marrow circulation also revealed intimate circulatory connections between bone marrow, bone, and joint tissue compartments. Subsequent studies on bone and bone marrow regeneration emphasized the close functional relationship between bone marrow and bone in repairing bone defects[2].

Swedish orthopedic surgeon PI Brånemark coined the term bone integration and studied the circulation of bone marrow healing, which greatly influenced implant concepts. Brånemark defines Osseointegration as “the direct structural and functional connection between the ordered backbone and the surface of the bearing implant”. Then there are materials like titanium and many materials that are biocompatible with the human body that have been used[3].

To achieve osseointegration: a) Only the minimal amount of remaining bone should be removed. b) The basic terrain of the region should not be changed. c) Retention of the original prosthesis or transition prosthesis should be maintained during the healing period[2].

Implant stability means lack of mobility after insertion. It depends on whether the implant is mechanically incorporated into the fresh bone fossa. Implant stability increases over time due to new bone formation at the bone-implant interface and gradual bone remodeling. Various factors influence the primary stability of dental implants, including implant morphology, bone quality and quantity, surface topography, implant surface roughness, and surgical technique[4].

Secondary stability is influenced by dental implant properties and surgical technique. On the other hand, first-order stability also directly affects second-order stability. Secondary stability determines when the implant is loaded and how long it can withstand masticatory forces. Therefore, it is important to assess the stability of the implant at different time points to determine the ideal loading time[5].

Improved stability of dental implants improves prognosis and extends clinical use. A technique proposed to improve the primary stability of dental implants in low-density bone is to follow an underdrilling protocol. Low-level laser therapy (LLLT) is another treatment recommended to improve primary stability.

In the field of dental implantology, the potential of PBM to reduce healing time after implant placement and improve the chances of bone regeneration is being investigated. Experimental studies have shown that PBM stimulates osteoblast proliferation and differentiation and also improves binding to titanium implants. According to these studies, early postoperative he applied PBM increased the mechanical strength of the bone–implant interface and stimulated bone matrix formation. On the other hand, the efficacy of his PBM application in clinical practice of dental implants is still unclear[6].

The reason for using LLLT is its efficacy at the cellular level to enhance the biochemical and molecular processes associated with tissue healing. Various in vivo and in vitro studies have shown beneficial effects of LLLT on tissue healing processes. Processes stimulated by LLLT include protein and collagen synthesis, cell proliferation, bone remodeling and healing potential, wound healing, cell regeneration, osteoblast and chondrocyte differentiation, and restoration of neural function after injury, regulation of the immune and lymphatic systems, and reduction of inflammation and edema, balances hormonal function and relieves pain. In addition, LLLT improves blood circulation, accelerates activation processes, reduces the risk of infection, improves metabolic activity and accelerates healing of damaged tissue(7).

PATIENTS AND METHODS

The present study was conducted on 8 patients divided into 2 equal groups with badly decayed lower anterior and premolar teeth, the patients were selected from those who were referred to the department of oral and maxillofacial surgery Faculty of Dentistry, Suez Canal University.

All selected patients were informed about the details of the study and signed an informed consent. Approval of the Research Ethical Committee was obtained before starting the study (351/2021). Patients were divided into two equal groups randomly using a research randomizer software (https://www.randomizer.org/):

Group 1: 4 implants will be inserted in 4 fresh extraction sockets (act as control group)

Group 2: 4 implants will be inserted in 4 fresh extraction sockets followed by low level laser therapy session (zolar soft tissue DIODE laser with wavelength 980 nm and power 10 watt), First session was carried out immediately on surgery time after implant insertion, then the second one was on the 4th day of surgery, the third one was on the 7th day (act as study group).

Both groups had received frontier implant from GMI ilerimplant group

All patients were evaluated radiographically by CBCT preoperatively and by digital radiograph immediately after implant placement and 6 months postoperatively, and clinically using OSTELL device immediately after insertion and 6 months postoperatively.

Patient Selection:

Inclusion criteria:

1- Medically free patients.

2- Patients with lower anterior or premolar teeth loss.

3- Adequate oral hygiene.

4- No radiographic evidence of bone loss.

Exclusion Criteria:

1- Patients with vertical or horizontal bone loss.

2- Smoking patients.

3- Bruxism.

I. Preoperative assessment:

Patients medical history were collected preoperatively to exclude patients with medical problems or bad habits that impair bone integration.

Pre-operative Clinical examination:

- Inter occlusal arch space was determined preoperatively.
- Bone width was determined clinically.

Pre-operative Radiographic evaluation:

Radiographic assessment pre-operatively by CBCT to detect patient having badly decayed non-restorable tooth without periapical infection.

Each patient was evaluated for bone quantity, quality, mesio-distal distance and buccolingual dimension of the potential site for implant insertion as well as its relation to the mental foramen, and the evaluation of major carious lesions in the remainder of the dentition and the detection of the remaining roots or any suspected pathological lesions. Cone beam computed tomographic evaluation will be performed to allow for a more comprehensive overall view and better interpretation of the anatomic structures. As well as the patients who reveal severe bone loss were excluded, others with neighbouring remaining roots or carious lesions will planned for treatment.

Surgical procedure

All the surgical procedures were performed by the same surgeon using standardized technique under aseptic condition. All patients were operated under local anesthesia using Articaine hydrochloride 4% (Artinibsa) by (Laboratories Inibsa, S.A. in Barcelona) with 1:100.000 epinephrine. All the patients were anesthetized by infiltration technique for the buccal mucoperiostium and infiltration technique for the palatal mucoperiostium. All patients received frontier implant from GMI ilerimplant group.

(A) Surgical procedure for immediate implant placement instudy group(1):

Extraction was performed with minimal force and wedging with periotomes placed mesial and distal to the remaining roots. Anterior forceps were then applied to remove the remaining dislocated root. Implant preparation osteotomy was done and Frontier implant with suitable size and length was inserted.

Implant stability was measured initially at the time of implant placement using Osstell device by using smart beg attached to the implant. (Fig.1)

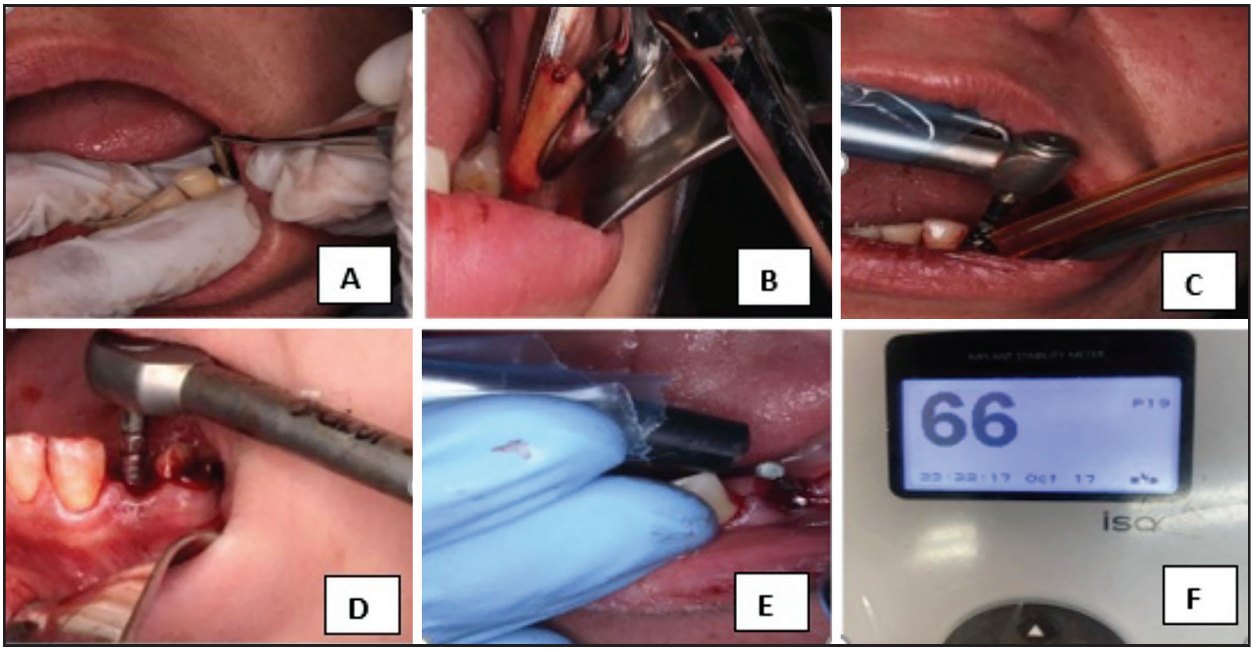

Fig. (1) Surgical procedure for group 1 showing: (A) application of periotome. (B) extraction of the luxated remaining root. (C) Osteotomy preparation. (D) Implant insertion. (E) showing smart beg attached to the implant for implant stability reading with Osstell device. (F) OSTELL reading immediately following implant insertion

(B) Surgical procedure for immediate implant placement and soft tissue laser application in study group (2):

Extraction was performed with minimal force and wedging with periotomes placed mesial and distal to the remaining roots. Anterior forceps were then applied to remove the remaining dislocated root. Implant preparation osteotomy was done and Frontier implant with suitable size and length was inserted.

Implant stability was measured initially at the time of implant placement using Osstell device by using smart beg attached to the implant.

Low Level Laser was applied buccally and lingually on implant site in circular motion (zolar soft tissue DIODE laser with wavelength 980 nm and power 10 watt) immediately post-operative, then the second one was on the 4^{th} day of surgery, the third one was on the 7^{th} day.

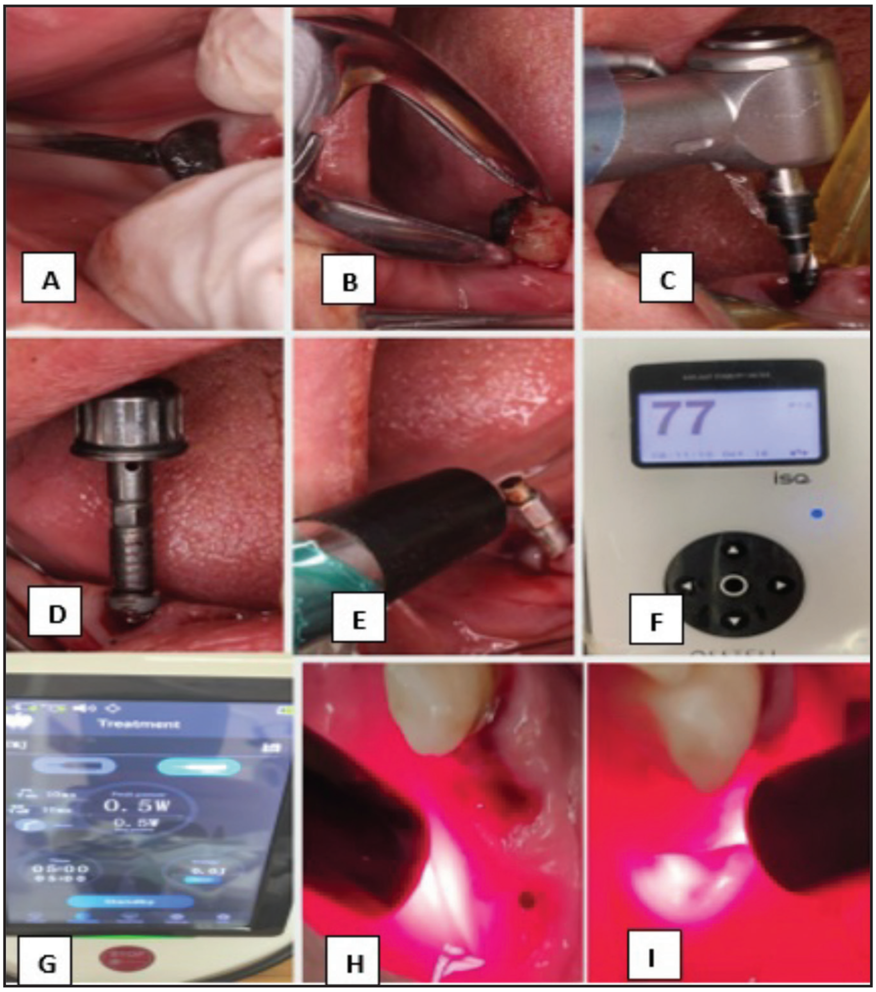

Fig. (2) Surgical procedure for group 1 showing: (A) application of periotome. (B) extraction of the luxated remaining root. (C) Osteotomy preparation. (D) Implant insertion. (E) showing smart beg attached to the implant for implant stability reading with Osstell device. (F) OSTELL reading immediately following implant insertion. (G): zolar soft tissue DIODE laser. (H,I): Laser Application

Each session was performed using a semiconductor diode (Zolar soft tissue DIODE laser with a wavelength of 980 nm and a power of 10 watts). The buccal, lingual and apical surfaces were irradiated with laser light for a preset time (5 minutes). A laser beam is continuously emitted from the tip of the laser applicator, exposing the target surface while the tip is in contact with the tissue and aimed at the implantation site. The applicator tip was moved in a continuous slow circular motion to ensure complete exposure of the target surface to the laser beam. (Fig. 2)

Post-operative follow up

Postoperative Clinical Assessment by:

Osstell device which:

- Allows accurate and objective monitoring of osseointegration.
- Osstell helps objectively and non-invasively determine implant stability.
- The probe is connected to the instrument by a cable and the readings are shown on the black backlit display.

The implant stability using OSTELL device was measured immediately postoperative and was assessed after 6 months, where abutment placement decision was taken based on the OSSTELL readings. When the reading was 70 or more abutment was placed, then the final prosthesis was fabricated.

Post-operative Digital Radiographic Assessment:

Intraoral parallel periapical direct digital radiography procedure:

Indirect standard digital radiographs were taken using the KaVo Scan eXam™ One and the periapical film holder Rinn Extension Cone Paralleling (XCP). KaVo Scan eXam™ One is an intraoral digital imaging plate system “PSP”. A system with an optical disc that is a film-like thin flexible wireless phosphor optical disc that acts as a wireless receiver.

Using a size 2 imaging plate results in an active area of 31 x 41 mm, 1034 x 1368 microns (pixel size) and an image size of 2.69 megabytes.

A long cone (16 inches long) was attached to the X-ray tube and the plastic target ring of the XCP film holder was attached flush with the rounded end of the long cone.

The imaging plate is exposed to the Fona XDC digital intraoral X-ray machine. Exposure parameters were considered fixed for all patients. After exposure by the Scan eXam™ One unit, processing begins and the image is displayed on the screen.

The stored images of each patient are interpreted by the examiner at two different time points to reduce intra- and inter-observer error, and the average of the two trials is recorded.

Each patient underwent radiological examination immediately after surgery and 6 months later.

Digital Image analysis and bone density calibration

Image analysis was performed using IDRISI Kilimanjaro software to facilitate image reconstruction, enhancement and densitometry. Image restoration enabled image retrieval, and then image enhancement enabled contrast adjustment of all images, facilitating the determination of implant edges. (Fig3)

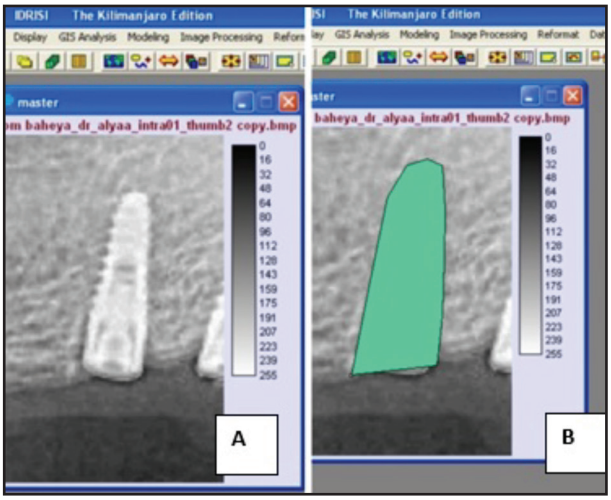

Fig. (3A, B): photography showing evaluation of bone density around implant

RESULTS

Comparison between control and laser at the same time and the time interval for each group in clinical test

The results in table 1, shows the comparison between the control and laser group at immediate and after 6months for immediate implant clinical stability.

At immediate, statistical analysis showed no significant difference between the control and laser group using independent sample T-test (P.0.072). At 6 months there are highly significant difference between the two groups (P=0.002). The comparison between time interval in each group, statistical analysis showed significant difference between the immediate and 6months in control (P=0.004) and laser (P=0.001) groups using T-test.

Generally, the mean values were clearly high for laser group than control group and also, the values were high after 6 months than immediate .

Table (1) *comparison between control and laser at the same time and the time interval for each group in clinical test*

	Control		Laser		T -Test	P value
	Mean	SD	Mean	SD		
Immediate	**63.31**	5.22	**67.88**	4.08	1.949	0.072
6 Months	**69.31**	4.33	**81.56**	8.15	3.753	0.002**
T -Test	***4.20***		***5.276***			
P value	***0.004****		***0.001****			

Comparison between control and laser at the same time and the time interval for each group in X-ray test

The results in table 2, shows the comparison between the control and laser group at immediate and after 6months for bone density around dental implants.

At immediate statistical analysis showed no significant difference between the control and laser group using independent sample T-test(P=0.190). At 6 months there are highly significant difference between the two groups (P<0.001). The comparison between time interval in each group, statistical analysis showed significant difference between the immediate and 6months in control (P=0.0162) and laser (P=0.0002) groups using F-test at significant levels P<0.05.

Generally, the mean values were clearly high for laser group than control group and also, the values were high after 6 months than immediate.

Table (2) *Comparison between control and laser at the same time and the time interval for each group in X-ray test*

	Control		Laser		T- Test	P value
	Mean	**SD**	**Mean**	**SD**		
Immediate	138.44[b]	19.40	155.20[b]	28.28	1.37	0.190
6 Months	153.29[a]	18.66	199.82[a]	15.19	5.470	<0.001**
F Test	5.053		13.76			
P value	0.0162**		0.0002**			

DISCUSSION

Osseointegration is a key requirement for successful dental implants, and numerous studies have evaluated the efficacy of biophysical and biological tools to promote bone healing at the implant surface. One of them was low-level laser irradiation[3]. Low-level laser therapy is a non-invasive adjunctive treatment that uses light-emitting diodes or low-power lasers (low-level lasers) and is known to accelerate bone healing[8]. In cellular models, low-level laser therapy has been shown to increase adhesion and proliferation of human mandibular bone cells cultured on titanium implant materials. Laser irradiation with an energy density of 3 J/cm2 significantly increased the production of osteocalcin and TGF-b1, suggesting a dose-dependent stimulation of osteoblast-like cell differentiation. The authors concluded that low-level laser can modulate peri-implant cell and tissue activity. They also concluded that low-level laser improves the functional fixation of titanium implants to bone, promoting bone healing and mineralization [9].

Similar results were reported by Romao et al. report. Laser irradiation of the alveolar bone cavity after molar extraction suggests that laser phototherapy improves alveolar bone repair and results in a more homogenous trabecular design with thin, closed trabeculae [10].

Mayer et al. In an experimental study, significant differences were observed in the percentage of newly formed bone volume and the implant stability index after applying diode laser treatment with a wavelength of 830 nm and a power of 50 mW [11].

Soleimani et al. concluded that LLLT administration improves the proliferation of mesenchymal stem cells and their differentiation into osteoblasts. Nicola et al., examined bone cell activity after application of LLLT near the site of bone damage and concluded that LLLT increased bone cell activity and remodeling (resorption and formation) around the bone repair site without altering the bone structure [12].

Similar to our study, Radwan D. demonstrated in an in vivo study that LILT significantly improved bone density around immediate and delayed titanium implants. The laser was delivered to subjects in the laser group immediately after implant surgery. They used laser parameters of 904 nm wavelength, 30 mW output power, and 9,999 Hz frequency in continuous mode for 3 minutes. Through density analysis, they concluded that laser irradiation significantly improved bone density around the implant[13].

Similarly, in Petri's study, gene expression of alkaline phosphatase, osteocalcin, bone sialoprotein, and bone morphogenetic protein 7 was higher in LLLT-treated cultures, while runt-related transcript

2 bone and Osteoprotegerin were lower than in non-irradiated cells(14).

Under study by Torkzaban et al. Seven of the low-level laser sessions were irradiated on the buccal and palatal sides of the implant. Although the number of implants increased over time in the laser group, there was no statistically significant difference between the laser and control groups (15).

Our results disagree with those of Morales et al. who reported that the use of an 830 nm diode laser did not significantly increase implant stability(16).

In contrast to our results, Gokmenoglu et al. Use an energy intensity of 46 joules/cm2 extraorally. No significant differences were demonstrated in ISQ values between groups. This may be due to insufficient energy penetration into the tissue due to the lower wavelength of the laser used(17).

While in the present study low-level diode laser with wavelength 980 nm and power 10 watt showed significantly high difference for laser group than control group in both implant clinical stability in clinical evaluation using ISQ values and also in Radiographic evaluation of osseointegration around the implants 6 months following implant placement.

CONCLUSION

The use of Low Level Laser Therapy following immediate dental implants enhances osseointegration and implant stability.

REFERENCES

1. Jayesh, R. S., Dhinakarsamy, V. Osseointegration. J Pharm Bioallied Sci 2015;7(Suppl 1), S226-9. doi:10.4103/0975-7406.155917
2. Paolantonio, M., Dolci, M., Scarano, A., D'Archivio, D., Placido, G. Di, Tumini, V., & Piattelli, A. Immediate Implantation in Fresh Extraction Sockets. A Controlled Clinical and Histological Study in Man. J. Periodontol. 2001; *72*(11), 1560–1571.
3. Brånemark, P.-I. The osseointegration book : from calvarium to calcaneus. Quintessence 2005.
4. Chen, S.T. , Buser, D. Esthetic outcomes following immediate and early implant placement in the anterior maxilla – a systematic review. Int J Oral Maxillofac Implants 2014; 29, 186–215.
5. Misch, C.E., Scortecci, G.M.: Immediate load applications in implant dentistry. In Misch CE (ed): Dental implant prosthetics. St. Louis, Mosby-Year Book; 2015; pp 531-567.
6. García-Morales JM, Tortamano-Neto P, Todescan FF, de Andrade JCS, Marotti J, Zezell DM. Stability of dental implants after irradiation with an 830-nm low-level laser: a double-blind randomized clinical study. Lasers Med Sci 2012;27:703–11.
7. Jawad MM, Husein A, Azlina A, Alam MK, Hassan R, Shaari R. Effect of 940 nm low-level laser therapy on osteogenesis in vitro. J Biomed Opt 2013; 18:128001 5+
8. Cremonini CC, Dumas M, Pannuti CM, et al. Assessment of linear measurements of bone for implant sites in the presence of metallic artefacts using cone beam computed tomography and multislice computed tomography. Int J Oral Maxillofac Surg. 2011 ;40:845–850.
9. Renvert S, Lindahl C, Roos Jansaker AM, Persson GR. Treatment of peri-implantitis using an Er: yAG laser or an air-abrasive device: a randomized clinical trial. J Clin Periodontol 2011 ; 38: 65–73.
10. Khadra, M., Lyngstadaas, S. P., Hans, R., Haanæs, H. R., Mustafa, K. Effect of laser therapy on attachment, proliferation and differentiation of human osteoblast-like cells cultured on titanium implant material**:** Biomater. 2005; 26: 3503–3509.
11. Romão MMA, Marques MM, Cortes ARG, Horliana A, Moreira MS, Lascala CA. Micro-computed tomography and histomorphometric analysis of human alveolar bone repair induced by laser phototherapy: a pilot study. Int J Oral Maxillofac Surg. 2015;44(12):1521–8.
12. Soleimani M, Abbasnia E, Fathi M, Sahraei H, Fathi Y, Kaka G. The effects of low-level laser irradiation on differentiation and proliferation of human bone marrow mesenchymal stem cells into neurons and osteoblasts—an in vitro study. Lasers Med Sci. 2012;27(2):423–30.

13. Radwan, D.A. A clinical study on the effect of diode laser therapy on the osseointegration of delayed immediate implants. A thesis of doctor's degree in oral surgery, Cairo University 2005.

14. Petri AD, Teixeira LN, Crippa GE, Beloti MM, Oliveira PT de, Rosa AL. Effects of low-level laser therapy on human osteoblastic cells grown on titanium. Braz. Dent. J. 2010;21:491–8.

15. Mayer L, Gomes FV, Carlsson L, Gerhardt-Oliveira M. Histologic and resonance frequency analysis of peri-implant bone healing after low-level laser therapy: an in vivo study. Int J Oral Maxillofac Implants 2015;30(5):1028-35. doi: 10.11607/jomi.3382.

16. García-Morales JM, Tortamano-Neto P, Todescan FF, de Andrade JCS, Marotti J, Zezell DM. Stability of dental implants after irradiation with an 830-nm low-level laser: a double-blind randomized clinical study. Lasers Med Sci 2012;27:703–11.

17. Gokmenoglu C, Ozmeric N, Erguder I, Elgun S. The effect of light-emitting diode photobiomodulation on implant stability and biochemical markers in peri-implant crevicular fluid. Photomed Laser Surg. 2014;32(3):138–45.