EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 71, 191:201, JANUARY, 2025
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
ORAL SURGERY
Submit Date : 13-10-2024 • Accept Date : 25-11-2024 • Available online: 01-01-2025 • DOI : 10.21608/edj.2024.255141.3231

# OUTCOME OF LOW-LEVEL LASER THERAPY ON DENTAL IMPLANT OSTEOINTEGRATION -A COMPARATIVE STUDY

Ahmed Ali Ajal*, Abd Aldayim Jummah Qidarah**
*and* Sari Soliman Hagig*

## *ABSTRACT*

**Objective:** The purpose of the study was to assess the reliability of LLLT to accelerate dental implant osteointegration and healing process.

**Materials and Methods:** The study sample included eight female patients according the inclusion criteria with total twenty dental implant placed in healed sites (maxillary `2premolars) by using split mouth method. Group I was study group that receive LLLT, and group II was control group. Implant stability was assessed using ISQ scale in separate intervals at 6, 8 and 12 months postoperatively.

**Results:** In Group I, the ISQ values at 3, 6, and 12 months after implant placement ranged from 60 to 74, 62 to 78, and 68 to 80, respectively, with statistically significant differences observed between 3 and 6 months, 3 and 12 months, and 6 and 12 months . In Group II, the ISQ values at 3, 6, and 12 months after implant placement ranged from 54 to 69, 56 to 70, and 60 to 72, respectively, with statistically significant differences observed between 3 and 6 months, and 6 and 12 months. No mobility was observed in any implants in either group. Group I had significantly higher ISQ values at all follow-up intervals than Group II.).

**Conclusion:** the LLLT has positive influence on increasing dental implant stability postoperatively.

**KEY WORDS**: Low Level Laser Therapy (LLLT), Dental Implant Stability, Implant Stability Quotient (ISQ

* Dental Technology Department, Yefren's Collage of Medical Technology. Yefren, Libya.
** Oral Surgery Department, Faculty of Dentistry, Zintan University. Zintan.Libya

## INTRODUCTION

In recent decades, implant dentistry has become a highly reliable method for replacing lost teeth and is now one of the most common oral surgical procedures performed worldwide.[1] It is a successful approach to restoring oral function and esthetics in totally or partially edentulous patients by osseointegrated dental implants.[2]

The posterior maxilla presents the most challenging area for dental implant stability primarily due to its poor bone quality and low density. Compared to other maxillary regions, this area mostly has Type III or Type IV bone quality, which is characterized by thinner trabecular bone and a lack of cortical bone support, drastically affecting the initial implant stability. The presence of the maxillary sinus further complicates implant placement, often requiring additional procedures like sinus floor elevation to increase bone volume, yet this can delay the healing process and extend treatment timelines. Studies show that primary implant stability in this region can be compromised due to low bone density, which affects osseointegration and increases micromotion risk, affecting the long-term implant success.[3,4]

Laser technology has been beneficial in modern dentistry, with its first application in both hard and soft tissue being highly advantageous.[5,6] Currently, laser therapy in clinical dentistry is at an advanced stage of development and has a promising future.[7]

Low-level laser therapy (LLLT), also known as photo bio-modulation therapy (PBMT) as well (, is a treatment that utilizes low-power radiation (between 5 and 500 mw) to achieve non-thermal effects, such as healing, pain relief, and reducing inflammation.[8,9] The effect of LLLT on cellular mitosis and the enhancement of metabolic cycles and protein synthesis have been shown to improve wound healing through increased cell proliferation.[10,11.]

Some studies have indicated that LLLT is beneficial in improving bone-implant interface strength, thus promoting the osseointegration process.[11, 12] While, other studies have shown little or no positive outcomes.[13- 15] Therefore, this study aims to assess the outcomes of LLLT use in dental implant treatment.

## MATERIALS AND METHODS

This study was caried out in the dental clinic at Yefren's poly clinics compound from January 2023 to November 2023 after been approved by ethical committee under number (2023-186 ). Eight adult patients were selected in this study after they had signed an informed consent form according to following criteria: 1) Bilaterally missing maxillary premolar teeth indicated for dental implant placement with sufficient bone volume for dental implant placement (minimum length of 16 mm ( form alveolar crest to the maxillary sinus floor and 8mm diameter ( mesio-distally \ buco- palatal ) and minimum bone density D3 ; 2) good oral hygiene;3) non-smoking. All patients had the following criteria excluded: 1) Parafunctional habits; 2) any systemic or local condition that contraindicates dental implant placement; 3) pregnancy.

### Patient Grouping

A split-mouth design was employed in this study, where the implants inserted on the right side were categorized as group I (study group) and those placed on the left side as group II (control group).

**In group I**, low-level laser therapy (LLLT) was administered after implant placement, followed by an early loading protocol. The laser beam was applied to the implant area in a continuous slow-motion wave, with an exposure dose of 3 J/cm$^2$, and for a duration of 1 minute, twice a week for the first three weeks. This study employed a soft laser delivery system MKW* laser system (LA-X

* MKW-Therapiesysteme GmbH Landstraße 67 D- 76547 Sinzheim, Germany www.mkw-laser.de

point laser) which provided GaAlAs laser - 785 nm, maximum total diode output of 700 mW (14 x 50 mW), and continuous waves with exposure. Implants were left submerged for three months, after which abutment connection and fabrication of the final prosthesis were undertaken.

**In group II**, conventional implant placement and loading protocols were followed. Implants were left submerged for three months before abutment connection and fabrication of the final prosthesis.

**Preoperative Measures**

1. Medical and dental history were obtained to identify any pre-existing medical conditions that may lead to complications during or after the surgery. The dental history was recorded to establish previous dental treatments and the patient's attitude toward these procedures, with particular attention given to the cause of tooth loss.
2. Clinical examination was conducted, which included a comprehensive intraoral examination in combination with dental history. Extraoral examination was performed to identify any swellings and lymph node enlargement. Appropriate oral hygiene was necessary for patient selection. The jaw relationship was accurately assessed to evaluate occlusion, teeth alignment, and the horizontal and vertical relationships of the maxillary and mandibular jaws. Patients with parafunctional habits such as clenching, and bruxism were excluded from the study.
3. Radiographic examination was carried out using OPG to detect any existing pathological conditions and to determine the exact bone height and width at the intended implant site. The evaluation of vital anatomical structures was also conducted. (Fig.1).

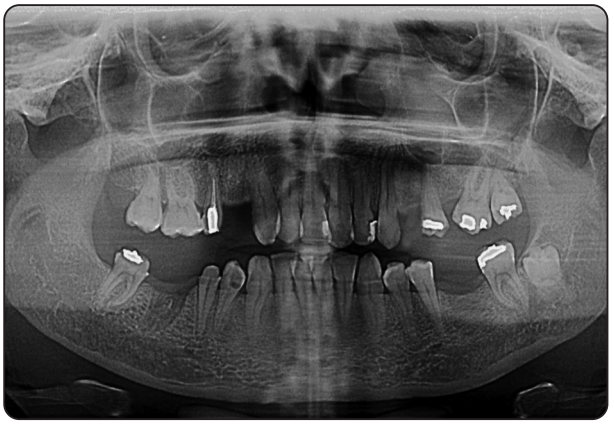

Fig. (1) A radiograph showing the preoperative panoramic view.

**Preoperative preparation**

Before the surgery, several preoperative measures were undertaken to ensure successful implant placement.

- These included advising patients to maintain strict oral hygiene measures one week prior to surgery, such as tooth brushing and rinsing with a Chlorhexidine 0.12% DG* mouth wash to prevent plaque accumulation and gingival inflammation.
- Patients were also prescribed oral antibiotics (amoxicillin/Clavulanic acid 625mg)** as prophylaxis against infection.
- Dental impressions were taken for both maxillary and mandibular jaws to evaluate occlusion status.
- Computer-guided length measurements (using computer software)*** were taken to ensure a safe distance from vital structure ( Fig.2).

**Surgical procedure**

All implants were placed according to the two-stages surgical protocol, following the next steps:

- The surgeon and his assistant followed a strict sterile technique and all patients were instructed to rinse with chlorhexidine mouth wash for 30 seconds immediately before the surgery.

* Kin Laboratorios Kin S,A , Diagonal 200, 08018 Barcelona – Spain
** Glaxo Wellcome, 53100 Mayenne, France
*** Planmeca Romexis Viewer V. 5.1.0.R , Planmeca USA Inc.

- Labial and palatal infiltration anesthesia were given using lidocain Hcl 2% with Epinefrin*
- Crestal incision with careful releasing of the adjacent mesial and distal papillae was performed, and a muco-periosteal flap was then elevated (Fig. 2). The position of the implants was mainly determined by a surgical stent, while its direction was decided in relation to the neighboring teeth or with the aid of a CAD CAM surgical stent.

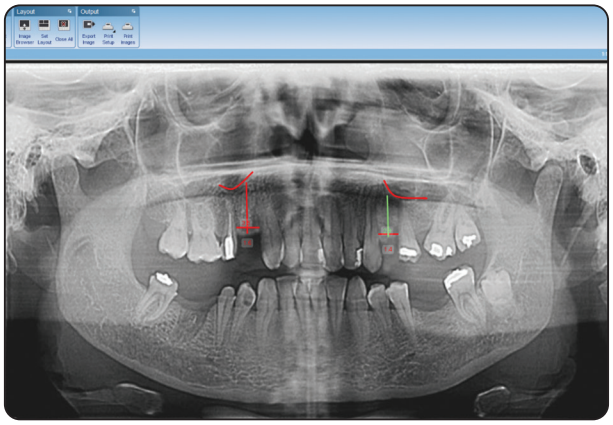

Fig. (2) Showing Computer-guided length measuring on panoramic radiograph.

- The implant bed was prepared using a progressive sequence of drills, starting with a 2mm diameter drill, and gradually widening to fit the fixture**.
- Drilling was performed using an electric motor irrigation system with adequate flow of irrigation and a speed reduction low speed high torque handpiece with a drilling speed between 600-850 rpm. After irrigating the implant bed with saline, the sealed sterile implant package was opened, and the implant was guided into its position with light stable finger pressure.
- The coupling wrench with a ratchet was used to complete the installation of the implant, which was leveled 1mm apical to the alveolar bone crest.
- Finally, the cover screw was attached to the implant top with the aid of the hex tool.
- The flap was repositioned and secured in its proper position with 4/0 black silk sutures (Fig.3).
- An immediate periapical radiograph was taken to verify the final position of the implant (Fig. 4).

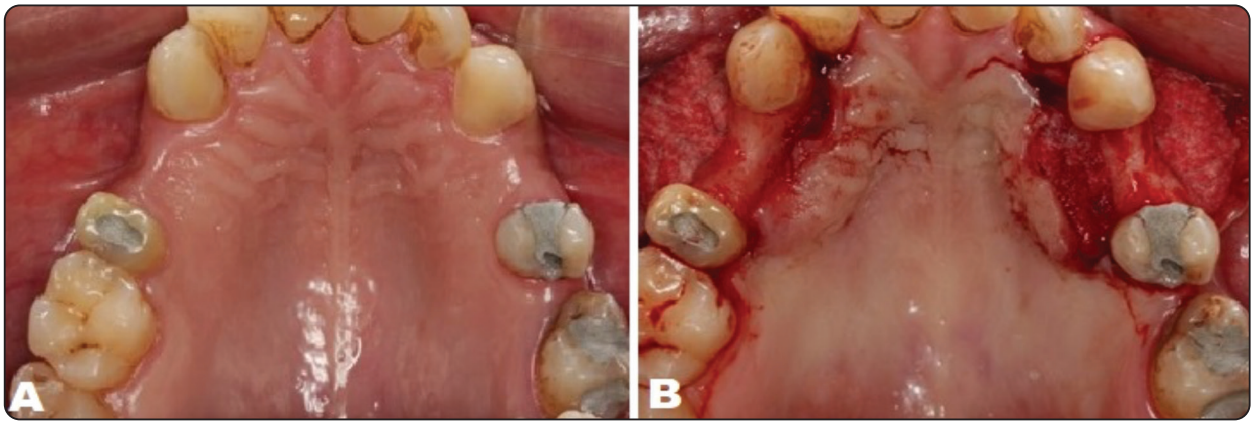


Fig. (3) A preoperative photograph showing the bilaterally missing of maxillary first premolars. B photograph showing the flap after elevation and reflection

* LIGNOSPAN LIDOCAINE ANESTHESIA, Septodent, France
** HexaconeAllfit dental system, Dr.Ihde Dental AG 8737 Gommiswald Switzerland

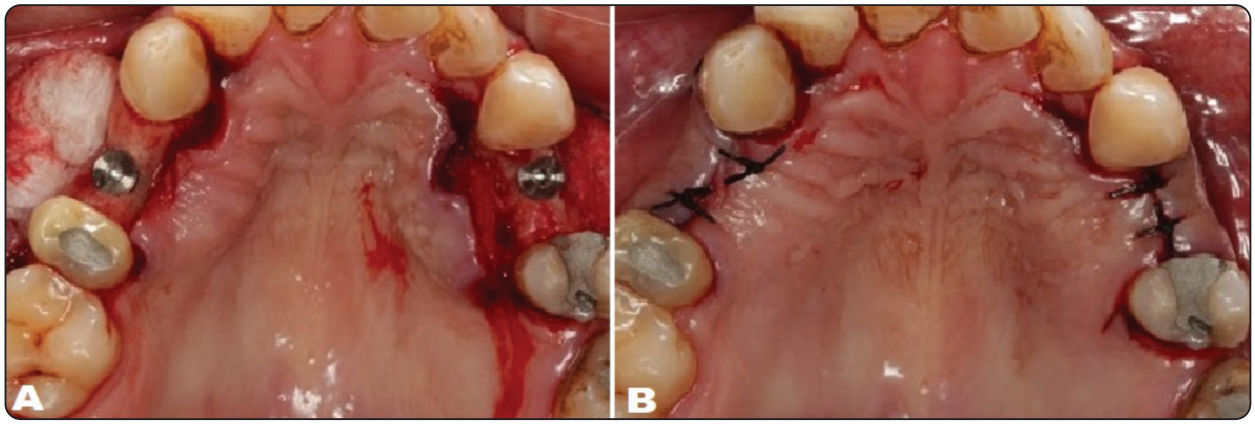


Fig. (4) A photograph showing the dental implants after complete installation and attachment of the cover screws. B Photograph showing the primary closure of flap.

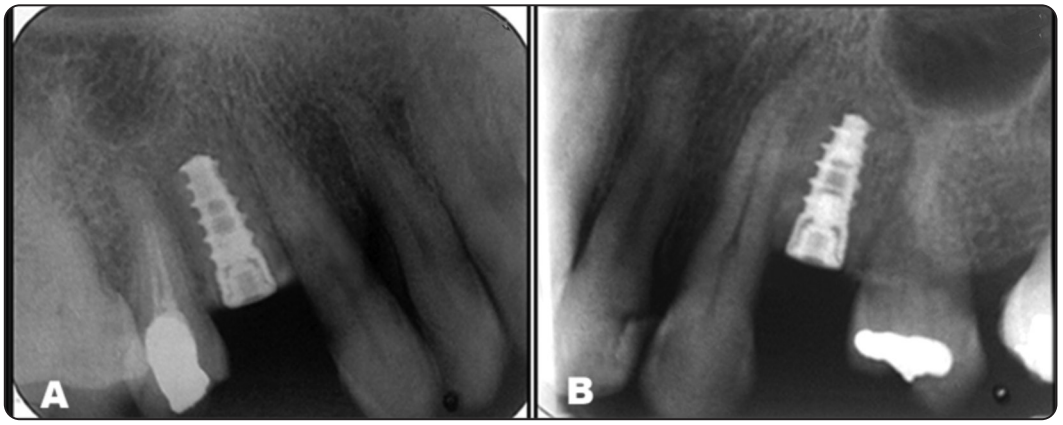


Fig. (5) Showing immediate postoperative periapical radiograph after placement for group I(A) and group II (B).

**Postoperative Care:**

1. Patients were advised to apply gentle pressure on a sterile gauze pack to promote hemostasis and reattachment of the flap to the underlying bone.
2. Ice packs were applied for 20 minutes every 2 hours postoperatively to minimize edema formation.
3. Prescribed postoperative medications included continuing Amoxicillin /Clavulanic acid 625mg antibiotic every 12 hours for 7 days, and Diclofenac potassium* 50mg tablets as non-steroidal anti-inflammatory and analgesic drug, twice daily.
4. Patients were instructed on optimal oral hygiene with 0.12% Chlorhexidine DG mouthwash and to avoid chewing solid food.
5. The surgical wound was evaluated for dehiscence, and sutures were removed after 7 days. Patients were motivated for oral hygiene instructions.

**Second Surgery of Implant Loading:**

1. The second stage surgery was performed for both groups 3 months after implant insertion.
2. After local anesthesia administration, the implant cover screw was exposed and removed, and the healing cap was attached for 2 weeks.

** Tabuk Pharmaceutical Mfg.Co , Tabuk Saudi Arabia.*

3. An impression was made using an impression post and laboratory analogue with silicone rubber base material to fabricate the working cast.
4. The final restoration of porcelain fused to metal was fabricated and cemented to the abutment (Fig. 6 and 7).

**Implant stability evaluation**

Implant stability was evaluated using resonance frequency analysis (RFA) with the Osstell IDX Mentor* and its wireless transducer (Smart Peg). The Smart Peg was attached to the implant body fixture with a torque not exceeding 10Ncm using a smart peg wrench. The stability was measured and presented as Implant Stability Quotient (ISQ) values, (ISQ is scaled from 1 to 100, the higher the ISQ value, the more stable is the implant) which are derived from the resonance frequency of the smart Peg and indicate the implant's stability. The technique is contactless, non-invasive, and takes 1-2 seconds, and the implant stability was recorded at 3, 6, and 12 months after implant placement for both groups.

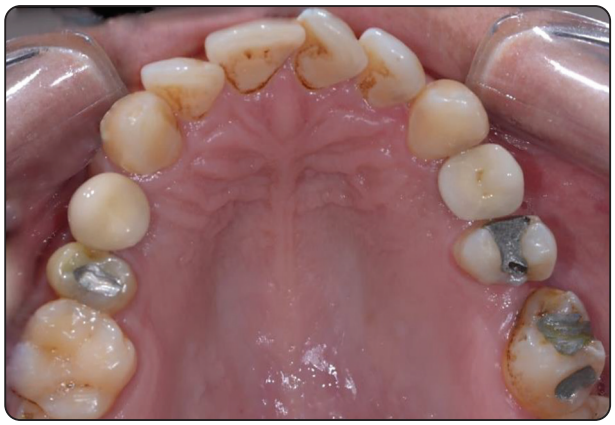

Fig. (6) A photograph showing an occlusal view of the final restorations.

**Statistical analysis**

Statistical analysis was performed using SPSS version 21. Normality of data was tested with the Shapiro-Wilk test. Continuous variables were presented as mean ± SD for parametric data and median for non-parametric data. Independent and paired t-tests were used for parametric data, and Mann-Whitney and Wilcoxon Signed Ranks tests were used for non-parametric data to compare the two groups. The threshold of significance was set at a 5% level (p-value), and the results were considered non-significant if $p > 0.05$, significant if $p < 0.05$, and highly significant if $p < 0.001$.

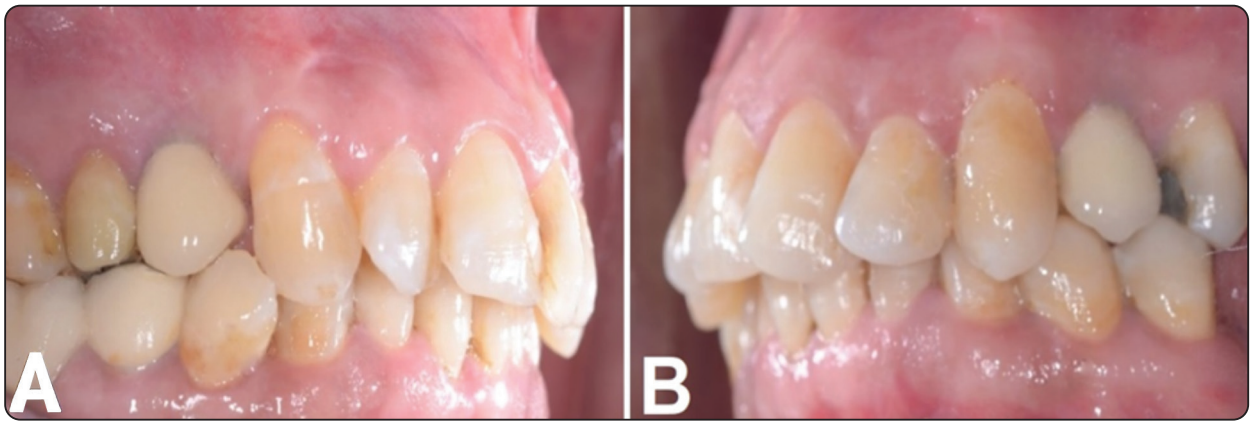


Fig. (7) Photographs showing the final restorations in occlusion for group I (A) and group II (B).

* Osstell USA. C/O Gross Mendelsohn & Associates 1801 Porter Street, Suite 500 Baltimore, MD 21230

## RESULTS

This study involved eight healthy female patients with an age range of 25 to 45 years and a mean age of 34.20±6.59 years. The study included the replacement of seven second premolars and thirteen first premolars with dental implants of varying lengths and diameters. Implant lengths used in the study ranged from 10mm to 15mm, with the most used length being 11.5mm, and diameters of 3.3mm and 3.7mm were used. Patients were clinically and radiographically evaluated at 3, 6, and 12 months after loading to assess implant stability, gingival health, esthetics, and marginal bone loss. The results showed a 100% success rate for osseointegration of all implanted teeth.

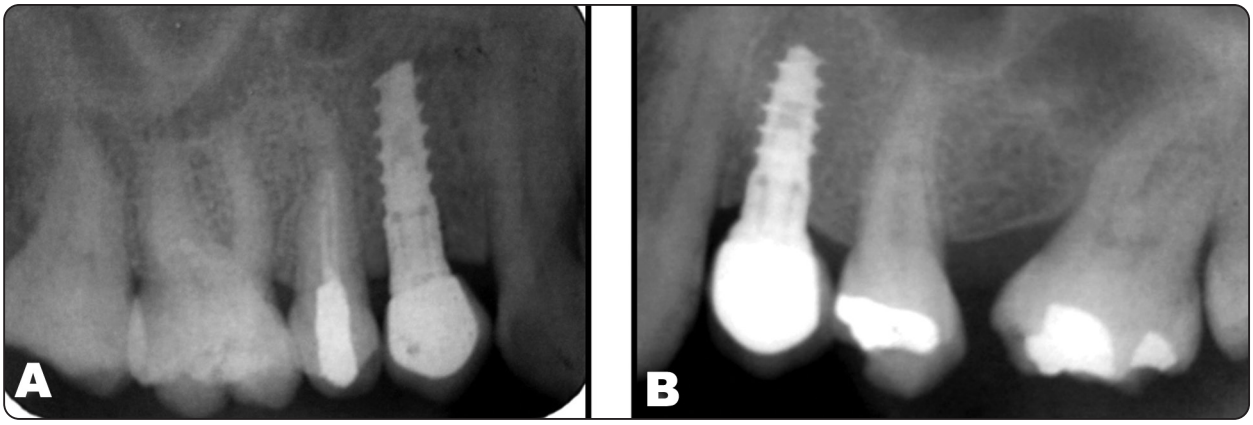


Fig. (8) Showing Periapical radiographs revealing marginal bone level changes 3 months after loading for group I(A) and group II (B)

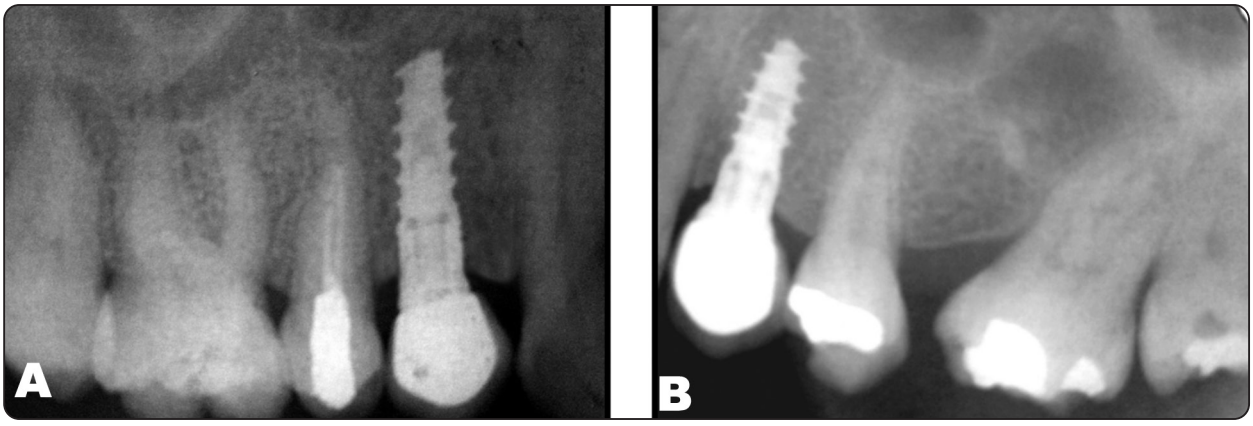


Fig. (9) Periapical radiographs showing marginal bone level changes 6 months after loading for group I(A) and group II (B)

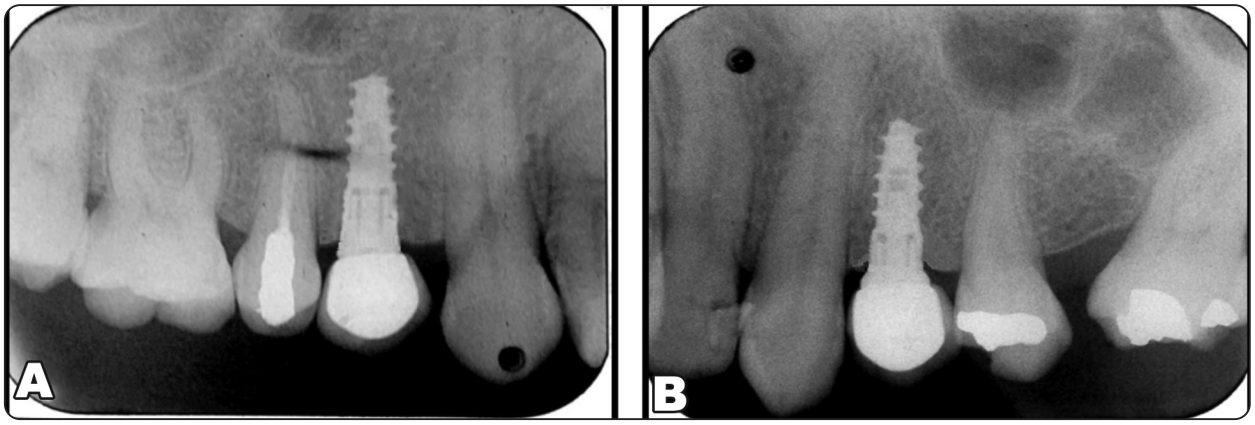


Fig. (10) Periapical radiographs showing marginal bone level changes 12 months after loading for group I(A) and group II (B)

**Implant stability**

The study investigated the Implant Stability Quotient (ISQ) values in two groups of dental implant patients. In Group I, the ISQ values at 3, 6, and 12 months after implant placement ranged from 60 to 74, 62 to 78, and 68 to 80, respectively, with statistically significant differences observed between 3 and 6 months, 3 and 12 months, and 6 and 12 months.

In Group II, the ISQ values at 3, 6, and 12 months after implant placement ranged from 54 to 69, 56 to 70, and 60 to 72, respectively, with statistically significant differences observed between 3 and 6 months, 3 and 12 months, and 6 and 12 months. No mobility was observed in any implants in either group. Group I had significantly higher ISQ values at all follow-up intervals than Group II. (Table 1,2, Bar chart 1).

TABLE (1) Showing implant stability recorded at 3, 6 and 12 months:

| **Time** | **Group (I) no=10** | | **Group (II) no=10** | | ***P*** |
|---|---|---|---|---|---|
| | ISQ Range | Mean±SD | ISQ Range | Mean±SD | |
| **3 months** | 60-74 | 67±5.43 | 54-69 | 61.90±6.04 | P=.048* |
| **6 months** | 62-78 | 69.10±3.47 | 56-70 | 64.60±5.12 | P=.034* |
| **12 months** | 68-80 | 73.70±3.77 | 60-72 | 68.60±4.45 | P=.013* |

TABLE (2) ISQ values recorded at 3, 6, and 12 months:

| **ISQ** | **3 months** | **6 months** | **12 months** | **Test of sig. (p-value)** |
|---|---|---|---|---|
| | | **Group (I):** | | |
| **Mean±SD** | 67±5.43 | 69.10±3.47 | 73.70±3.77 | P1=.05* |
| | | | | P2=≤.001** |
| | | | | P3=≤.001** |
| | | **Group (II):** | | |
| **Mean±SD** | 61.90±6.04 | 64.60±5.12 | 68.60±4.45 | P1= .012* |
| | | | | P2=≤.001** |
| | | | | P3=≤.001** |

***paired t-test used, P1=comparison between 3m-6m, P2=comparison between 3m-12m, P3=comparison between 6m-12m.***

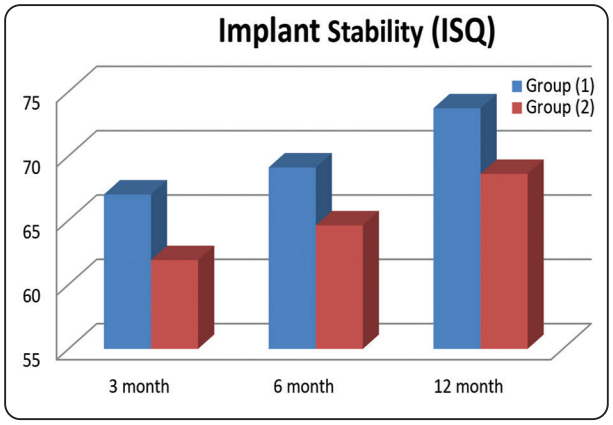


Chart (1) Bar chart showing the ISQ values for implants placed in both groups:

## DISCUSSION

Low-level laser therapy (LLLT) has gained attention in recent years for its potential applications in dentistry, particularly in implantology.[18-20] However, most studies on LLLT in dentistry have been animal experiments conducted in vitro. While these studies have shown positive results, more investigations on human subjects are necessary. [21-22]

In this study, the split technique was used to control for individual bias factors, and implant stability was evaluated using Resonance Frequency Analysis (RFA) as a realistic and less invasive parameter for assessing osseointegration during the healing period. [16,14,24-28] While, other clinical studies that measured LLLT on implant osseointegration were limited. [14,15, 29-32] The secondary implant stability was assessed at 3, 6, and 12 months since all implants were inserted in healed bony sites.

Although the ISQ value in this study showed increasing patterns throughout the measuring intervals in 3, 6, and 12 months compared to the controlled group, it contradicts with ***Kinalski et al'***[16] study, which tested ISQ at insertion and at the abutment phase within 4-6 months, and ***Lobato et al'***[15] study, which used the same parameters to measure the effect of LLLT on implant stability in freshly extracted sockets. Additionally, ***Garcia-Morales et al***[12] and ***Torkzaban et al'***[26] studies showed no significant difference in implant stability that induced by LLLT.

However, this study agreed with ***Mandić et al'***[29] study, which used the split-mouth technique in the posterior maxilla, in which the irradiated implants achieved higher stability compared to the control group. Furthermore, ***Gokmenoglu et al'***[34] study concluded that LLLT application to the surgical area has a positive effect on the osseointegration process, and implant stability can be maintained.

Although the results of the present study showed limited agreement with other published studies, it should be noted that most human trials have shown no positive impact of LLLT on implant osseointegration due to a lack of studies in this subject matter compared to animal studies. [22] Some authors have highlighted the lack of a fixed protocol for LLLT use, [15,35] while others have pointed out the variety of treated surfaces of dental implants. [36]

Overall, while LLLT shows promising potential for improving implant osseointegration, further investigations on human subjects are needed to establish a definitive protocol for LLLT use and to determine its effectiveness in different clinical scenarios.

## CONCLUSION

From the results of our study, we concluded that LLLT has positive influence on increasing dental implant stability postoperatively.

## REFERENCES

1. Ebenezer, S., Kumar, V.V., Thor, A. (2021). Basics of Dental Implantology for the Oral Surgeon. In: Bonanthaya, K., Panneerselvam, E., Manuel, S., Kumar, V.V., Rai, A. (eds) Oral and Maxillofacial Surgery for the Clinician. Springer, Singapore. https://doi.org/10.1007/978-981-15-1346-6_18

2. Egilmez F, Ergun G, Cekic-Nagas I, Bozkaya S. Implant-supported hybrid prosthesis: Conventional treatment method for borderline cases. Eur J Dent. 2015;9(3):442-448. doi: 10.4103/1305-7456.163324. PMID: 26430378; PMCID: PMC4570001.

3. Cleber Rosa , Victor Bento , Nathalia ´ Duarte , Joao Sayeg, Thawan Santos, Eduardo Pellizzer. Do dental implants installed in different types of bone (I, II, III, IV) have different success rates? A systematic review and meta-analysis, The Saudi Dental Journal 2024: (36) 428–442.
4. Chrcanovic BR, Albrektsson T, Wennerberg A. Bone Quality and Quantity and Dental Implant Failure: A Systematic Review and Meta-analysis. Int J Prosthodont. 2017 May/June;30(3):219–237. doi: 10.11607/ijp.5142. Epub 2017 Mar 20. PMID: 28319206.
5. Luke AM, Mathew S, Altawash MM, Madan BM. Lasers: A Review With Their Applications in Oral Medicine. J Lasers Med Sci. 2019;10(4):324-329. doi: 10.15171/jlms.2019.52. Epub 2019 Oct 1. PMID: 31875126; PMCID: PMC6885906.
6. Liaqat S, Qayyum H, Rafaqat Z, Qadir A, Fayyaz S, Khan A, Jabeen H, Muhammad N, Khan M A. Laser as an innovative tool, its implications and advances in dentistry: A systematic review. Journal of Photochemistry and Photobiology. 2022; 12:1-8 https://doi.org/10.1016/j.jpap.2022.100148
7. Campanha BP, Gallina C, Geremia T, Loro RC, Valiati R, Hübler R, de Oliveira MG. Low-level laser therapy for implants without initial stability. Photomed Laser Surg. 2010 Jun;28(3):365-9. doi: 10.1089/pho.2008.2429. PMID: 19860572.
8. Fekrazad, R., Chiniforush, N., Bouraima, S. A., Valipour, M., Aslani, M., Zare, M., and Ashtiani Safari, O. Low Level Laser Therapy in Management of Complications after Intra Oral Surgeries. Journal of Lasers in Medical Sciences. 2012 3(4), 135-140. https://journals.sbmu.ac.ir/jlms/article/view/3543
9. Hall G, Anneroth G, Schennings T, Zetterqvist L, Rydén H. Effect of low level energy laser irradiation on wound healing. An experimental study in rats. Swed Dent J. 1994;18(1-2):29-34. PMID: 8052949.
10. Honmura A, Ishii A, Yanase M, Obata J, Haruki E. Analgesic effect of Ga-Al-As diode laser irradiation on hyperalgesia in carrageenin-induced inflammation. Lasers Surg Med. 1993;13(4):463-9. doi: 10.1002/lsm.1900130411. PMID: 8366747.
11. Karu T. Photobiology of low-power laser effects. Health Phys. 1989 May;56(5):691-704. doi: 10.1097/00004032-198905000-00015. PMID: 2651364.
12. Reza B, Soheil N, Ehsan B, Kourosh S, Reza F. Efficacy of photo bio-modulation therapy for pain relief and soft tissue wound healing after dental implant surgery: A double-blind randomized clinical trial Journal of Photochemistry and Photobiology.2021; 8:1-6 https://doi.org/10.1016/j.jpap.2021.100062
13. Boldrini C, de Almeida JM, Fernandes LA, Ribeiro FS, Garcia VG, Theodoro LH, Pontes AE. Biomechanical effect of one session of low-level laser on the bone-titanium implant interface. Lasers Med Sci. 2013 Jan;28(1):349-52. doi: 10.1007/s10103-012-1167-3. Epub 2012 Jul 24. PMID: 22825319.
14. García-Morales JM, Tortamano-Neto P, Todescan FF, de Andrade JC Jr, 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 Jul;27(4):703-11. doi: 10.1007/s10103-011-0948-4. Epub 2011 Jul 6. PMID: 21732113.
15. Lobato RPB, Kinalski MA, Martins TM, Agostini BA, Bergoli CD, Dos Santos MBF. Influence of low-level laser therapy on implant stability in implants placed in fresh extraction sockets: A randomized clinical trial. Clin Implant Dent Relat Res. 2020 Jun;22(3):261-269. doi: 10.1111/cid.12904. Epub 2020 Apr 24. PMID: 32329198
16. Kinalski MA, Agostini BA, Bergoli CD, Dos Santos MBF. Influence of low-level laser therapy on implant stability in implants placed in healed sites: a randomized controlled trial. Int J Implant Dent. 2021 Jun 1;7(1):49. doi: 10.1186/s40729-021-00331-0. PMID: 34059974; PMCID: PMC8166992.
17. Basford JR. Low intensity laser therapy: still not an established clinical tool. Lasers Surg Med. 1995;16(4):331-42. doi: 10.1002/lsm.1900160404. PMID: 7651054.
18. Walsh LJ. The current status of laser applications in dentistry. Aust Dent J. 2003 Sep;48(3):146-55; quiz 198. doi: 10.1111/j.1834-7819.2003.tb00025.x. PMID: 14640367.
19. Ohshiro T, Calderhead RG. Development of low reactive-level laser therapy and its present status. J Clin Laser Med Surg. 1991 Aug;9(4):267-75. doi: 10.1089/clm.1991.9.267-275. PMID: 10149466.
20. Chen Y, Liu C, Chen X, Mo A. Clinical evidence of photobiomodulation therapy (PBMT) on implant stability and success: a systematic review and meta-analysis. BMC Oral Health. 2019 May 7;19(1):77. doi: 10.1186/s12903-019-0779-4. PMID: 31064350; PMCID: PMC6505209.
21. Prados-Frutos JC, Rodríguez-Molinero J, Prados-Privado M, Torres JH, Rojo R. Lack of clinical evidence on low-level laser therapy (LLLT) on dental titanium implant: a

systematic review. Lasers Med Sci. 2016 Feb;31(2):383-92. doi: 10.1007/s10103-015-1860-0. Epub 2016 Jan 11. PMID: 26754180.

22. Shadid RM, Sadaqah NR, Othman SA. Does the Implant Surgical Technique Affect the Primary and/or Secondary Stability of Dental Implants? A Systematic Review. Int J Dent. 2014;2014:204838. doi: 10.1155/2014/204838. Epub 2014 Jul 7. PMID: 25126094; PMCID: PMC4121016.

23. Weber JB, Pinheiro AL, de Oliveira MG, Oliveira FA, Ramalho LM. Laser therapy improves healing of bone defects submitted to autologous bone graft. Photomed Laser Surg. 2006 Feb;24(1):38-44. doi: 10.1089/pho.2006.24.38. PMID: 16503787.

24. Oh JS, Kim SG, Lim SC, Ong JL. A comparative study of two noninvasive techniques to evaluate implant stability: Periotest and Osstell Mentor. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Apr;107(4):513-8. doi: 10.1016/j.tripleo.2008.08.026. Epub 2008 Dec 17. PMID: 19095473.

25. Caulier H, Naert I, Kalk W, Jansen JA. The relationship of some histologic parameters, radiographic evaluations, and Periotest measurements of oral implants: an experimental animal study. Int J Oral Maxillofac Implants. 1997 May-Jun;12(3):380-6. PMID: 9197104.

26. Torkzaban P, Kasraei S, Torabi S, Farhadian M. Low-level laser therapy with 940 nm diode laser on stability of dental implants: a randomized controlled clinical trial. Lasers Med Sci. 2018 Feb;33(2):287-293. doi: 10.1007/s10103-017-2365-9. Epub 2017 Oct 29. PMID: 29082462.

27. Kinalski MA, Agostini BA, Bergoli CD, Dos Santos MBF. Influence of low-level laser therapy on implant stability in implants placed in healed sites: a randomized controlled trial. Int J Implant Dent. 2021 Jun 1;7(1):49. doi: 10.1186/s40729-021-00331-0. PMID: 34059974; PMCID: PMC8166992.

28. Lobato RPB, Kinalski MA, Martins TM, Agostini BA, Bergoli CD, Dos Santos MBF. Influence of low-level laser therapy on implant stability in implants placed in fresh extraction sockets: A randomized clinical trial. Clin Implant Dent Relat Res. 2020 Jun;22(3):261-269. doi: 10.1111/cid.12904. Epub 2020 Apr 24. PMID: 32329198

29. Mandić B, Lazić Z, Marković A, Mandić B, Mandić M, Djinić A, Miličić B. 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. 2015 Mar;72(3):233-40. doi: 10.2298/vsp131202075m. PMID: 25958474.

30. Medina-Huertas R, Manzano-Moreno FJ, De Luna-Bertos E, Ramos-Torrecillas J, García-Martínez O, Ruiz C. The effects of low-level diode laser irradiation on differentiation, antigenic profile, and phagocytic capacity of osteoblast-like cells (MG-63). Lasers Med Sci. 2014 Jul;29(4):1479-84. doi: 10.1007/s10103-014-1557-9. Epub 2014 Mar 12. PMID: 24619140.

31. 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 Dec;18(12):128001. doi: 10.1117/1.JBO.18.12.128001. PMID: 24337495.

32. 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 Sep-Oct;30(5):1028-35. doi: 10.11607/jomi.3382. Erratum in: Int J Oral Maxillofac Implants. 2016 Jan-Feb;31(1):141. PMID: 26394337.

33. Mayer L, Gomes FV, de Oliveira MG, de Moraes JF, Carlsson L. Peri-implant osseointegration after low-level laser therapy: micro-computed tomography and resonance frequency analysis in an animal model. Lasers Med Sci. 2016 Dec;31(9):1789-1795. doi: 10.1007/s10103-016-2051-3. Epub 2016 Aug 17. PMID: 27534769.

34. 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 Mar;32(3):138-45. doi: 10.1089/pho.2012.3473. Epub 2014 Feb 19. PMID: 24552468.

35. Khadra M, Rønold HJ, Lyngstadaas SP, Ellingsen JE, Haanaes HR. Low-level laser therapy stimulates bone-implant interaction: an experimental study in rabbits. Clin Oral Implants Res. 2004 Jun;15(3):325-32. doi: 10.1111/j.1600-0501.2004.00994.x. PMID: 15142095.

36. Primo BT, da Silva RC, Grossmann E, Miguens SA Jr, Hernandez PA, Silva AN Jr. Effect of surface roughness and low-level laser therapy on removal torque of implants placed in rat femurs. J Oral Implantol. 2013 Oct;39(5):533-8. doi: 10.1563/AAID-JOI-D-10-00141. Epub 2011 May 2. PMID: 21534821.