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Evaluation of the Osteogenic Efficacy of Low Level Laser on Immediate Dental Implant

Mohamed F. Edrees[*1], Mohamed M. Al ashmawy[2], Hossam N. Abo-Aldhab*[1]

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Aadj@azhar.edu.eg

ABSTRACT

Aim: this study aims to evaluate the clinical effect of low level laser on immediate dental implant stability, as well as the osteogenic efficacy on immediate dental implant through radiographic evaluation of marginal bone loss and biochemical assessment of osteoprotegerin (OPG) level in GCF around implant. **Subjects and methods**: twenty patients having isolated hopeless teeth indicated for extraction followed by immediate dental implant placement following phase I therapy were classified into two groups, Group I: received extraction of the desired teeth combined with immediate dental implants placement, and Group II: received extraction of the desired teeth combined with immediate dental implants placement followed by applications of low level laser. Clinical and radiographic parameters were recorded at base line, 3 and 6 months post treatment and biochemical assessment of OPG level in GCF base line, 2,4,12 weeks. **Results:** The use of Low Level Laser (LLL) seemed to be an effective adjunctive therapy in improving probing depth, marginal bone level and osteoprotegrin (OPG) level around immediately placed dental implant. **Conclusion:** LLL therapy is safe and effective methods for stimulation of Osseo- integration around dental implant

KEYWORDS

LLL, Osseointegration, OPG, immediate dental implant, marginal bone loss

INTRODUCTION

Implantology has become an indispensible part of mainstream dentistry, concerned with the replacement of missing teeth with artificial prostheses anchored to the jawbone. It is the treatment of choice for the rehabilitation of severe functional, anatomical or aesthetic problems arising from tooth loss [(1)]. Placement of implants immediately following extraction has now become an increasingly common strategy to preserve bone and reduce treatment time. It can improve esthetics because the soft tissue envelope is preserved [(2)] and reduces the number of surgical procedures. In addition, osseointegration is also more favorable when placing implants immediately following an extraction. The bony receptors are preserved by preventing atrophy of the alveolar ridge and preventing recession of the mucosal and gingival tissues [(3)]. In order to

1. Department of Oral Medicine, Periodontology, Oral Diagnosis and Dental Radiology, Faculty of Dentistry, Al-Azhar University, Assuit , Egypt.
2. Department of Oral and maxillofacial surgery, Faculty of Dentistry, Al-Azhar University, Assuit , Egypt.

* Corresponding Author e-mail: hossamaboaldahab.96@azhar.edu.eg

improve the aesthetic outcomes and reduce the bone dimensional changes several techniques have been proposed, such as flapless protocols, immediate pro-visionalization, connective tissue grafting, GBR techniques or filling of the gap with a bone replacement graft [4]. Another suggested modality to enhance the process of bone healing is the application of Low-level laser therapy (LLLT) [5].

The use of low-level laser therapy on the biostimulation of bone repair has been growing steadily and several studies have demonstrated positive results on the healing of bone tissues [6]. (LLLT) has been used to accelerate healing through induction of formative cells and angiogenesis [7].

Resorption and reformation of alveolar bone stimulate the release of several bone remodeling markers, which are first released into periodontal tissues and gingival crevicular fluid (GCF), from which they end up to saliva. Osteoprotegerin, RANKL, osteocalcin, and osteopontin concentrations have been investigated in patients with periodontitis [8]. Osteoprotegerin (OPG) is a bone turnover marker that plays an essential role in the process of osteogenesis and bone hemostasis. It is also a glycoprotein having a high affinity for Receptor activator of ligand (RANKL) and suppresses its activity by inhibiting osteoclasts formation. (OPG) is expressed primarily by bone marrow stromal cells, but can be induced in B lymphocytes, dendritic cells, osteoblast that is generally considered to be a secreted soluble receptor.

The primary research questions in the present study were that: upon the proved efficacy of LLLT on peri-implant bone healing, as it modulates inflammation, accelerates cell proliferation and enhances healing, **Is** the application of LLLT to immediately placed dental implant can be enhance the clinical and radiographic treatment outcomes?, and upon the significant characteristics of OPG as bone biomarker, **Is** it can be used as a diagnostic tool of peri-implant crevicular fluid to evaluate the osteogenesis around dental implants?

SUBJECTS AND METHODS

The current study carried out on 20 adult patients of both sexes undergoing periodontal therapy at the out patients clinic of Oral Medicine and Periodontology Department, Faculty of Dentistry Al-Azhar University, Assiut Branch having isolated hopless teeth indicated for immediate implant placement. All selected patients having isolated hopless teeth were thoroughly informed of the nature, potential risks and benefits of their participation in the study and signed their informed consent.

Inclusion criteria:

Patients were physically and psychologically able to tolerate conventional surgical and restorative procedures and free from any systemic disease according to Cornell medical index [9].The implant sites had sufficient vertical inter-arch space to accommodate the restorative components and had sufficient bone quantity (width & height) and adequate bone quality.

Exclusion criteria:

Smokers, pregnant or lactating female patients. Patients with para functional habits such as bruxism and clenching. Presence of active infection around the failing tooth. Inability to achieve primary implant stability following immediate implant placemen.

Patients were classified randomly into the following equal two groups using flipping coins. ***Group I:*** received extraction of teeth combined with immediate dental implants placement, ***Group II:*** received extraction of teeth combined with immediate dental implants placement followed by application low level laser.

Periodontal and radiographic evaluation:

1. Clinical evaluation by the following periodontal parameters Modified bleeding index, modified plaque index and Peri-implant probing depth as well as primary implant stability were done at; base line, 3 and 6 months post treatment.

2. Radiographic evaluation for the marginal bone level was done at; base line, 3 and 6 months post treatment A standardized periapical radiographs were taken using long cone parallel technique, customized bite, metal rod and parallel dental film positioning system.

Biochemical evaluation:

Sampling technique

Samples collection were frozen at -80 degree till they were assayed for OPG level using commercially available enzyme-linked immunosorbent assay (ELISA) according to the manufacturer's instructions.

Surgical Procedures:

1. The surgical site was locally anaesthetizied using local anaesthesia.
2. A traumatic tooth extraction was done using forceps of anatomic design.
3. Initiation of the osteotomy was performed in standard fashion with the initial penetration point for the anterior maxillary teeth approximately 2 mm coronal to the extraction apex and along the palatal wall.
4. SGS Swiss dental implant was placed within the body of the alveolus and torque wrench was used to obtain good primary stability.
5. The smart peg was screwed to the implant fixture to measure the implant stability quotient (ISQ) and Healing abutment was positioned to enable the clinical and biochemical evaluation during the observational periods of the study.
6. The final wound closure was performed by interrupted 0/3 non- resorbable sutures.
7. In patients of ***Group II***, each implant was submitted to 8 sessions of (LLL) SIROLaser advance intra orally started from the surgery day, the LLLT application was repeated every 48 hrs for 2 weeks for 2 minutes.

Low level laser application

each implant was submitted to 8 sessions of Diode laser (type IV) SIROLaser advance intra orally with wavelength of 660 nm was set to the power of 25mW and directed to the labial and palatal surfaces of the implant (in non-contact mode) 5 mm away from the gum, started from the surgery day, the LLLT application was repeated every 48 hrs for 2 weeks for 2 minutes.

Post-operative instructions and medications:

Oral hygiene instructions and reinforcement, as a preventive measure, patients were advised to apply cold packs over the first 24 hours. Patients were placed on systemic antibiotic, analgesic and mouthwash for one week. Patients instructed to maintain soft diet after surgery and avoid the use of the surgical site for 6 weeks.

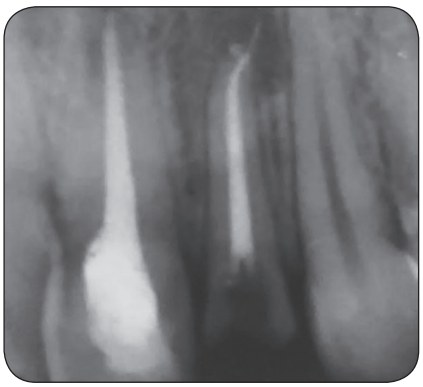

Fig. (1) Preoperative x –ray film

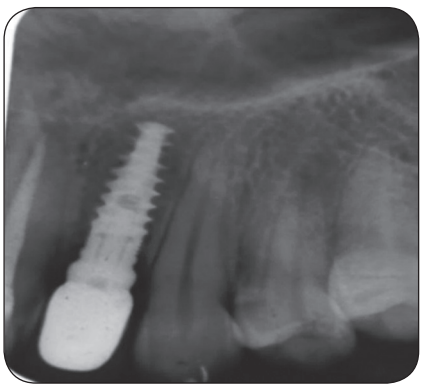

Fig. (2) Post-operative periapical x ray film

Fig. (3) Low level laser application

Fig.(4) Final PFM crown

Statistical analysis:

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov- Smirnov and Shapiro-Wilk tests, data showed non-parametric (not normal) distribution. Mann-Whitney was used to compare between the two groups in non-related samples. Wilcoxon was used to compare between the two groups in related samples.

RESULTS

This study was conducted on 20 adults of both sex (8 females and 12 males, ranged in age between 18-40 years with mean age of 29.25±7.04 years). Results of clinical parameters, radiographic Marginal bone level and GCF level of OPG illustrated in table 1

Parameters	Interval	GI	GII	P
Implant stability	Baseline	67.80 ^{bA}	67.90 ^{bA}	0.952ns
	6m	79.00 ^{aA}	80.50 ^{aA}	0.540ns
	p-value	<0.001*	<0.001*	
MPI Mean	Baseline	0.18 ^{bA}	0.13 ^{bA}	0.450ns
	3m	0.53 ^{aA}	0.48 ^{aA}	0.371ns
	6m	0.55 ^{aA}	0.45 ^{aA}	0.246ns
	p-value	0.003*	0.001*	
MBI *Mean*	Baseline	0.08 ^{cA}	0.05 ^{bA}	0.615ns
	3m	0.65 ^{aA}	0.45 ^{aB}	0.019ns
	6m	0.45 ^{bA}	0.40 ^{aA}	0.680ns
	p-value	<0.001*	0.001*	
PPD Mean	Baseline	3.65 ^{aA}	3.50 ^{aA}	0.534ns
	3m	3.05 ^{bA}	2.80 ^{bA}	0.046*
	6m	2.60 ^{cA}	1.95 ^{cB}	0.005*
	p-value	<0.001*	<0.001*	
MBL Mean	Baseline	0.00 ^{cA}	0.00 ^{cA}	1 ns
	3m	0.35 ^{bA}	0.28 ^{bB}	0.001*
	6m	0.59 ^{aA}	0.46 ^{aB}	<0.001*
	p-value	<0.001*	<0.001*	
OPG level Mean	Baseline	1.05 ^{bA}	1.05 ^{bA}	0.979ns
	2w	0.99 ^{bA}	1.05 ^{bA}	0.034*
	1m	1.09 ^{abA}	1.32 ^{aA}	0.042*
	3m	1.28 ^{aA}	1.36 ^{aA}	0.123ns
	p-value	0.035*	<0.001*	

*GI=control GII=study (MPI) = Modified plaque index, (MBI)= Modified bleeding index, (PPD)=Pre-implant probing depth , (MBL)=Marginal bone loss , OPG level=osteoprotegerin level. *; significant (p<0.05) ns; non-significant (p>0.05).*

Implant stability

In *Group I* there was a statistically significant difference between (baseline) and (6m) where (p<0.001). In *GroupII* there was a statistically significant difference between (baseline) and (6m) where (p<0.001). There was no statistically significant difference at (baseline) between (Group I) and (Group II) where (p=0.952) and there was no statistically significant difference at (6m) between (Group I) and (Group II) where (p=0.540).

Modified plaque index (MPI)

In *Group I* there was a statistically significant difference between (baseline), (3m) and (6m) where (*p*=0.003), a statistically significant difference was found between (baseline) and each of (3m) and (6m) where (p=0.012) and (p=0.011) respectively. In *Group II* there was a statistically significant difference between (baseline), (3m) and (6m) where (*p*=0.001) and a statistically significant difference was found between (baseline) and each of (3m) and (6m) where (p=0.006) and (p=0.006) respectively. There was no statistically significant difference at (baseline) between (*Group I*) and (*Group II*) where (p=0.450) and at (3 M) where (p=0.371) and also at (6M) where (p=0.246)

Modified bleeding index (MBI):

In *Group I* there was a statistically significant difference between (baseline), (3m) and (6m) groups where (p<0.001)and it was found between (baseline) and each of (3m) and (6m) where (p=0.005) and (p=0.011) respectively also was found between (3m) and (6m) where (p=0.021). In *Group II* there was a statistically significant difference between (baseline), (3m) and (6m) where (p=0.001) and was found between (baseline) and each of (3m) and (6m) where (p=0.006) and (p=0.010) respectively. There was a statistically significant difference at (3M) between (*Group I*) and (*Group II*) where (p=0.019).

Pre-implant probing depth (PPD)

In *Group I* there was a statistically significant difference between (baseline), (3m) and (6m) where (p<0.001) and was found between (baseline) and each of (3m) and (6m) where (p=0.003) and (p=0.001) respectively. Also, was found between (3m) and (6m) where (p=0.019). In *Group II* there was a statistically significant difference between (baseline), (3m) and (6m) where (p<0.001) and was found between (baseline) and each of (3m) and (6m) where (p=0.001) and (p<0.001) respectively. Also, was found between (3m) and (6m) where (p<0.001). There was a statistically significant difference at (3M) between (*Group I*) and (*Group II*) where (p=0.046) and at (6M) between (Group I) and (Group II) where (p=0.005).

Marginal bone loss (MBL):

In *Group I* a statistically significant difference was found between (baseline) and each of (3m) and (6m) where (p<0.001). Also, was found between (3m) and (6m) where (p<0.001). In *Group II* a statistically significant difference was found between (baseline) and each of (3m) and (6m) where (p<0.001). Also, a statistically significant difference was found between (3m) and (6m) where (p<0.001). There was a statistically significant difference at (3M) between (*Group I*) and (*Group II*) where (p=0.001) and at (6M) between (*Group I*) and (*Group II*) where (p<0.001).

OPG level:

In *Group I* there was a statistically significant difference between (baseline), (2w), (1m) and (3m) where (p=0.035) and was found between (3m) and each of (baseline) and (2w) where (p=0.001) and (p<0.001). No statistically significant difference was found between any other groups. In *Group II* There was a statistically significant difference between (baseline), (2w), (1m) and (3m) where (p<0.001) and was found between (baseline) and each of (1m) and (3m) where (p<0.001). Also, was found between (2w) and each of (1m) and (3m) where (p<0.001). No statistically significant difference was found

between any other groups. There was a statistically significant difference at (2weeks) between (*Group I*) and (*Group II*) where (p=0.034) and was found at (1month) between (*Group I*) and (*Group II*) where (p=0.042).

DISCUSSION

Restoring masticatory function and replacing missing teeth with minimal pain and discomfort are the most important issues for the patient and clinician. Nowadays dental implants became the most popular line of treatment to replace missing teeth: offering a comfortable long-lasting prosthesis [10].

Immediate dental implant in fresh extraction sockets was introduced, in order to reduce the number of surgical procedures and potentially limit physiological bone resorption [11]. However, immediate implant placement may not always provide successful clinical outcomes and has been documented that this surgical protocol fails to prevent the horizontal and vertical ridge alterations [12]. This may result in impaired esthetics such as marginal soft tissues recessions with subsequent bone dehiscence especially if treating the buccal side of maxillary sites in patients with a high smile line [13].

The era of using Low-level laser therapy (LLLT) as non-invasive modality to overcome the drawbacks of immediately placed dental implant in fresh extraction socket has been everted. This use of LLLT is due to its efficacy in cellular level to enhance biochemical and molecular processes involved in tissue healing [14]. A reduction in the survival rate of implant was recorded in smoker patients [15]. All cases included in the present work were free from any systematic disease and non-smokers. The selected patients to participate in the present study ranged in age between (18-40).

Generally, implant placement in elderly patients is not contraindicated but as the age is a prognostic factor in implant success and older patients have potentially longer healing times, more systemic health factors, and the likelihood of poorer local bone conditions that increased the risk of implant failure [16].To standardize the case selection and to avoid the risk of bias assessment as well as the larger extraction sockets with multirooted teeth may affect primary implant stability and may be in need for bone grating in some cases [17], all selected sites had a single-rooted tooth in the anterior regions of the maxilla. The placement of implant immediately following extraction permitting direct bone-to-implant contact in the apical area providing the apical osseous anchorage and result in a high degree of initial mechanical stability. To obtain adequate initial primary stability, the bony height of the socket (from the apex of the alveolus to the crest of alveolar bone) should demonstrate a minimum measurement of 7- 10 mm [18]. So that, the least vertical bone height selected in the present study was more than 10 mm minimum. The application of LLL started immediately after implant placement and repeated every 48 hrs, for only 2 weeks. It was demonstrated that the duration of the positive effect of LLLT is not longer than 2 weeks postoperatively [19] because laser irradiation of bone stimulates the proliferation of fibroblastic, osteoblastic and mesenchymal cells in the inflammatory and early proliferative stages. Immediately after injury, the bone repair process starts in the vascularized regions in tissue anoxia and is accelerated by the stimulatory effect of laser on bone matrix [20].

The present study showed no statistically significant difference in implant secondary stability to LLL application around immediately placed dental implants after 6 months which is the end of the observational periods of the study, which is consistent with some previous clinical studies [21,22]. While other studies reported that LLLT increases the number of osteogenic cells in the primary phase of healing, but it has no significant effect on prolonged implant stability [23,24], and another animal study, showed significant differences in implant stability quotients (ISQs) and percentage volume of newly formed bone after application of low-level laser therapy [25], that can be explained by the rapid turnover and the reduced bone thickness of

the animal models which facilitate the penetration of laser even after maturation. Regarding the results of peri-implant probing depth (PPD), there were statistically significant differences to the application of LLL over the control group after 3 and 6 months, which are consistent to clinical study reported that, patients treated with the laser achieved a significant reduction in PPD that probably due to a healing process with the formation of an epithelium seal, similar to the long junctional epithelium [26].

The present study exhibited statistically significant differences in marginal bone loss (MBL) to laser group after 3 and 6 months when compared to control group where p=0.001 and <0.001 respectively. These results are consistent to several clinical studies reported that, when performing nonsurgical treatment, a statistically significant MBL was detected after repeated application of LLL to the implant sites that preserve the bone around it and may aid in improving the longevity of the implants [27,28].

Biochemical parameters within the peri-implant crevicular fluid (PICF) provide information about the microenvironment around dental implants, thereby helping to monitor the health and disease state of surrounding tissues. Low-level laser therapy has the ability to promote bone formation by inducing the proliferation and differentiation of osteoblasts as well as enhancing the functional attachment of titanium implants to bone [29,30] through increased alkaline phosphatase activity and expression of the mRNA for osteoblastic differentiation markers, such as osteopontin, bone sialoproteins and osteocalcin in osteoblasts [31].

In the present study, the biochemical analysis of PICF for OPG levels using ELISA reveled a statistically significant difference to LLL application during the early stage of osseointegration where (p=0.034) and (0.042) after 2 weeks and 1 month of implant placement respectively, and no statistical significancy after 3 months which reflect the maturity of bone at this stage.

CONCLUSIONS

Application of Low Level Laser (LLL) seemed to be an effective adjunctive therapy in improving probing depth, marginal bone level and Osteoprotegrin (OPG) level around immediately placed dental implant. The significant advancement in both marginal bone and osteoprotegrin (OPG) levels can be considered as an indicator for the osteogenic efficacy of using Low Level Laser (LLL) around immediate dental implant. In addition osteoprotegrin (OPG) level can be used as a good bone formation biomarker not only to evaluate the treatment outcomes but also the disease progression

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جامعة الأزهر أسيوط
مصر

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مجلة أسيوط لطب الأسنان

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الملخص العربي: تقييم فاعلية تكوين العظام باستخدام الليزر منخفض الطاقة علي غرسات الاسنان الفورية

محمد فؤاد ادريس1 , محمد محجوب العشماوى2 ,حسام نادى ابو الدهب1*

1. قسم طب الفم وأمراض اللثة، والتشخيص والأشعة، كلية طب الأسنان، جامعة الازهر، أسيوط، مصر
2. قسم جراحه الفم والوجه والفكين ، كلية طب الأسنان، جامعة الازهر، أسيوط، مصر

* البريد الإلكتروني HOSSAMABOALDAHAB.96@AZHAR.EDU.EG:

الملخص:

الهدف: الغرض من الدراسة: اجريت هذه الدراسة لتقييم فاعلية تكوين العظام باستخدام الليزر منخفض الطاقة علي غرسات الاسنان الفورية عن طريق استخدام الفحص الاكلينيكي والاشعة وعينات من سائل الجيوب اللثوية لتعيين نسبة الاوستروبروجترين.

المواد والأساليب: تم عمل الدراسة علي عشرين مريض من الجنسين تتراوح اعمارهم مابين 18-40 سنة لدي كلا منهم سنة ميؤس منها في الفك العلوى نتيجة (فشل فى علاج الجذور , اسنان ذات جذور مكسورة,وجود تاكل داخلي او خارجي في الجذور او بواقي اسنان لبنية) تم تقسيمهم عشوائيا الي مجموعتين. المجموعة الاولي: تحتوي علي 10 مرضى استقبلوا غرسات فورية فقط.المجموعة الثانية :تحتوي عل 10 مرضي استقبلوا غرسات فورية مع استخدام الليزر منخفض الطاقة . حيث تم تعريض الانسجة المحيطة بالغرسة الفورية لجلسات من جهاز الليزر منخفض الطاقة تمت في يوم الزراعة وتوالت كل ثمانية واربعين ساعة على التوالي لمدة اسبوعين ومدة هذه الجلسات استغرقت دقيقتين. وقد تم اخذ القياسات الاكلينيكية وبالاشعة وعينات من سائل الجيوب اللثوية حول الغرسات للتقييم ثم تتابع التقييم خلال فترات متابعة الدراسة.

النتائج: مؤشر نزيف اللثة المعدل: اظهرت نتائج هذه الدراسة وجود فروق احصائية بعد ثلاثة اشهر بين المجموعتين قياس الجيوب اللثوية حول الغرسات: اظهرت نتائج هذه الدراسة وجود فروق احصائية بعد ثلاثة وستة أشهر بين المجموعتين. مستوي العظام علي الجانبين: اظهرت نتائج هذه الدراسة وجود فروق احصائية بعد ثلاثة وستة اشهربين المجموعتين. مستوي الأوستروبروجترين: اظهرت نتائج هذه الدراسة وجود فروق احصائية عند فترات الاسبوعين والشهر بين المجموعتين.

الخلاصه: ابدى استخدام الليزر منخفض الطاقة تاثيرا فاعلا كعلاجا مساعدا في تحسين عمق الجيوب اللثوية ومستوى العظم الحافي ومعدل الاستيوبروجترين حول غرسات الاسنان الفورية.

الكلمات المفتاحية: ليزر منخفض الشده، التعظم , البانوراما، غرسه الاسنان الفوريه، مستوى نأكل العظم الحافى.