

Comparison Between the Effect of (650 nm) and (810 nm) Diode Laser Photobiomodulation as an Adjunctive Therapy for Alveolar Socket Preservation: A Clinical and Radiographic Study.

Mohamad Anwar Abd-Elhaleem Othman,^{1*} Ahmed Abbas Zaky,² Nesma Mohamed Khalil,³ Elsayed Abdullah Eltayeb.⁴

1. PhD candidate at National Institute of Laser Enhanced Sciences, Cairo University Egypt.
2. Professor and Head of Medical Applications of Lasers Department, National Institute of Laser Enhanced Sciences, Cairo University Egypt.
3. Assistant Professor of Oral Biology, Faculty of Dentistry, Alexandria University, Egypt.
4. Lecturer of Medical Applications of Laser, National Institute of Laser Enhanced Sciences, Cairo University Egypt.

Email: m.anwar39@gmail.com

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Abstract

Socket preservation aided by laser photobiomodulation is proven to show superior results in comparison to control or placebo standard alveolar socket preservation. **Objective of this study** Compare between two different lasers as a supportive therapy in alveolar socket preservation procedure. **Methodology** Twenty extraction sockets were randomly allocated into two equal groups of ten sockets, first group was treated with Diode 650 nm, while the other was treated with Diode 810 nm using the same power and time parameters and following the exact protocol of sessions after standard alveolar socket preservation procedure using collagen plugs. Clinical assessment of socket healing took place by visual scoring during first 15 days' post extraction, while radiographic analysis by Cone Beam Computed Tomography was used to compare between immediately post extraction and 3 months' post-operative scans. **Results** The red laser yielded a higher statistically significant outcome on soft tissue healing. Concerning hard tissue: no significant difference was detected between both test groups. **Conclusion** Under applied conditions and laser parameters; the 650 nm Diode seems to have better effects on soft tissue healing than the 810 nm. However, regarding bone parameters (socket dimensions & bone density), both showed comparable outcomes when used as an adjunctive therapy in alveolar socket preservation procedure.

Keywords: Low Level Laser, Photobiomodulation, Extraction Socket Healing, Alveolar Ridge Preservation.

INTRODUCTION

Despite recent advances in restorative dentistry, tooth extraction still accounts for a considerable share of daily dental practice around the world.⁽¹⁻³⁾ Regardless of being avoidable, dental caries and periodontal disease remain the most common reasons for tooth extraction, especially in developing nations, then there is severe trauma that represents the third reason.⁽⁴⁻⁶⁾ The use of dental implants has been widely implemented in successful rehabilitation of completely, or partially edentulous patients.⁽⁷⁻¹⁰⁾

Unfortunately, post extraction, it's inevitable that the alveolar ridge at the edentulous site undergoes a physiological bone loss process resulting in a bucco-lingual as well as apico-coronal reduction. Most of the alveolar bone resorption occurs during the first 3 to 6 months after tooth extraction.⁽¹¹⁻¹⁴⁾ Socket preservation is becoming the standard of care for patients willing to restore teeth planned for extraction.⁽¹⁵⁾ Lasers are classified into high and low power. The former is generally applied for the removal, cutting and coagulating of tissues, while the low-power ones "cold lasers" are more commonly employed in the processes of tissue repair, such as muscle, joint, nerve, bone and skin injuries.⁽¹⁶⁻¹⁸⁾ The effects of low-level laser therapy, or photobiomodulation (PBM), could be detected in the attitude of increased lymphocytic proliferation and activation, on macrophages, elevated phagocytosis; and on fibroblasts, increasing the

secretion of growth factors and enhancing the uptake of both fibrin as well as collagen. Moreover, it helps increase the motility of epithelial cells, the amount of granulation tissue and may lower inflammatory mediators' synthesis.^(19,20)

The influence of photobiomodulation on bone repair in animals has been extensively examined. Animal studies have shown that PBM therapy enhances proliferation, collagen synthesis and the production of the mineralized matrix by osteoblastic cells. Therefore, animal studies have indicated that PBM therapy increases the amount and speed of new bone formation as well it improves the epithelial cell proliferation while stimulating angiogenesis.⁽²¹⁻²³⁾ The role of PBM therapy as an adjunctive therapy for alveolar socket preservation has become undeniable, however, the optimal parameters are controversial. There is no agreement on the literature regarding the optimal wavelength, dose, frequency, and light intensity parameters to minimize bone loss post tooth extraction.⁽²⁴⁻²⁶⁾

In almost all reviewed literature, laser photobiomodulation rendered the most successful outcomes related to alveolar socket healing when compared to control or placebo treatments.⁽²⁶⁻³⁵⁾ Therefore, we thought that it would be innovative to compare two lasers against each other in one study in order to determine the best tool for photobiomodulation of extraction sockets.

MATERIALS AND METHODS

Twenty patients with twenty mandibular posterior tooth indicated for extraction (*Figure 1*) were enrolled from a private dental practice located in Alexandria, Egypt. Patients were all non-smoker males at the age group of 35 - 50, free of metabolic diseases and free of active infection at the extraction site, rendering them fit for dental implant rehabilitation.



Figure (1) Hopeless mandibular first molar indicated for extraction

Sample Size Calculation

The minimal sample size is calculated based on a previous study aimed to evaluate the effects of Photobiomodulation (PBM) therapy on alveolar bone repair.⁽²⁷⁾ The sample size was calculated to detect the difference in Landry, Turnbull & Howley healing index for soft tissue healing. Adopting a power of 80% ($\beta=0.20$) to detect a standardized effect size in Landry, Turnbull & Howley healing index of 1.524, and level of significance 5% (α error accepted =0.05), the minimum required sample size was found to be 8 patients per group (number of groups=2) (Total sample size=16 patients).^(36,37) After adjustment for a dropout rate of 10%, the sample size was increased to 10 patients per group (number of groups=2) (Total sample size=20 patients).⁽³⁸⁾

Software

The sample size was calculated using GPower version 3.1.9.2.⁽³⁹⁾

Following anesthesia administration (Articaine 4% 1:200,000, Laboratorios Inibsa, Spain) atraumatic extraction (*Figure 2*) was performed, then, standard alveolar socket preservation procedure⁽³⁹⁾ was completed using the following protocol; first, socket walls curettage, then, pure saline irrigation, followed by application of collagen plug (Collacone, Botiss Biomaterials GmbH, Germany) that fits into the socket and secured in place using a cross suture (Silk Braided 3/0, Non Absorbable, Surgical Suture, China). (*Figure 3 & 4*)

From this point, patients were randomly split into two equal groups, each group were subjected to photobiomodulation therapy using a different laser wavelength.

Group (A): 10 sockets received photobiomodulation therapy with 650 nm laser. (*Figure 5*)

Group (B): 10 sockets received photobiomodulation therapy with 810 nm laser. (*Figure 6*)

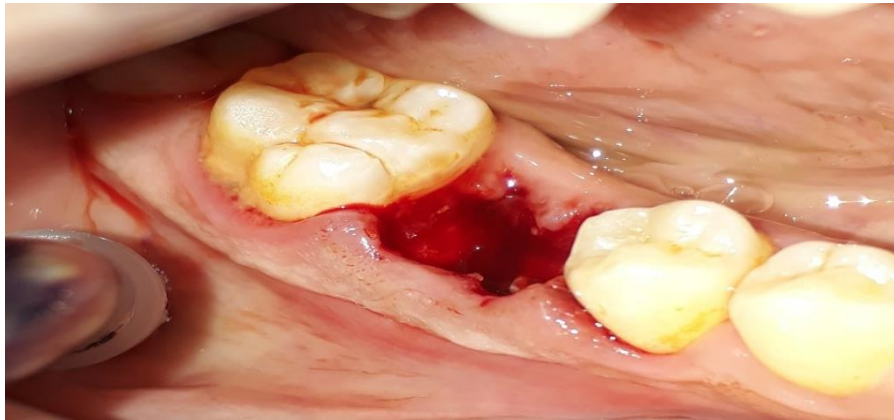


Figure (2) Atraumatic molar extraction



Figure (3) Collacone, Botiss, Germany



Figure (4) Colllacone plug fixed in place



Figure (5) Red (650 nm) Diode PBMT



Figure (6) Infrared (810 nm) Diode PBMT

Method of Randomization

The allocation sequence was generated using permuted block randomization technique and the block size was variable.⁽⁴⁰⁾ Allocation sequence/code was concealed from the person allocating the participants to the intervention arms using sealed opaque envelopes.⁽⁴¹⁾

Blinding

Double “full” blinded approach was adopted. Masking/blinding was employed to participants, and outcome assessors who were blinded to group allocation of patients.⁽⁴²⁾

Methods of sampling: Convenience sampling.

Diode laser device used was fabricated at the Department of Laser Engineering, Higher Institute of Laser Enhanced Sciences, Cairo University, Egypt.

Laser device included both selected wavelengths; 650 nm & 810 nm, fiber optic diameter of 6 mm was emitting continuous wave beam with power at 100 mW.

Photobiomodulation protocol included 3 surface touch mode irradiation; buccal, occlusal and lingual which lasted for one minute for each surface. Such therapy was carried out for 6 sessions; immediately post extraction and after 1, 3, 5, 7 and 15 days.^(27,28)

Laser irradiation parameters are detailed in table (1).

Table (1) Photobiomodulation Parameters

Parameter	Value
Wavelength	Group (A): 650 nm Group (B): 810 nm
Power	100 mW
Mode	Continuous
Spot Area	0.28 cm ²
Power Density	0.35 W/cm ²
Irradiation Time	180 s (60 seconds x 3 spots)
Energy Density	63 J/cm ²

Evaluation Procedures

1. Clinical Assessment for Soft Tissue Healing

The extraction sockets were evaluated for soft tissue healing on two points; 7th & 15th postoperative days based on Landry, Turnbull & Howley healing index,⁽⁴³⁾ which is detailed in table (2).

Table (2) Landry, Turnbull & Howley healing index

	Color	Palpation Response	Granulation Tissue	Suppuration
Class I	> 50% Red	Bleeding	Present	Present
Class II	>50% Red	Bleeding	Present	Absent
Class III	<50% Red	No Bleeding	Absent	Absent
Class IV	<25% Red	No Bleeding	Absent	Absent
Class V	Pink	No Bleeding	Absent	Absent

2. Radiographic Evaluation:

For each patient, a Cone Beam Computed Tomography was scanned twice; first, immediately post-operative and finally, 3 months post operatively (upon which, implant planning took place). Socket sites were compared on the radiograph in two ways; alveolar socket dimensions and bone density.

CBCT scans were carried out at the same maxillofacial scanning center using the same scanning device (Scanora, 3Dx, Soredex, Finland) for all patients at both stages.

Statistical methodology

Data were collected and entered to the computer using Statistical Package for Social Science (SPSS) program for statistical analysis (ver 25).⁽⁴⁴⁾

Kolmogorov-Smirnov test of normality revealed significance in the distribution of most of the variables, so the non-parametric statistics was adopted.⁽⁴⁵⁾

Data were described using minimum, maximum, median, 95% CI of the median, 25th to 75th percentile.

Comparisons were carried out using Mann-Whitney U test,⁽⁴⁶⁾ and Wilcoxon Signed Ranks test.⁽⁴⁷⁾

Comparisons were carried out between more than two studied independent not-normally distributed subgroups using Kruskal-Wallis test.⁽⁴⁸⁾

Percentage change was calculated as follows:

$$\text{Percentage change (\%)} = \frac{\text{Measurement (after)} - \text{Measurement (before)}}{\text{Measurement (before)}} \times 100$$

During sample size calculation, beta error accepted up to 20% with a power of study of 80%. An alpha level was set to 5% with a significance level of 95%. Statistical significance was tested at p value <.05.⁽⁴⁹⁾

RESULTS

Clinical Outcome

Visual assessment of extraction sockets soft tissue healing on 7th as well 15th day post extraction yielded two scores for each socket scaled from 1 to 5 according to Landry, Turnbull, Howley healing index.

On comparing median score of both groups at day 7, no statistically significant difference was found (p=.075). Meanwhile, both lasers were able to elicit a statistically significant score increase (p=.04 & .05 respectively) from day 7 to day 15. *Table (3)*

Excitingly, the red (650 nm) Diode was able to show a significantly higher improvement percentage change (p=.045) when related to the infrared (810 nm) Diode. *Table (3)*

Table (3) Landry, Turnbull, Howley healing index at postoperative Day 7 and Day 15 in both studied groups

Healing Index	Wave length group		Test of significance <i>p</i> value
	650 nm Group (n=10)	810 nm Group (n=10)	
Day 7 postoperatively - Min. – Max. - Median - 95% CI of the Median	2.00-3.00 2.00	2.00-3.00 3.00 3.00-3.00	$Z_{(MW)}=1.780$ $p=.075$ NS
Day 15 postoperatively - Min. – Max. - Median - 95% CI of the Median	3.00-4.00 4.00 4.00-4.00	3.00-4.00 4.00 4.00-4.00	$Z_{(MW)}=0.503$ $p=.615$ NS
Test of significance <i>p</i> value	$Z_{(WSR)}=2.889$ $p=.004^*$	$Z_{(WSR)}=2.810$ $p=.005^*$	
Healing Index (percentage change) (%) - Min. – Max. - Median - 95% CI of the Median	33.33-100.00 100.00 100.00-100.00	0.00-100.00 33.33 33.33-100.00	$Z_{(MW)}=2.006$ $p=.045^*$

n : Number of patients

CI: Confidence interval

WSR : Wilcoxon Signed Ranks Test

NS: Statistically not significant ($p \geq .05$)

Min-Max: Minimum – Maximum

MW: Mann-Whitney U test

*: Statistically significant ($p < .05$)

Radiographic Findings

OnDemand 3D software's fusion module (Cybermed, South Korea) was utilized as a visualization tool for superimposing pre and post-operative sets of DICOM data, on the way to accurately compare scans.

Socket Dimensions

Sockets were measured in terms of width, height, on the same cross section representing the center of edentulous space or the location of future implant, maximum ridge width was measured, in addition to the height of such width. *Figure (7,8)*

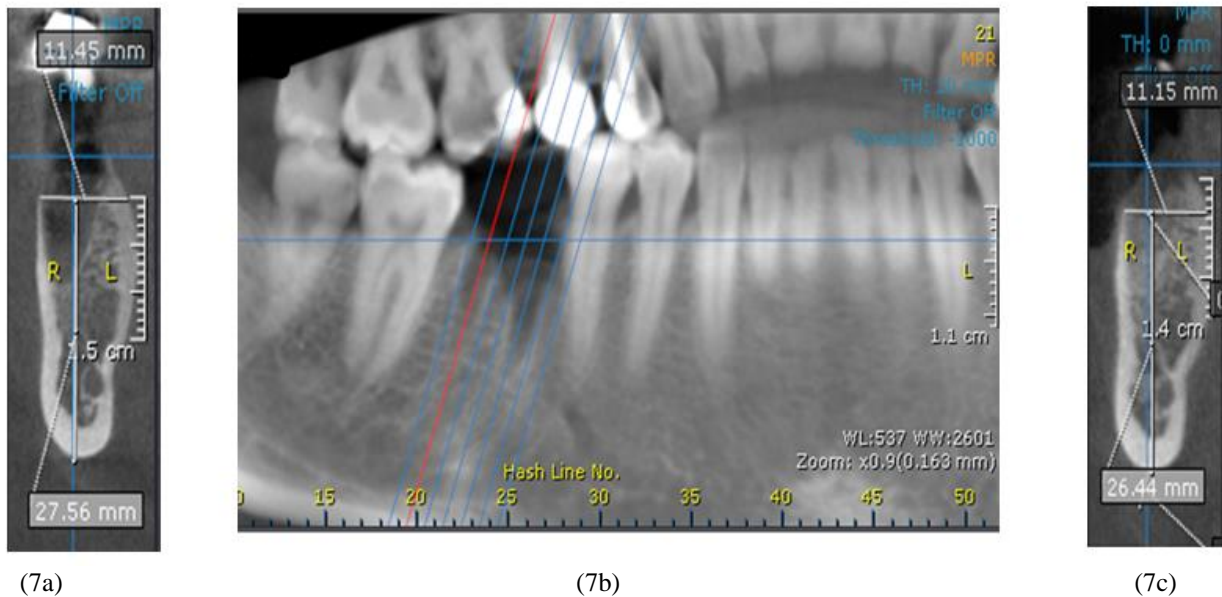


Figure (7): (a) Immediately post extraction socket dimensions' measurements. (b): Determination of exact cross section for accurate measurement. (c): 3 Months' post extraction socket dimensions' measurements



Figure (8) Alveolar ridge bone density analysis, OnDemand, Cybermed, South Korea.

Both groups presented comparable width and height measures immediately post extraction (width $p=.326$ & height $p=.940$). *Table (4)*

Regarding width, the 650 nm Diode showed a statistically insignificant decrease ($p=.074$) in width measures from immediate to 3 months' post extraction.

On the other hand, the 810 nm Diode has shown a statistically significant decrease ($p=.05$) in such parameter. *Table (4A)*

However, head to head comparison between percentage change across both groups has resulted in a non-statistically significant difference. *Table (4A)*

Table (4-A) Socket width immediately and 3 months postoperatively in both studied groups

Socket Width (mm)	Wave length group		Test of significance <i>p value</i>
	650 nm Group (n=10)	810 nm Group (n=10)	
Immediately postoperative			
- Min. – Max.	8.40-11.30	8.41-12.62	$Z_{(MW)}=0.983$ $p=.326$ NS
- Median	9.56	10.55	
- 95% CI of the Median	9.09-10.26	8.96-11.98	
Three months postoperatively			
- Min. – Max.	6.00-10.85	7.71-11.90	$Z_{(MW)}=0.378$ $p=.705$ NS
- Median	9.36	9.20	
- 95% CI of the Median	8.50-10.12	8.23-10.88	
Test of significance <i>p value</i>	$Z_{(WSR)}=1.784$ $p=.074$ NS	$Z_{(WSR)}=2.803$ $p=.005$ *	
Socket width (percentage change) (%)			
- Min. – Max.	-35.11 – 11.74	-21.28 - -2.17	$Z_{(MW)}=0.605$ $p=.545$ NS
- Median	-4.06	-5.88	
- 95% CI of the Median	-10.44 - -0.93	-8.32 - -3.23	

n : Number of patients
 CI: Confidence interval
 WSR : Wilcoxon Signed Ranks Test
 NS: Statistically not significant ($p \geq .05$)

Min-Max: Minimum – Maximum
 MW: Mann-Whitney U test
 *: Statistically significant ($p < .05$)

On the subject of height, association between two scans revealed a statistically significant height decrease in both groups ($p=.005$). *Table (4B)*

one more time, red vs infrared laser percentage change face to face comparison has shown a statistically insignificant difference. *Table (4B)*

Table (4-B) Socket height immediately and 3 months postoperatively in both studied groups

Socket Height (mm)	Wave length group		650 nm Group
	650 nm Group (n=10)	810 nm Group (n=10)	
Immediately postoperative			
- Min. – Max.	25.13-28.69	23.16-32.02	$Z_{(MW)}=0.076$ $p=.940$ NS
- Median	27.03	26.60	
- 95% CI of the Median	25.90-28.48	25.05-29.34	
Three months postoperatively			
- Min. – Max.	22.86-28.05	22.92-28.37	$Z_{(MW)}=0.227$ $p=.821$ NS
- Median	25.45	25.94	
- 95% CI of the Median	24.53-26.86	24.11-27.68	
Test of significance <i>p value</i>	$Z_{(WSR)}=2.803$ $p=.005^*$	$Z_{(WSR)}=2.803$ $p=.005^*$	
Socket width (percentage change) (%)			
- Min. – Max.	-13.99 – -0.12	-12.43 - -0.33	$Z_{(MW)}=0.454$ $p=.650$ NS
- Median	-5.62	-2.06	
- 95% CI of the Median	-8.45 - -1.48	-10.40 - -1.36	

n : Number of patients

CI: Confidence interval

WSR : Wilcoxon Signed Ranks Test

NS: Statistically not significant ($p \geq .05$)

Min-Max: Minimum – Maximum

MW: Mann-Whitney U test

*: Statistically significant ($p < .05$)

Density

Examination of bone density values extracted from CBCT scans has displayed a statistically significant ($p=.009$ & $.013$ respectively) rise in density in both groups. *Table (5)*

Table (5) Density immediately and 3 months postoperatively in both studied groups

Density (W)	Wave length group		Test of significance <i>p value</i>
	650 nm Group (n=10)	810 nm Group (n=10)	
Immediately postoperative			
- Min. – Max.	-263.00 – 240.20	-197.57 – 227.27	$Z_{(MW)}=0.227$ $p=.821$ NS
- Median	112.00	32.03	
- 95% CI of the Median	-124.35 – 138.45	-100.85 – 137.23	
Three months postoperatively			
- Min. – Max.	85.55-457.90	-40.53 – 257.57	$Z_{(MW)}=1.058$ $p=.290$ NS
- Median	186.85	183.82	
- 95% CI of the Median	139.00-295.25	38.00-218.20	
Test of significance <i>p value</i>	$Z_{(WSR)}=2.599$ $p=.009^*$	$Z_{(WSR)}=2.497$ $p=.013^*$	
Density (percentage change) (%)			
- Min. – Max.	-179.56 – 244.03	-3288.40 – 3807.77	$Z_{(MW)}=0.151$ $p=.880$ NS
- Median	33.50	-7.20	
- 95% CI of the Median	-167.03 – 169.66	-106.49 – 87.69	

n : Number of patients

CI: Confidence interval

WSR : Wilcoxon Signed Ranks Test

NS: Statistically not significant ($p \geq .05$)

Min-Max: Minimum – Maximum

MW: Mann-Whitney U test

*: Statistically significant ($p < .05$)

Finally, a comparison was drawn between the percentage increase in density values of red Diode group and infrared Diode group, which, again, showed a non-significant difference ($p=.880$) between both groups. *Table (5)*

DISCUSSION

Optimum alveolar socket healing post extraction is the ultimate goal of dental surgeons as well as prosthodontists. From a surgeon's perspective, the better the healing the lesser possibilities of post-operative complications. On the other side, prosthodontists aspire faster and, of course, good healing in order to proceed with the rehabilitation procedures.^(10,50)

Laser Photobiomodulation – aided alveolar socket preservation is a proven technique that recently has gained momentum over the natural uninterrupted process of healing.⁽⁵¹⁾

However, what draws our attention, the lack of solid accordance between previous studies about laser parameters that should be used.⁽⁵²⁻⁵⁵⁾

This work was intended to help clear the controversy in this regard. Two different lasers; visible (red) 650 nm Diode & invisible (near infrared) 810 nm Diode, were used against each other under unified parameters in the same study, each laser for a separate test group, to decide the optimal wavelength for alveolar socket photobiomodulation.

The use of collagen-based plugs in this study has been supposed as an economic and simple substrate for socket preservation to maintain the ridge dimensions after tooth extractions. As opposed to other grafting material, the collagen sponge is highly biocompatible and fully resorb even if the cross-linked collagen has a relatively slower resorption rate.⁽⁵⁶⁾

About laser wavelengths determined, our intention was to use different laser families, which means visible vs invisible lasers, this way, each laser would give a representable image about possible outcome of utilizing its group. The 650 nm Diode is not well represented in the field of PBMT in humans. Regarding the other group, the 810 nm Diode has been extensively researched as a proven PBMT source, so, we thought it should take place in our clinical trial.

In the current work the 6 mm fiber optic diameter was previously planned to perfectly adapt to the posterior extraction socket from either the occlusal, buccal or lingual surfaces, narrower diameters used in previous studies mandated multiple points applications for buccal and lingual surfaces which complicates tip positioning. On the other hand, wider tip may interfere with neighboring teeth during occlusal surface irradiation.^(27,28)

Head to head with smaller diameter spot size, larger optical spots have shown a better clinical outcome for superficial and sub-surface treatment. That is because its ability to compensate for tissue attenuation at depth following energy scatter and the resultant photon diffusion.⁽⁵⁵⁾

On the subject of energy density, time of irradiation was adjusted in relation to power and spot area (63 J/cm²) to approximate the least effective value found in the literature, which was 50 J/cm².⁽³¹⁾ Furthermore, seeking higher energy density would mandate longer irradiation time which may cause patient discomfort due to longer mouth opening for operating posterior mandible area.

We preferred to start photobiomodulation sessions immediately after the dental extraction, such protocol was backed by the fact that PBM therapy alone or as associated therapy has significant effects on the early stages of the tissue repair and deemed more effective than any particular period. In the same context, since it was well documented that multiple irradiations at regular intervals are superior than one dose,⁽⁵⁷⁻⁶⁰⁾ our scheduling pattern of sessions was intended to be rather convenient to the patients. It was not that complicated to the patients to show up the day next to the extraction then every other day for a week, and finally, a week after that, for the sum of 6 sessions during the two weeks following extraction.

Soft tissue healing is closely related to the underlying bone healing. In addition, it represents an integral part of the overall healing process. Such fact could not be neglected during evaluation procedures.⁽⁶¹⁾

The period of 3 months determined in this study was deemed appropriate for a couple of reasons; first, to give a representable image about the socket healing process, plus, to permit ideal implant planning and placement.⁽⁶²⁾

Bone density measurements are basically carried out using Dual energy x ray absorptiometry (DXA) scans and medical computed topographies (CT).⁽⁶³⁻⁶⁵⁾ Cone beam computed tomography (CBCT) represents an economic and convenient pre dental implant assessment tool. Current CBCT scans are able to show suggested bone density values that are based on the degree of grayscale (Voxel Value) that was approved to be correlated with actual bone density values measured in Hounsfield units (HU). Moreover, such values were proven to be directly proportionate to implant primary stability which, in turn, hugely reinforce dental implant success.^(66,67)

In our study, both lasers have considerably affected soft tissue healing in a positive way, such statement was evidenced due to the statistically significant increase in the soft tissue healing index between 7th and 15th days observation scores. A fair number of sockets treated in this work has shown some sort of challenge for the typical physiological healing process due to the extensive breakdown of extracted tooth structure, or the presence of chronic infection, such

circumstances mandated some advanced surgical techniques during as well as after extraction such as; roots separation, elevator luxation, minimal buccal troughing and deep socket curettage. Therefore, for most sockets to reach the healthy end of the healing index at 15 days' mark was considered an encouraging sign, even for the patients themselves.

Only a single reviewed research has investigated soft tissue healing with photobiomodulation, that was in 2012 when Paschoal and Santos-Pinto used 830 nm Diode laser with energy density of 60 J/cm² for biostimulation of premolar extraction sockets but noticed no significant difference between lased and non lased groups.⁽³²⁾

Although the mentioned work applied nearly the same laser parameters of group B in our study (810 nm wavelength and 63 J/cm² energy density), however, number of sessions was half what we applied in our study (3 versus 6), in addition, their narrower spot size seemed to play a role in delivering lesser energy to deeper tissues compared to our fiber optic 0.28 cm² spot area, moreover, the 1 cm distance between laser source and tissue was definitely an energy decreasing factor in contrast to our technique where fiber optic was directly touching the tissue.

Finally, it's of prime importance that their sample was inclusive for premolars extracted as a strategic part of orthodontic planning, which, mostly, are sound teeth that most probably needed simple, straight forward, extraction procedure, and in turn, favorable healing nonetheless. All of these mentioned factors seem to favor our outcome owing to better energy diffusion, plus, more challenging clinical situations.

On comparing improvement across both groups of our study, we detected a statistical significance leaning towards the red (650 nm) Diode, which hints to the potential advantage of this wavelength when it comes to soft tissue healing.

Our CBCT findings look interesting, once again, a possible advantage in favor of the 650 nm (red) Diode was detected while comparing immediately and 3 months' post extraction scans, where it showed a statistically insignificant decrease in width measures, denoting the probable ability of this laser to preserve alveolar ridge width.

Regarding the rest of dimensional measures, even though the 810 nm Diode presented a significant width decrease, furthermore, both study groups showed a statistically significant decrease in alveolar ridge height on comparing 1st and 2nd radiographs, yet, some apparent facts stand out, first, none of the treated sockets presented a problem during implant planning without further augmentation needed. Second, minor dimensional collapse was expected putting in mind the simplicity of the technique with the application of collagen plug and not using bone grafting materials. Lastly and remarkably, in a similar study, when oral surgery researchers approved this socket preservation technique using just collagen plug (without PBMT), using the same radiographic technique (CBCT) their mean dimensional loss (width 1.3 mm & height 2.4 mm) was higher than that detected in both groups of our study (width 0.9 – 0.92 mm & height 1.38 – 1.54 mm) after the exact period of healing (3 months). Such difference could point to the biostimulatory effect of PBMT.⁽⁵⁶⁾

Revised literature showed couple of studies with nearly same parameters (wavelength 808 nm & energy density 89, 75 J/cm²) as our study group B, that noticed advantageous new bone formation with PBMT over control (non PBMT) group, however, they used micro Computed Tomography as an investigation tool, which resembles our findings but with a different radiographic technique.^(27,28)

Once again, comparing rate of improvement between both study groups in our work has shown a statistically insignificant difference suggesting the comparable effectiveness of both laser wavelengths in the field of socket preservation.

The second most important factor in dental implant planning, after alveolar ridge dimensions, has to be bone density.⁽⁶⁸⁾

Our results showed a statistically significant difference between immediately and 3 months' postoperative bone density values in both groups.

One more time, an exciting possible positive outcome regarding PBMT could be concluded when comparing this result with the work done by Schnutenhaus et al, who used approximately the same surgical protocol for socket preservation (without PBMT) and noticed no statistical significance between bone density values of 1st and 2nd CBCT scans, however, it should be mentioned that their second scan was 2 months post operatively.⁽⁶²⁾

Previously, Kucerová and coworkers investigated bone density changes with PBMT (using 650 nm Diode) 6 months post operatively using digital radiovisiography and concluded that low level laser therapy has no effect on bone density, which was not the case with group A in our study. This dissimilarity in radiographic result might be owed to the significantly lower energy density dosage used in their protocol (1.5 J/cm² vs 63 J/cm²), plus the number and the spread of therapy sessions pattern (4 consecutive days' post extraction vs 6 days spread on 14 days). On the other hand, CBCT analysis used in our study is more comprehensive than RVG histogram they used because it is a 3 dimensional measurement tool unlike the latter, which only analyzes 2 dimensional images.⁽⁶⁹⁾

Back to the micro CT evaluated work, Rosero et al and Romao et al have demonstrated better bone quality using 808 nm Diode after 45 days. Such finding comes with agreement with the results shown in group B of this research.^(27,28)

Finally, relating the mean increase in density of both of our test groups has yielded no significance difference, which puts the final piece of puzzle in place for our conclusion, that, under used parameters and protocol, photobiomodulation with 650 nm Diode could be as effective as the heavily researched 810 nm diode when used as an adjunctive therapy in socket preservation procedure.

CONCLUSION

Under the conditions of this study, laser photobiomodulation using the 650 nm (red) Diode could yield comparable results to the 810 nm (near infrared) Diode in regard to bone characteristics like socket dimensions and density measured by Cone Beam Computed Tomography, and even more interesting than that, the 650 nm red Diode has potentially surpassed its near infrared counterpart (810 nm Diode) in regard to soft tissue healing of extraction sockets, such claim needs more investigations with larger size samples to validate.

Ethical Approval

This is to certify that this research article was approved by the research ethical committee (REC) at its meeting held on 3-1-2023. Approval references: NILES-EC-CU 23\1\3

Conflict of Interest

As far as the authors are aware, there are no commercial or associative interests that may be construed as a conflict of interest in relation to the work

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