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ORIGINAL RESEARCH

LASER-ASSISTED SOCKET PRESERVATION WITH COLLACONE

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Abstract

Background: Socket preservation is a method for minimising soft and hard tissue loss after tooth extraction. Photobiomodulation therapy (PBMT) can stimulate changes that occur as part of the normal socket healing process. This can preserve socket dimensions and promote ideal outcomes when dental prostheses are subsequently implanted with radiographic assistance.

Objectives: To evaluate the use of diode laser PBMT to accelerate bone healing in extraction sockets treated with collateral prior to dental implant placement using radiography and cone beam computed tomography.

Materials and Methods: We recruited 20 patients with 40 sockets. Twenty sockets were each assigned to the control group and the test group. The control group sockets were treated with collacone only, while the test group extraction sockets underwent PBMT plus collacone application. The split-mouth technique was employed, with the maxillary and mandibular anterior teeth split from the maxillary and mandibular premolar teeth.

Results: All extraction sockets demonstrated good healing with no complications. Ridge height and width reductions were lower in the test group than in the control group. Additionally, the test group exhibited higher bone density values than the control group.

Conclusion: PBMT via diode laser can be safely implemented following tooth extraction. Under clinical conditions, this simple technique can be used as a single-step procedure to preserve sockets successfully.

Keywords: Alveolar bone loss, bone resorption, collagen, socket preservation, enhanced healing process, Low-Level Light therapy.

INTRODUCTION

After tooth extraction, many changes occur in the hard and soft tissues in accordance with the physiological process of socket healing, which involves vertical and horizontal bone loss [1]. Alveolar ridge preservation is a method for reducing or arresting dimensional changes after tooth extraction to optimise subsequent prosthesis implantation – particularly dental implants [2]. The aim of preventing the loss of the alveolar ridge is to preserve enough bone to facilitate the placement of dental implants in the optimum position; bone augmentation is not required [3]. Photobiomodulation therapy (PBMT), also known as low-level laser therapy, is used to promote wound healing through the application of specific laser wavelengths [4]. Several changes occur in a cell irradiated by a laser of low energy, including metabolic, functional and physiological alterations [5]. PBMT can minimise inflammation by reducing inflammatory mediators, inhibiting prostaglandin and increasing plasminogen [5]. Additionally, it alters the cellular activity of osteoblasts and improves bone healing and regeneration [6]. PBMT may be considered an adjunctive therapy for preserving alveolar sockets [7].

Cone-beam computed tomography (CBCT) is considered the gold standard tool for accurately measuring socket dimensions [8]. CBCT helps estimate bone density by characterising cortical and trabecular bone architecture and biomechanics through the analysis of grey scale values [9]. Many studies have indicated that laser-treated samples exhibit greater bone density on radiographic evaluation than those in control groups. [10]. Bone density can be measured by transferring data in DICOM format to modified software, such as Blue-Sky Plan (MDI Europa Company, Germany), and measuring numerical values from different points as Hounsfield units; the mean of these points approximates the bone density in the selected area [11, 12].

Study Aim

This study examined the use of diode laser-based PBMT to accelerate bone healing in extraction sockets treated with collacone before dental prostheses were implanted with the help of radiography.

Materials and Methods

Design of Study

The split-mouth technique was implemented with a total of 20 patients (12 males and 8 females) aged 18–55 years. The Research Ethics Committee of the University of Anbar approved this study (on December 23, 2024, Reference No. 197). All patients signed consent forms. The study was conducted between November 2024 and June 2025.

Patient Selection and Treatment Protocol

Twenty patients with 40 total extraction sockets were divided into a control group and a test group with 20 sockets each. In the control group, a collagen plug was implemented after tooth extraction and sutured. In the test group, the extraction sockets were first treated with diode laser-based PBMT before a collagen plug was placed and sutured. The patients were selected according to the following criteria: being 18–55 years old; non-smokers; demonstrating acceptable oral hygiene; having no history of radiotherapy, chemotherapy or bisphosphonate use; possessing badly decayed, unrestorable bilateral lower and upper anterior teeth; and exhibiting no signs of (a) active infection at the extraction site or (b) active periodontal disease at the treatment segment.

Surgical Procedure

All surgical procedures were performed by the same operator under the supervision of the study supervisor. Local anaesthesia (2% lidocaine hydrochloride and 1.8-ml local anaesthetic carpools with 1:80,000 adrenaline) was applied on both the study and control sides, which were extracted at the same visit. Shortly after the tissues were anaesthetised, atraumatic tooth extractions were performed. An elevator and forceps were gently applied to minimise trauma to the surrounding bone and soft tissue. After the tooth was extracted, the buccal and lingual bone walls were carefully examined for fractures. Following extraction, the sockets were irrigated with saline to remove granulation. In the control group, following socket curettage and irrigation with pure saline, collacone was placed in the socket and then secured in place using a cross suture (Figure 1).

Figure 1. Collacone secured by cross sutures.

In the test group, following socket curettage and irrigation with normal saline, the socket was treated by laser from three points perpendicular to the occlusal, buccal (labial) and palatal (lingual) surfaces (Figure 2). In the latter group, the laser was placed 1 cm away from the operation site for 180 seconds (60 seconds for each surface). Laser therapy was administered using an 8-mm handpiece and a gallium–aluminium–arsenide (Ga–Al–As) diode laser device (Quicklase, UK). The Quicklase laser has a continuous dual wavelength of 810 nm and 980 nm at a power of 400 W (0.4 w). Both the patient and the operator had their eyes shielded with safety goggles. A cylindrical glass with a height of 10 mm (1 cm) was used to maintain a consistent distance between the laser fibre and the extraction socket. After finishing the laser treatment, we filled the socket with a collagen plug and secured it with a cross, as in the control group (Figure 1). The patient was then taken to the X-ray room, where CBCT was conducted immediately. The following instructions were given to each patient:

1. The small gauze placed after the procedure should be kept in place for 30 minutes.
2. Do not rinse the mouth for the first 24 h.
3. Avoid eating hot food and drinks on the first day. Depend on warm and soft food to avoid disturbing the clot.
4. Rinse the mouth every 24 h with warm salt water for 2 weeks and then switch to 0.12% chlorohexidine gluconate for the next 2 weeks.

5. Make a follow-up appointment for suture removal after 7 days.

The same analgesics and antibiotics were prescribed for all patients (500-mg mefenamic acid tablets as needed and 400-mg cefixime tablets). On the seventh day, when the patient returned to have their sutures removed, we assessed the socket site and scored it according to the healing index. The criteria for this index include suppuration, tissue colour, incision margin, bleeding on palpation and presence of granulation tissue. All patients were followed up after 3 months so CBCT could be reperformed.

CBCT Analysis

Radiographic CBCT was performed at two time points: immediately after the procedure to provide a baseline image and 3 months for comparison to the baseline (Figure 3). CBCT was used to evaluate variations in the width and height of the ridge and bone density 3 months postoperatively (Figure 4).

1. Measurement of ridge height and horizontal ridge width

We first measured buccal bone height (BBH), lingual bone height (LBH) and horizontal ridge width (HRW). The measurements were taken using the first image as a baseline and after 3 months using similar lines and points as reference. At the highest apex of the extraction socket, a reference point was set up. Next, two reference lines were established: a line that runs vertically through the middle of the socket from the apical reference point. A horizontal line perpendicular to the vertical line that is drawn from the socket's most apical point. The distance between the coronal edge of the socket and the apical reference point, parallel to the vertical reference line, was measured for height along the mid-lingual/palatal and mid-buccal/labial regions. At the coronal aspect of the alveolar crest, parallel to the horizontal reference line, the horizontal ridge width (HRW) was measured. By comparing measurements from two CBCT scans, the mean alveolar ridge resorption (in mm) was computed [13], as shown in Figure 4.

2. Measurement of bone density

Bone density (BD) was measured by choosing 5 points inside the socket and determining the voxel values at those points. Voxel values represent bone density in comparison with Hounsfield units on computer tomography scans, as shown in Figure 4. These points were located as follows:

a. Two points on the buccal and lingual surfaces of the sockets (coronally).
b. Two on the buccal and lingual surfaces of the sockets (middle of the socket).
c. One of the superior regions of the socket (bottom of the socket).

The average of these five voxel values was calculated as the mean bone density of the freshly produced bone in the extraction sockets. Figure 5, showed the periapical radiographs of dental implant insertion on both the test and the control sides after 3 months.

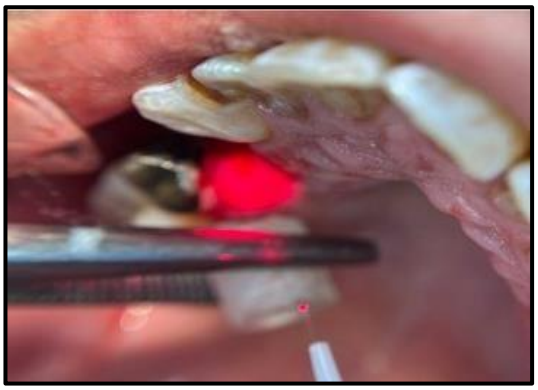

Figure 2. Laser treatment of the studied socket from three points perpendicular to the surface and keeping the distance of 1 cm by cylindrical glass, application of laser from the palatal surface.

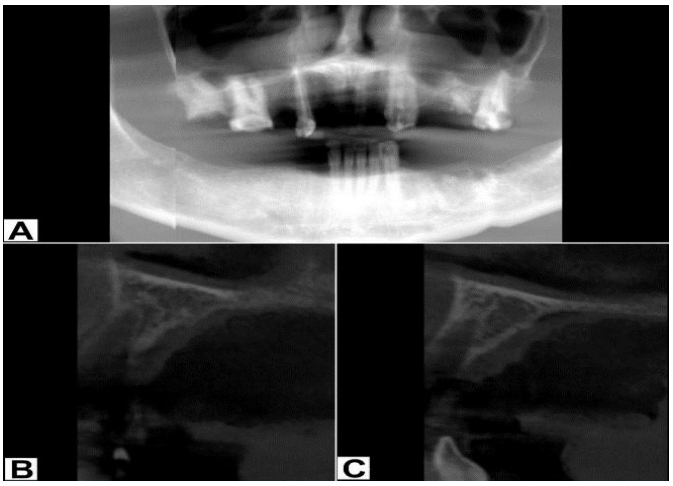

Figure 3. CBCT sections taken immediately after tooth extraction of left and right upper lateral incisors, A: A panoramic view, B: A cross-section view for the socket of the upper right lateral incisor, C: A cross-section view for the socket of the upper left lateral incisor.

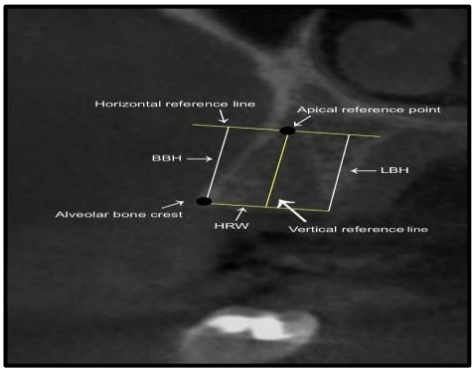

Figure 4. CBCT radiograph measurement of BBH: Buccal bone height, LBH: Lingual bone height, and HRW: Horizontal ridge width.

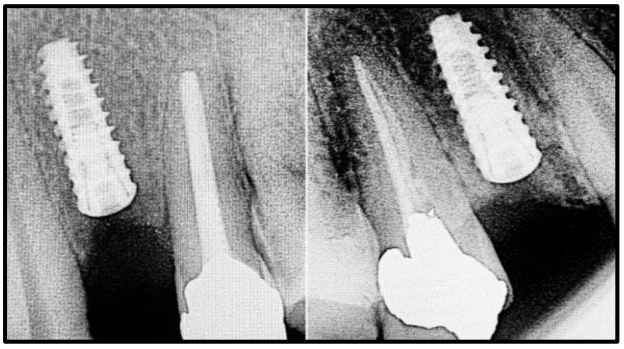

Figure 5. Periapical radiographs showing dental implants on both sides of A: the test and B: the control sides.

Statistical Analysis

Statistical analysis was performed using SPSS software (version 26; IBM crop, Armonk, USA). Data were expressed as means and standard deviations, while comparisons were made using paired and independent t-tests. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Of these patients, 15 had teeth extracted in the maxilla (75%), and 5 underwent extraction in the mandible (25%). In general, the mean values decreased in both the control and study groups after 3 months. The mean BBH loss (0.82 mm ± 0.09) in the study group was significantly less than that of the control group (1.1 mm ± 0.14; $p < 0.001$). Similarly, the study group's mean LBH loss (0.64 mm ± 0.06) was significantly less than that of the control group (0.85 mm ± 0.13; $p < 0.001$). The study group's mean HRW loss (0.44 mm ± 0.09) was significantly less than that of the control group (0.71 mm ± 0.16; $p < 0.001$). Correlations of age, gender and jaw type with radiographic measurements (BBH, LBH and HRW) were statistically insignificant within both groups ($p > 0.05$). Conversely, the mean BD value was higher in the study group than in the control group. The difference between the mean BD in the study group (370.06 ± 135.23) and the control group (304.98 ± 137.36) was statistically insignificant ($p = 0.139$), as shown in Tables 1 and 2. Differences by age and gender were statistically insignificant ($p > 0.05$), while differences in jaw type (maxilla vs mandible) within each group were statistically significant ($p < 0.05$).

Table 1. The rate of loss in BBH, LBH, and HRW after three months

Variable	Control group	Study group	p-value
	Mean ± SD (mm)	Mean ± SD (mm)	
BBH	1.1 ± 0.14	0.82 ± 0.09	< 0.001
LBH	0.85 ± 0.13	0.64 ± 0.06	< 0.001
HRW	0.71 ± 0.16	0.44 ± 0.09	< 0.001

*SD = Standard deviation, $p < 0.05$.

Table 2. The final measurements of bone density after three months for the control and study groups

Variable	Group	No. of cases	Mean ± SD (mm)	p-value
Bone density	Control	20	304.98 ± 137.36	0.139
	Study	20	370.06 ± 135.23	

*SD = Standard deviation, $p < 0.05$.

DISCUSSION

In this study, 15 patients (30 sockets) underwent extraction from the maxilla, and 5 (10 sockets) had teeth removed from the mandible. This reflects the general predominance of extraction sockets in the maxilla; anterior teeth in the maxilla are more frequently indicated for extraction for aesthetic and prosthodontic reasons. The reductions in BBH, LBH and HRW are related to normal alveolar bone resorption after tooth extraction. In this sense, the present study corroborates the results of [14], which highlighted the dimensional changes in sockets that occur after tooth extraction as the alveolar bone resorbs. BBH decreased more than LBH in this study, corroborating the findings of [15], which found that the alveolar bone resorbs more buccally than lingually. Buccal/labial bone resorbed more than lingual/palatal bone. This is because the buccal wall is thinner than the lingual wall [16]. Moreover, the lingual wall contains both bundle and lamellar bone, while the buccal wall contains only bundle bone [17,18]. The mean BBH loss in the study group was significantly lower than that in the control group. Furthermore, the decreases in LLH and HRW loss were significantly reduced in the study group. This is consistent with findings that PBMT accelerates healing [7, 19, 20].

Regarding gender, men exhibited more buccal bone loss after extraction for hormonal and anatomical reasons. The study is thus consistent with [21], which found greater height reductions in men. The losses in LBH and HRW were also greater in males, again corroborating [21], and this was also attributed to hormonal differences. In terms of age, the present study's data mirror the results of [22]: That study reported that older patients exhibit greater reductions in bone height, and there was an insignificant relation between age and bone height loss. In this study, jaw type did not correlate with ridge height. The higher reduction in mandibles can be explained by the decreased surface area, lower vascularisation and slower remodelling process compared to the maxilla. Although the mean BD value was higher in the study group than in the control group, the difference was statistically insignificant. Laser treatment to preserve the extraction socket was associated with increased BD in the

study group [23].

Our findings are consistent with recent studies that indicate an optimum of 980 nm for ablation, while 810 nm is ideal for coagulation [24]. A dual wavelength (980 nm +810 nm) was used to ensure standardisation because the potential laser parameters are wide-ranging. Using a dual wavelength improves ablation and coagulation and produces a decreased thermal effect [24]. Overall, our study corroborates past findings that low-power diode laser-based PBMT enhances and accelerates healing while promoting bone regeneration [25]. A laser of 980 nm can alter the cellular activity of osteoblasts and improve bone healing and regeneration [6]. A diode laser can remove inflamed tissue and facilitate biostimulation, enabling bone to regenerate and encouraging osteointegration [26].

Our findings corroborate [27], which noted a significant negative association between age and BD: As age increases, BD decreases. The present study is also consistent with the results of [22], which found an insignificant relationship between bone density and age. Bone diminishes in both quality and quantity with age. These changes occur in the cancellous compartment due to high oxidative stress with advancing age, which increases osteoclast activity within the bone trabeculae [28].

CONCLUSION

Photobiomodulation via diode laser can be safely implemented following tooth extraction. Under clinical conditions, it is a simple technique that can be used as a single-step procedure for successful socket preservation. PBMT is a straightforward and cost-effective method when compared with other approaches to socket preservation. However, a larger sample size should be used in future studies to strengthen the statistical results.

DECLARATIONS

Ethical approval: The Research Ethics Committee of the University of Anbar approved this study (on December 23, 2024, Reference No. 197).

Informed consent form: All patients signed consent forms.

Funding: No Funding.

Conflict of interest: The authors don't have any conflicts of interest.

Data availability statement: This paper (as well as its supplemental information files) contains all of the data generated or examined during this study. Upon reasonable request, the corresponding author will provide the generated data and analysis during the current study.

Author contributions: E.H.A. planned the study, and Y.W.M. evaluated the data from the patients. Y.W.M. wrote the Methodology section, did statistical analysis, and added to the literature review. E.H.A. revised the final draft, obtained ethical approval, and provided crucial feedback on the study's setup.

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