CASE REPORT

Photobiomodulation of surgical wound dehiscence in diabetic individuals by low level laser therapy following median sternotomy: A case series

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Abstract

In this single case study we attempt to outline the possible effect of low level laser therapy on delayed wound healing (LLLT) in chronic dehiscent sternotomy of a diabetic individual. The methods that were employed to evaluate changes pre and post irradiation were wound photography, wound area measurement, pressure ulcer scale of healing (PUSH) and visual analogue scale (VAS) for pain. After irradiation, proliferation of healthy granulation tissue was observed with decrease in scores of PUSH for sternal dehiscence and VAS for bilateral shoulders and sternal dehiscence. We found that LLLT irradiation could be a novel method of treatment for chronic sternal dehiscence following coronary artery bypass grafting (CABG), as it augments wound healing with an early closure of the wound deficit.

Key words: *Photobiomodulation, surgical wound, diabetes, median sternotomy*

Introduction

Sternal wound healing complications vary from superficial skin infections to sternal instability and mediastinitis. [1] Sternal Instability (SI) is defined as any abnormal motion that exists between the surgically separated sternum, either because of the bone fracture or due to disruption of wires that unite the sternum[1].Coronary artery bypass grafting (CABG) usually encounters surgical wound dehiscence as a serious complication. Clinically, it appears as a mechanical failure of the sternum at the surgical incision due to impaired wound healing. [2] Wound breakdown is a serious complication in median sternotomy and is generally managed with surgical sutures using monofilament surgical steel, following soft tissue debridement and closed irrigation. However, this has considerably higher rates of failure. [2, 3]

A non-invasive treatment, which helps in wound closure by secondary intention has been raising interest in medicine and related areas, is low level laser therapy (LLLT) or simply 'laser therapy'. The mechanism of action of laser on wound healing is postulated as modulation of inflammation by reducing the levels of pro-inflammatory cytokines and increasing the levels of anti-inflammatory growth factors.[4, 5]

Our objective was to observe the effect of LLLT irradiation on wound healing of postoperative sternal dehiscence as a possible or an alternative therapy in chronic sternal wound management in a diabetic individual , who had undergone CABG using internal mammary artery and saphenous vein graft.

Case Presentation

A 48-year-old male presented with the history of coronary artery (triple vessel) disease, type 2 diabetes, hypertension, ischemic heart disease (IHD), moderate pulmonary hypertension and moderate left ventricular systolic dysfunction. CABG was done using three grafts from the saphenous vein, the right and left internal mammary artery with a cardiopulmonary bypass of 127 minutes. The individual was discharged from the hospital after the 20th post operative day with an ejection fraction of 39%. On 58th post-operative day, there was a yellowish pus discharge from the surgical wound and pain in both the shoulders. VAS for pain in the surgical wound and shoulders were four and six respectively. The wound was surgically explored revealing a length of 21 cm and width of 2 cm for the dehiscence. The wound was classified as stage III wound with sloughing, PUSH score of 13 before the commencement of laser therapy. The individual had a New York heart association (NYHA) functional classification of III during the treatment sessions.

Received on: 9 October, 2012
Accepted on: 18 November, 2012

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Figure 1: A sternal wound area of 21 x 2 cm seen before the commencement of laser therapy

Figure 2: Closure of dehiscence area with decrease in wound surface to 21 x 0.5 cm after irradiation with laser.

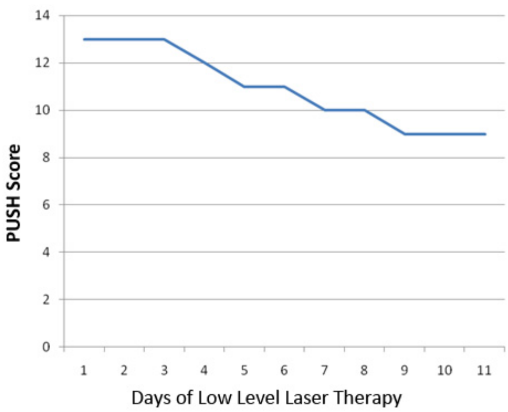

Figure 3: A gradual decrease in PUSH score after irradiation for one week, 11th day of irradiation with laser shows the lowest scores.

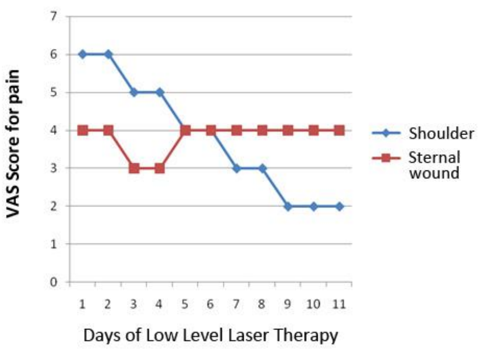

Figure 4: Blue and red line represents shoulder and sternal VAS respectively. VAS for shoulder pain declined to a score of 2 on 11th day of irradiation with laser.

Investigations

Investigations before the commencement of the therapy were as follows: haemoglobin - 8.2 gram/decilitre, Platelet count- 461x 10^3 / µL(microliter),erythrocyte sedimentation rate-140 mm/hr.; total white blood cells-11400 /µL (microliter), C-reactive protein 36 milligram (mg)/litre, blood urea- 65 mg%, serum creatinine - 1.1 milligram (mg) /decilitre (dl), serum potassium 4.5 miliequivalent(mEq)/litre(L). The individual had a fasting glucose of 115 mg/dl. Moderate growth of gram negative pseudomonas aeruginosa was isolated from a wound swab that was found to be resistant to penicillinase, aminopenicillins and extended spectrum penicillin.

Treatment

The Individual was on linezolid (600 mg), antiplatelet therapy (aspirin and clopidogrel, 75 mg), atorvastatin, antiarrhythmic agents, furosemide (loop diuretics), isosorbide mononitrate (vasodilators) and beta blockers. For the management of diabetes a combination of short acting (15 units) and intermediate acting insulin (5 units) was administered daily, during the treatment session. When no significant healing of the wound was noticed in spite of daily dressing, frequent debridement and standard medical care, on the 70th post-operative day (about two weeks after the wound dehiscence was noticed), the individual was counselled regarding the nature of treatment with LLLT. LLLT irradiations commenced on 71st post-operative day after the sutures were removed. The individual was evaluated for any possible absolute and relative contraindications with laser therapy at baseline. Before undergoing the irradiation with laser a written informed consent was obtained.

The accuracy for output dosage of the laser machine was tested prior to irradiation using specialized photodiode equipment (dosimeter). After deciding the parameters, the individual was asked to wear wavelength specific goggles throughout the treatment sessions to obviate any risk of accidental application into the eye. The subject was comfortably placed in a semi-reclining position with his back and spine well supported. Before beginning with the irradiation, the surrounding skin surface along the surgical incision was cleaned to enhance the absorption of laser in the wound area. The frequency of the irradiation was kept to once a day for 5 days till 2 weeks.

A hand-held class 4 LED (gallium aluminum arsenide) was used at a distance of 1 cm from the surgical incision. The probe was a collection of 69 such Light Emitting Diodes (LED), of which 34 LEDs of 660nm had a spectral width of 50nm at a 50% intensity, an average power of 10mW, a spot size of 0.2cm^2 and a power density (irradiance) of 50mW/cm^2 . The remaining 35 LEDs were of 950nm wave-length with a spectral width of 50nm at 50% intensity, generating a total power of 865 mW and a frequency of 156Hz. For the sternal wound, an energy density of 14 J/cm^2 was used for 700 seconds/session per day and for each shoulder single point was irradiated, anterolaterally with an analgesic dosage of 4 J/cm^2 for 240 seconds/session per day.

Outcome and follow up

The PUSH score became 12 and then 9 on the 8th and the 11th day of the irradiation, respectively. The length of the wound remained 21 cm but the breadth decreased to 0.5 cm (fig.1 and 2), and proliferation of healthy granulation tissue filling up the wound deficit was observed on 11th day of irradiation. The VAS score became 2 for the shoulder joints but remained 4 for the surgical incision on the 11th day of the irradiation. (Fig 3 and 4, approximately 82nd day postoperatively).

Discussion

In CABG, the mechanical retraction of sternal halves in order to have adequate view of the surgical area causes excessive strain and compromises the anatomy of chest, back, shoulder and neck.[1] For the concerned individual in the study, separation was observed along the entire sternum. This abnormality might have resulted in excessive sternal movement, pain at the shoulders and difficulty in performing functional tasks. Furthermore, it had contributed to delay in sternal wound healing. *Sushma et al.* had reported sternal dehiscence to be a common complication among Indians, with an incidence of 4.5 % post CABG. [9]

The combination of primary and secondary risk factors increases the chance of post-operative sternal wound complications in CABG. [1, 4] In this case study, we found a number of primary risk factors contributing to dehiscence, as the individual had a history of coronary artery (triple vessel) disease with internal mammary artery grafting, prolonged duration of cardiopulmonary bypass surgery, and an increased blood loss during the surgery. In addition, individual also had type 2 diabetes mellitus, hypertension, moderate pulmonary artery hypertension and moderate left ventricular systolic dysfunction. Personal history of chronic alcoholism, secondary risk factors like increased prothrombin time (25 sec), had made the situation more trivial, possibly increasing the likelihood of morbidity during the healing process, resulting in dehiscence.

Delayed wound healing is a complex situation and irradiation with laser therapy involves stimulation of certain growth factors and cytokines that orchestrate various stages of wound healing, resulting in an accelerated resurfacing of wounds (re-epithelization), and filling up of the wound area by granulation tissue [5]. In the present case study, LLLT facilitated wound closure by photobiomodulation. LEDs were used that are postulated to generate both red and infrared laser radiations causing reduction in inflammation, increase blood flow to the tissues leading to the proliferation of endothelial cells thereby increasing the formation of new blood capillaries within the damaged tissues.[5, 6]

Though in LLLT, a significant difference exists between lasers and light emitting diodes in the way light energy is delivered (optical power output), LEDs provides a gentler delivery of the same wavelength of light compared to other lasers. The LED also has an advantage of different wavelengths being combined together to ensue delayed wound healing.[7] However efficacy of LED in wound healing can be undermined as LED has increased light transmission to the target tissue when the LED is in contact with the skin that might be questionable in individuals with chronic wounds. Another concern with LED is that the absolute transmission depth of irradiation cannot be determined. Moreover very precise adjustments of irradiation parameters to human physical characteristics are required prior to therapy for optimal beam delivery to the target tissue for attaining maximum physiological effects.[8]

However, in a systematic review by *Peplow et al*, the authors posit LLLT irradiation to regulate the formation of nitric oxide synthase leading to increased production of nitric oxide- which is known for its anti-inflammatory, anti-thrombotic effects in wound healing.[5] We found that LLLT application also produced analgesia for the bilateral shoulders, as is also claimed by *Peplow, et al.* in a review.[5] A possible mechanism for it could be increased blood flow after irradiation leading to resolution of inflammatory response in the shoulder joints.

Conclusion

Laser therapy induces biomodulation of dehiscence sternal wound following median sternotomy in CABG. Laser therapy may be heralded as a potential new method for non-invasive, effective and safe wound care in post-operative dehiscent wound. Analgesic effect of laser therapy may be useful for incorporation into shoulder joint rehabilitation for painful shoulders following mechanical failure of sternum post-operatively in CABG.

Though we have outlined the merits of LLLT in this single case study, a more rigorously controlled study design using LLLT is required to provide conclusive evidence for a potentially important role of LLLT in sternal wound healing.

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