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Effects Of Low-Level Laser Therapy (LLLT) On Wound Healing In Abdominal Surgeries Among Obese Individuals

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ABSTRACT

Objective: Obesity is defined as excess adipose fat in the body. There is disruption in the immune mediated inflammatory process and vascular insufficiencies which delays the process of wound healing in obesity. Studies show that Low Level Laser Therapy (LLLT) facilitates the healing of wound in postoperative abdominal surgeries. When LLLT is administered within 24hrs post-surgery has shown to be beneficial, at wavelength of 632.8nm at power of 3-5W/cm2 stimulates cellular migration and increase the production of interleukin-6. This prevents the infection and spread of pathogens.

Aim: To find the effects of low level laser therapy (LLLT) on wound healing in obese abdominal surgeries in reducing pain and promoting surgical scar healing in exploratory abdominal surgeries

Material and Methods: This study is a Randomized Control Trial (RCT) with a sample size of 30, experimental (n=15) and control (n=15). The participants were collected from Sri Ramachandra Hospital, Chennai, Tamil Nadu. The consented participants who underwent elective abdominal surgeries with BMI >30 were allocated into the experimental and the control group through simple randomization, respectively. Both the groups were measured for their baseline data, VAS (for pain) and photographs of surgical suture site on day 1 and at the day of discharge which were assessed for surgical scar closure using Autocad 2014. The experimental group received low level laser therapy at wavelength of 635nm and power of 3W/cm2 from postoperative day 1 till the day of discharge, three sessions, on every alternate day.

Results: The data was tabulated for statistical analysis which was done using SPSS software version v29. Test for normality was done using Shapiro Wilks test. Since the suture site measurement followed the normality, independent T-test was done for suture site closure have shown healing in the experimental than the control group, the p-value is 0.06, 0.08. Additionally, the pain score which was assessed using VAS also showed significant reduction in the experimental group at the time of discharge with p-value 0.021.

Conclusion: This study shows that LLLT used at red spectrum (wavelength of 635nm) is effective in reducing pain and enhances suture site healing because of analgesics and anti-inflammatory properties.

Keywords: *LLLT, obesity, abdominal surgeries*

1. INTRODUCTION

Obesity is defined as excess adipose fat in the body. While obesity poses risk for cardiovascular and other non-communicable diseases, studies also shows that it's associated with slow wound healing process and its complications. Adipose-derived stromal cells (AD-MSCs) which is a type of mesenchymal cells, present in adipose tissue. This is one of the factors responsible for wound healing and regeneration by replacing dermal compartments and promoting wound re-epithelialization. They also promote fibroblast proliferation, collagen secretions and wound bed vascularization.[1] The ADSC is affected by obesity. Although obese individuals have high level of ADSC, they have lesser ability to proliferate, cell senescence and higher ability to produce inflammatory cytokines. Additionally, accumulation of adipose tissue causes changes in the composition of cells, physiological function of the skin and subcutaneous tissues.

Obese patients are in chronic low grade inflammation due to increased production of pro-inflammatory cytokines which causes prolonged inflammatory phase, thereby, affects the wound healing. Obesity causes adipocyte hyperplasia which causes metabolic dysfunctions of the adipocytes, such as storing fat. There is disruption in the immune mediated inflammatory process along with vascular insufficiencies also delays the process of wound healing. Additionally, mechanical forces by excess adipose tissue increases tension leading to stretched scarring.[2] Body mass index (BMI) is the tool used to categorize OBESITY in three categories; Class I (BMI 30-34.9kg/m^2) and Class II (BMI 35-39.9kg/m^2), Class III (BMI more than 40kg/m^2).

LLLT is a therapeutic modality which uses electromagnetic radiation at an optimal range to promote wound healing. It facilitates the healing of wound by reducing pain, inflammation and accelerates the immune response on pathological conditions such as trauma, surgical procedures and transplantation. The regenerative process is augmented by changing the cellular composition at the wound site by increasing neutrophils, aiding in capillary growth and collagen product accumulation which increases the speed of the healing process and improves the quality of wound. The reparative property of LLLT occurs by enhancing the antioxidants, activation of WBC such as macrophages. This also stimulates the cellular proliferation and restores the morpho-functional state of the cell membrane. [3,4] The immune response of cells is increased by LLLT administered at 660nm by enhancing the production of M1-chemokines and pro-inflammatory cytokines in monocytes. This M1-related immunoregulators plays a major role in immunity.[5]

Low Level Laser Therapy releases intracellular calcium ions which distributes to the cytosol and tissues. Within the cells, there is an increase in calcium ion concentration, DNA and RNA synthesis, redox potential of mitochondria, increases ATP synthesis, NO release, changes in the intracellular response to hormone actions, activates endo and exocytosis. Altogether this improves microcirculation, inflammatory process, reparative process, increased immune response and anaesthetization. The secondary effects associated with LLLT are:

1. Activation of cellular metabolism and its functional activity
2. Stimulation of reparative process
3. Anti-inflammmatory effects
4. Activation of blood microcirculation
5. Increase in tissue trophic support
6. Analgesic and immunomodulatory effect

Studies shows that low level laser therapy (LLLT) can accelerates the process of wound healing in postoperative abdominal surgeries. When this is incorporated with surgical scar healing in obese individuals, it can accelerate the process of wound healing in these individuals. Studies show that using LLLT in red and near infrared increases proliferation of fibroblast, regeneration of epidermis, normalizes cell function, relieves pain and heals the wound. Hence, the use of LLLT within 24hrs post-surgery has shown to be beneficial. [6,7] LLLT at wavelength of 632.8nm (red spectrum) and 830nm (infrared spectrum) at power of 3-5W/cm2 stimulates cellular migration and increasing the production of interleukin-6. This improves the cellular proliferation and migration and assist in immune response of lymphocytes, thereby, prevents the infection and spread of pathogens. [8]

Low Level Laser Therapy (LLLT) reduces postoperative suture site pain associated with abdominal surgeries and lowers the frequency of analgesics when administered 24hrs after the surgery. Additionally, it also reduces the edema and inflammation after the surgery. LLLT act as an anesthetic agent by causing inhibition of action potential followed by nociceptive blockade in somatosensory potential and decreases the release of pro-inflammatory neuropeptides. [9,10,11] LLLT inhibits the release of nitric oxide and increases the cellular detox state by inducing numerous intracellular signaling pathways and increases the affinity of transcription factors concerned with cell proliferation, tissue repair and regeneration. [12]

2. MATERIAL AND METHODS

Material

Low level laser with dosage of 3J/cm^2 and 635nm

VAS (Visual analogue scale) and AUTOCAD to assess scar

3. OUTCOME MEASURES

1. Visual Analogue Scale (VAS)

This is a pain assessment tool used to subjectively measure the severity and progression of pain based on patient rating of pain in a numerical scale. In this study, VAS will be used to measure the pain associated with surgical scar on session 1, 3 and 5 in both the experimental and the control group to find the effectiveness of LLLT on scar healing.

2. Suture site healing

The photographs of the surgical scar will be taken in Oneplus Nord CE at a distance of 12cm which will be assessed using free version AUTOCAD 2014 to measure the reduction in the area of scar. [13] The photographs were taken on postoperative day 1 and on the day of discharge were used. Photographs of both the experimental and control group will be assessed to find the difference in the suture healing. The suture site was measured at mid-level, on upper-one third and on lower one-third (0.5cm from above and below the suture site, respectively).

4. METHODS

The study was approved by the Ethics committee of Sri Ramachandra Institute of Higher education and Research (Deemed to be University) (reference- EC/NEW/INST/2023/TN/0321). This study was registered in clinical trial registry- India with registration number CTRI/2024/03/063447.

5. SUBJECT RECRUITMENT

The study was conducted in General surgery department, Sri Ramachandra Hospital (G-Block), Chennai-116.

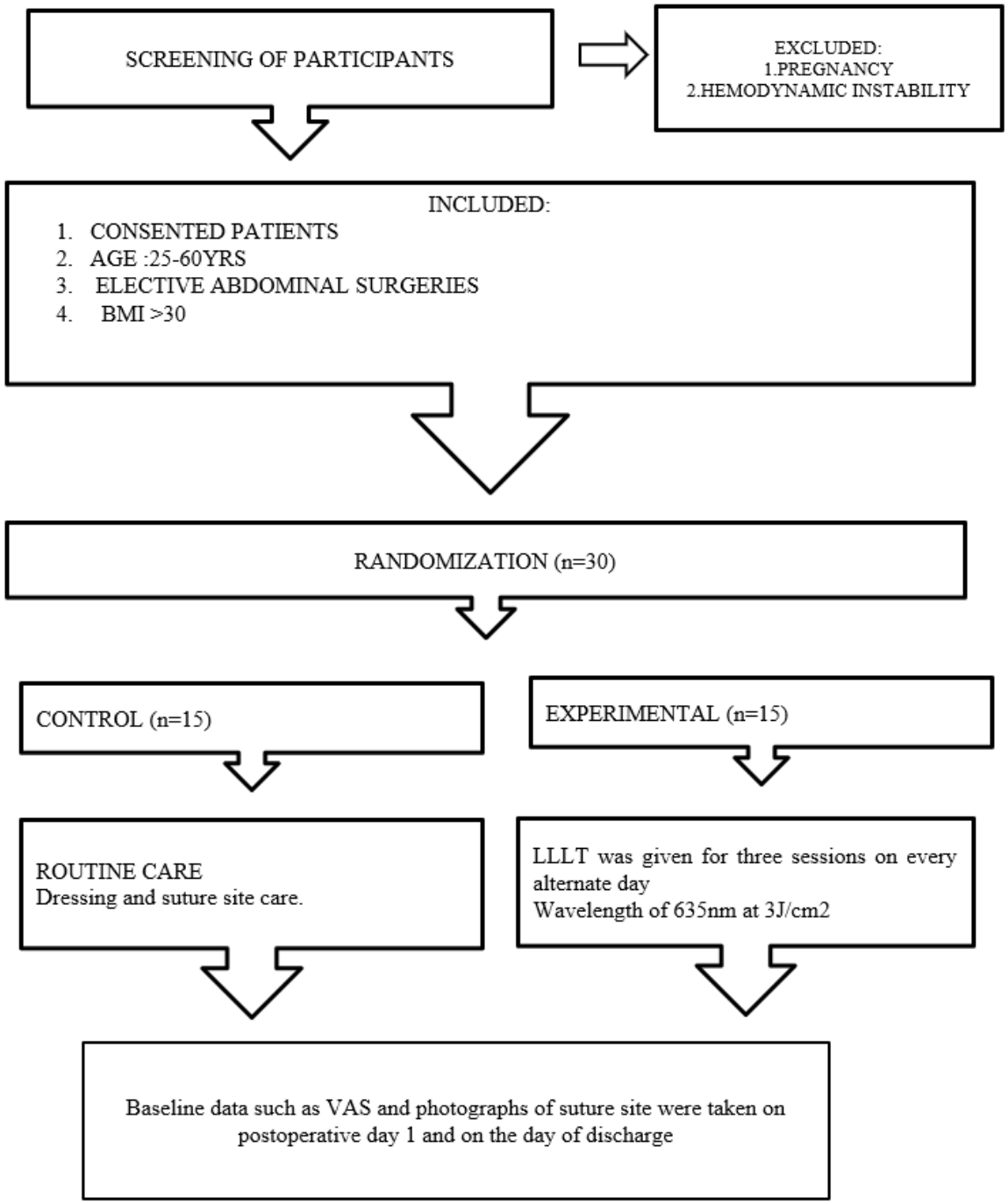
6. INCLUSION CRITERIA

- Consented participants of both the genders
- BMI of class I (greater than or equal to30 to 34.9Kg/m2) and class II obesity (35-39.9Kg/m2)
- Elective abdominal
- Age group of 25 to 60 years

7. EXCLUSION CRITERIA

- Hemodynamic instability
- Pregnancy
- History of epilepsy/seizures

Study protocol was submitted and approved by the institutional Ethics Committee of Sri Ramachandra Institute of Higher Education and Research (SRIHER) prior to conduct of the study. Participants who had undergone abdominal surgery were referred for physiotherapy treatment by General surgeon. The patients in this study were recruited on the basis of the inclusion criteria. The purpose of the study was clearly explained followed by which the consent was obtained. The participants were randomized into two groups, the interventional and the control group. The interventional group received low level laser therapy on the surgical scar while the control group will be receiving routine care. The baseline data will be collected on postoperative day 1 and on the day of discharge. The interventional group received LLLT at the dosage of 632nm wavelength and energy of 3J, for every alternate day. The control group received routine care for the surgical site. The baseline data includes VAS for assessing the pain associated with the surgical scar and the photographs of the suture site were assessed using AUTOCAD software to the appearance of the suture site following LLLT. The suture site were measured using AUTOCAD 2014 and the measurements were done (in millimeters) at the center, upper and lower one-third, respectively.



8. RESULTS

A total of 30 subjects, 15 in each group were recruited for this study out of which two dropped out as they were not willing to participate in the study. An average age of 47.47(8.14) and 48.8(6.54) in the experimental and control group. Out of all subjects included in this study, 49% were male and 51% were female. The average BMI 31.58(4.51) and 30(3.57) in the experimental and control group, respectively.

The result shows that the majority of the patients had underwent open umbilical hernioplasty with 60% in both the experimental and the control group. The open insicional hernioplasty with 20% in the control group and open inguinal with 20% in the experimental group and 2.6% in the control group followed by 1% of open epigastric hernioplasty in the experimental group and 6.6% paraumbilical hernioplasty in the control group.

The statistical analysis of the suture site shows that there is a significant suture site healing in the experimental group (p value <0.01 and 0.025) than the control group (p-value 0.57 and 0.09). Additionally, the pain score on VAS also shows significant results during the day of discharge (p value 0.021).

With 43.7% male and 53% female in experimental group and 49% of male and 51% of female in the control group. This study shows that administering Low Level Laser therapy within 24hrs post-surgery in abdominal surgeries improves the scar healing. Although VAS shows statistical significance in both the groups, incisional healing when assessed using AUTOCAD 2014, shows improvement in the experimental group. The incident of infection and prolonged hospital stay was noted among individuals in control group than the experimental group.

CONTROL **EXPERIMENTAL**

FIGURE 1: PHOTOGRAPS OF SUTURE SITE ON THE DAY OF DISCHARGE

TABLE 1: DEMOGRAPHIC DATA

Demographic data	Experimental group (n=15)	Control group (n=15)
Age (in years)	45.47 (81.4)	48.8 (6.54)
Gender (%)		
Male	46.7	49
Female	53	51
BMI (kg/m2)	31.58 (4.51)	30 (5.57)

Table 1 shows that the age group (mean (S.D)) were predominantly between 45-52 and the majority of the patients involved in this study were female with average BMI of 31-37kg/m2.

TABLE 2: TYPES OF SURGERY

Types of surgery	Experimental group %	Control group %
Open Umbilical hernioplasty	60	60
Open incisional hernioplasty	0	20
Open inguinal hernioplasty	20	2.6
Open epigastric hernioplasty	1	0
Paraumbilical hernioplasty	0	6.6

Table 2 shows that the open umbilical hernioplasty is the common surgery involved in both the experimental and control group.

TABLE 3: BETWEEN GROUP COMPARSION OF THE EXPERIMENTAL AND THE CONTROL GROUP

Suture site on post-operative day 1 (in mm)	Control (Mean (S.D))	Experimental (Mean (S.D))	p-value
MID level	0.54 (0.31)	0.43 (0.4)	0.443
Upper one-third	0.35 (0.2)	0.35 (0.18)	0.944
Lower one third	0.39 (0.27)	0.38 (0.28)	0.974

Table 3 describes independent t test of suture site healing between the experimental and the control group on postoperative day 1 with no significant result at mid-level, upper one-third and lower one-third.

TABLE 4: SUTURE SITE CLOSURE AT THE DAY OF DISCHARGE

Suture site on the day of discharge (in mm)	Control group (mean (S.D))	Experimental group(mean (S.D))	p-value
Mid- level	0.43 (0.28)	0.17 (0.1)	0.006*
Upper one-third	0.29 (0.23)	0.21 (0.2)	0.334
Lower one -third	0.29 (0.24)	0.21 (0.19)	0.008*

Table 4 shows the result of independent t test with significant improvement at the mid-level and lowers one-third part of the suture site (p-value 0.006, 0.008) on the day of discharge.

TABLE 5: BETWEEN GROUP COMPARISON OF VAS ON POSTOPERATIVE DAY 1 AND ON THE DAY OF DISCHARGE

VAS on day 1	Experimental group	Control group
Mean (S.D)	5.33 (2.43)	4.93 (1.83)
p-value	0.412	
VAS on the day of discharge	Experimental group	Control group
Mean (SD)	1.16 (0.67)	1.63 (2.35)
p value	0.021*	

Table 5 shows the result of Mann- Whitney U test of VAS which shows significant reduction in pain among the experimental group than the control group on the day of discharge (p-value 0.0021).

9. DISCUSSION

The current study was done in Sri Ramachandra hospital for the obese patients who had undergone elective abdominal surgeries. A total of 30 (interventional=15, control=15) patients who had undergone elective abdominal surgeries were recruited for this study. The randomization process was done using block randomization method. In order to find the effectiveness of LLLT, VAS and photographs of suture site was used, respectively. With regards to suture site healing, measured using AUTOCAD 2014, there was significant change noted in suture site closure at the time of discharge than the control group. In a study by Rodrigo et al., LLLT at 830nm with power output at 40mW for the 30 patients who had underwent inguinal hernioplasty, within 24hrs of surgery. A total of five sessions were given on every alternate day. The follow up was done at sixth month after the surgery which showed improvement in pain score (VAS) and appearance of the suture site.[4] Our study used LLLT at wavelength of 635nm for three session on every alternate day which still showed significant healing of surgical wound. From this finding, it is shown that LLLT at just three sessions can be effective in

reducing pain and suture site healing within the hospital stay.

Several studies were done to investigate the efficacy of Low Level Laser Therapy (LLLT) on wound healing. These studies mainly focused on effects of LLLT on the suture site associated pain, improvement in the appearance of suture site, analgesic and antimicrobial effects. The antimicrobial property of LLLT was found in many studies as the incident of infection has reduced. Many studies also showed LLLT in reducing pain within one session or within second day of the surgery when irradiated LLLT. [3,4] However, the protocol for the dosage of LLLT still remains unclear as studies shows LLLT on both 630nm (red) or 809nm (infrared spectrum) is effective. An in vitro study by Tzu Sen Yang et al., have used LLLT on human fibroblast at wavelength of 633nm, 450nm and 520nm. At wavelength of 633nm red light illumination activated collagen production and remodeling. [5] Hakan Solmaz et al. conducted an in-vivo and in-vitro study to find the healing of wound at wavelength at 635nm and 809nm. The result showed that both the wavelength had better healing. The wavelength of 809nm have shown better healing in terms of fibroblastic activity and vascularization while 635nm have shown high degree of collagen formation and fibroblast proliferation. [8] Our study was conducted at 635nm at 3J and has shown significant improvement in suture site healing which corroborates with the above-mentioned study.

Alecsander R Ojea et al., study on 86 patients who underwent post bariatric surgery, three sessions of LLLT (immediate post op, on fifth day and on seventh day). This study involved analyzing inflammatory biomarkers, C-reactive protein, creatinine kinase (CK), lactate dehydrogenase (LDH) and erythrocyte sedimentation rate (ESR) and temperature. This study demonstrated LLLT ability to act as anti-inflammatory mediator and analgesic effects on surgical wounds. [6] The current study used a wavelength of 635nm at the power of 3J and showed improvement in surgical incision healing. The result of our study corroborates with this study as the incidence of infections and the use of analgesics was reduced in patients who were exposed to LLLT than the control group.

In another study conducted by Elham Saffarieh et al, LLLT was administered for patients following C-section (wavelength 830nm and energy of4J/cm2) for 6 days. The result in this study show there was a significant pain reduction in the interventional group. Additionally, Vancouver scar scale was not different in the group which received LLLT. [9] In our study, there was significant pain reduction the experimental group along with suture site healing. In our study, LLLT showed added effects on suture healing along with VAS. This could be due to use of Vancouver Scale (VSS) as outcome to measure the appearance of the scar as evidence suggests that this scale has low validity and reliability. A systematic review by Armin Behrouz Pirnia et al., to investigate the early intervention of laser in wound healing have shown uncertain results as four out of 17 RCTs had Vancouver Scar Scale (VSS) as their primary outcome measure. [4]

Madadi Mohamad et al., used LLLT at wavelength at infrared spectrum on 50 patients who underwent Gastrointestinal surgery. Their result has shown that although both the group had similar pain score (VAS) at the time of first session, the pain score significantly reduced by 4th postoperative day. [10] Our study shows similar result as the patient at both the group had reduced pain score at the day of discharge. However, the pain score was further decreased in the interventional than the control group.

10. CONCLUSION

Our study shows that Low Level Laser Therapy (LLLT) at red spectrum (635nm) is effective in suture site healing and reducing pain associated with elective abdominal surgeries. The study shows that irrespective of the type of suture, LLLT was effective in wound healing. When LLLT is administered within the hospital stay, it aids in reducing the chances of infection which thereby reduces the length of hospital stay associated with infection or oozing of pus from the suture site. Additionally, the ambulation around the bed was made easier as the pain on suture site while standing and walking was significantly reduced after the second session. This also explains the reduction the frequency and dosage of analgesics for patients who were exposed to LLLT. Hence, LLLT is an effective electromagnetic modality for suture site healing when started within postoperative day one, within the hospital stay.

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Conflict of interest

There are no potential conflicts of interest to declare.

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