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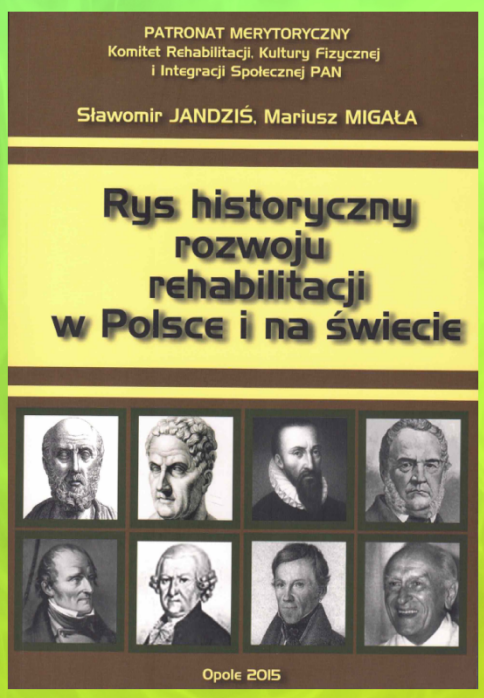

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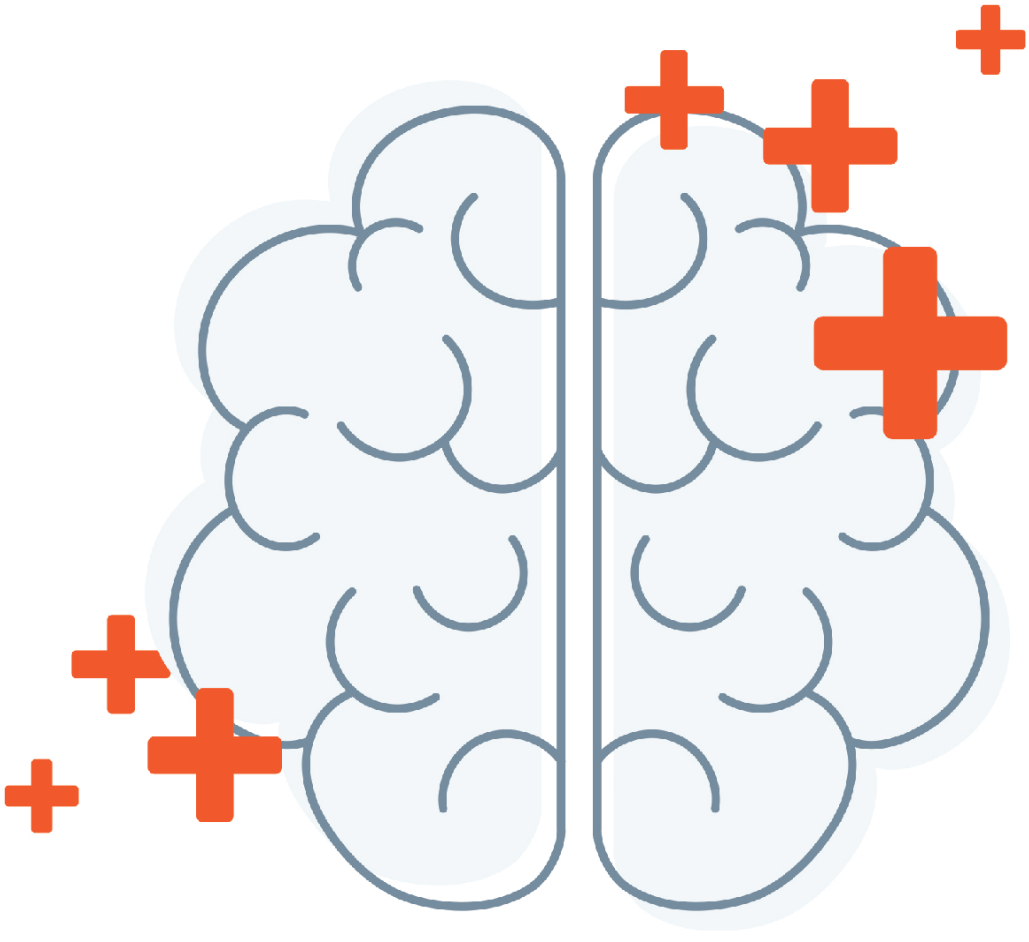

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Scar prevention by low level laser therapy on surgical wound post hand flexor tendon repair

Zapobieganie bliznom przy użyciu terapii laserowej niskiego poziomu stosowanej na ranę

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Abstract

Objective. To evaluate the effect of an early intervention of Low Level Laser Therapy (LLLT) on incisional wound scar formation and range of motion (ROM) of interphalangeal (IP) joints post surgical repair of hand flexor tendon laceration.
Material and methods. Thirty male patients between the ages of 20 and 40 who underwent unilateral zone II flexor tendon repair of the hand were assigned randomly into two equal groups in number of 15 patients each group. Group (A) (Laser therapy group) received early LLLT in addition to post surgical medical care while the group (B) (Control group) received only post surgical medical care. The primary outcomes were color, pigmentation, pliability and height of wound scars which was measured by Vancouver Scar Scale (VSS). In addition to Total Active Motion (TAM) of hand's digits which measured by hand goniometer. The assessment was taken after 4 weeks and 12 weeks postoperative.
Results. After 12 weeks compared to after 4 weeks in both groups, there was a significant decrease in the VSS and a significant increase in Total Active Motion (TAM) according to within group comparisons ($p < 0.001$). When compared to the control group at 4 and 12 weeks, the laser group had a significantly lower VSS and a significantly higher TAM ($p < 0.01$).
Conclusion. Early applications of LLLT post surgical repair of flexor tendon improve TAM and minimize scar formation.

Keywords

flexor tendon repair, low level laser therapy, scar prevention, zone II, surgical wound

Streszczenie

Cel. Ocena wpływu wcześnie wprowadzonej terapii laserowej niskiego poziomu (LLLT) na tworzenie się blizny po ranie pooperacyjnej i zakres ruchu (ROM) stawów międzypaliczkowych (IP) po chirurgicznej naprawie uszkodzenia ścięgna zginacza ręki.
Materiał i metody. Trzydziestu pacjentów płci męskiej w wieku od 20 do 40 lat, którzy przeszli jednostronną naprawę ścięgna zginacza ręki w strefie 2, przydzielono losowo do dwóch równych grup po 15 pacjentów w każdej. Grupa (A) (grupa terapii laserowej) była poddawana terapii LLLT oprócz pooperacyjnej opieki medycznej, podczas gdy grupa (B) (grupa kontrolna) otrzymała tylko pooperacyjną opiekę medyczną. Rezultaty dotyczyły głównie koloru, pigmentacji, elastyczności i wysokości blizn, które zostały zmierzone za pomocą skali Vancouver Scar Scale (VSS). Ponadto, obliczono Total Active Motion (TAM) dłoni, gdzie pomiarów dokonano za pomocą goniometru ręcznego. Oceny dokonano po 4 tygodniach i 12 tygodniach po operacji.
Wyniki. Porównując wyniki po 12 tygodniach i po 4 tygodniach zaobserwowano, że w obu grupach nastąpił znaczny spadek na skali VSS i znaczny wzrost w zakresie (TAM) ($p < 0,001$). W porównaniu z grupą kontrolną po 4 i 12 tygodniach, grupa, u której zastosowano terapię laserową miała znacznie lepsze wyniki na skali VSS i znacząco wyższy TAM ($p < 0,01$)
Wniosek. Wczesne zastosowanie terapii LLLT po chirurgicznej naprawie ścięgna zginacza poprawia TAM i minimalizuje powstawanie blizn.

Słowa kluczowe

naprawa ścięgien zginaczy, terapia laserowa niskiego poziomu, profilaktyka blizn, strefa 2, rana pooperacyjna

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Introduction

The aberrant fibrous wound healing process that leads to hypertrophic scars and keloids occurs when the control of the tissue repair and regeneration regulatory mechanisms is disrupted. Every year, almost 100 million people experience new scarring due to accidents, burns and operations [1].

Most wound healing research focuses on keloid and scar avoidance, maintaining normal wound breaking strength and accelerating wound and soft tissue recovery. According to recent studies, certain physical procedures, like therapeutic ultrasound and laser treatments, speed up and aid in the healing of wounds and enhance the quality of scars [2].

Preventing the production of aberrant scars should always be the top concern after surgery or trauma. Scar prevention strategies should be started during or even before surgery in the case of an operational procedure. The position and length of the incision line should be carefully considered when doing elective surgery and if at all possible, they should always run parallel to the relaxed skin tension lines [3].

The peak incidence of hand injury occurs with age varying from 20–29. Because of the higher prevalence of doing risky tasks at this age, young individuals and men in particular, are more likely to sustain injuries. Men are also more likely to engage in jobs or hobbies that put them in danger of getting hurt [4].

It is challenging to achieve good hand functioning after the restoration of zone II flexor tendons. This functional impairment results in dependency and disability in daily living activities [5].

Edema, followed later by severe scarring with or without adhesions between the tendon and sheath or other structures, can significantly restrict finger motion after surgical repair [6].

Due to its anti-inflammatory qualities, low intensity laser therapy has been used in the therapeutic environment as a supplemental technique for pain management. Additionally, it has been used to speed up the recovery from muscle damage, burns, surgical wounds and persistent ulcers [7].

Due to its favourable effect on fibroblast proliferation and differentiation, neoangiogenesis and the production of collagen and elastin, low level laser treatment (LLLT) can change the architecture of scar tissue in skin wounds [8].

An early intervention of LLLT may be has a high impact on scar prevention of surgical wound post unilateral zone II flexor tendon repair of the hand. For confirming this conclusion we need more clarification concerning its influences on scar process. So, this study was conducted to determine the effect of early intervention of LLLT on wound scar formation and range of motion of injured digits post surgical repair of hand flexor tendon laceration.

Subjects, materials and methods

Design of the study

A prospective, parallel group, single-blind, post-test only randomized controlled trial with a 1:1 affection ratio was conducted from March 2019 to March 2021 at Alexandria University hospitals, Alexandria, Egypt in compliance with the Helsinki Declaration. The protocol has been accepted by the institutional review board at Faculty of Physical Therapy, Cairo University, Egypt (P.T.REC/012/002264). Prior to study enrolment, each patient provided a signed informed consent after receiving full information about all study procedures.

Randomization

The randomization assignment into two equal groups in numbers with rolling a dice by an independent person. Group (A) (when the dice revealed an even number) and group (B) (when the dice revealed an odd number. The randomization was constrained to allow blocks to ensure that all groups ad an equal number of participants. There was no drop out after randomization.

Blinding

The study was a single-blind clinical study. Group allocation and assessment were blinded. The primary investigator and biostatistician were blinded to the treatment allocation.

Participants

Thirty male patients with unilateral zone II flexor tendon repair by bruner zigzag incision and bunnell suture with age between 20–40 years old were recruited from the hand surgery clinic, Alexandria University Hospital, to assess the therapeutic impact of an early intervention of low level laser therapy on incisional wound scar formation and range of motion (ROM) of injured digits of the hand following surgical repair of hand flexor tendon laceration. They were split into two equal groups in number of 15 patients for each group. Group (A) (Laser therapy group), these patients received early low level laser therapy in addition to post surgical medical care and group (B) (control group), these patients received only post surgical medical care. The inclusive criteria of patients included only male patients, due to the differences in hand grip parameters between both sexes, underwent unilateral zone II flexor tendon repair with age varying from 20 to 40. They had one operated finger or more. The subjects were excluded in the following conditions: vascular injuries requiring arterial repair, crush injuries, soft tissue loss, nerve injuries, fractures, tendon injuries of other zones, preexisting problems such as arthritis limiting joint motion, tendon injuries in both hands, diminished cognitive capacity, history of prior failed repair, history or suspicion of malignant neoplasia, photosensitive patients, diabetic patients and any medical conditions preventing repair.

Instruments

Therapeutic equipment used in study were Zimmer low level laser device class 4 IEC 60825-1:2007 made in Germany, protective goggles for both of therapist and patient, Vancouver Scar Scale to investigate the maturity of incisional wound scar formed and hand goniometer to assess total active motion of treated digits.

Interventions

Evaluation procedures

All patients underwent complete history taking including the name, age, occupation, weight, height and marital status. In addition, they were asked about any previous trauma, any previous operation, any systematic diseases and any medication. Detailed analysis of surgical scar color, pigmentation, pliability and height was included in patient medical sheet.

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Vancouver Scar Scale (VSS)
In each group, scar at suture site of each involved digits for each patient measured by Vancouver Scar Scale after 4 weeks and 12 weeks post operation of flexor tendon repair (table 1).
The response to the treatment was rated as excellent, good, minimal and no response based on the following guidelines. An excellent response was given when the scar scale changed seven or more points after treatment. A good response was given for an improvement of between four and six points. Minimal response was given for an improvement of between one and three points. No response was assigned to those patients who had no change in the Vancouver scar scale [9].

Table 1. Vancouver Scar Scale

Scar characteristic		Score
Vascularity	normal	0
	pink	1
	red	2
	purple	3
Pigmentation	normal	0
	hypopigmentation	1
	hyperpigmentation	2
Pliability	normal	0
	supple	1
	yielding	2
	firm	3
	ropes	4
	contracture	5
Height	flat	0
	< 2 mm	1
	2–5 mm	2
	> 5 mm	3
Total score		**13**

Total Active Motion (TAM)
Total active motion (TAM) is described by the American Society for Surgery of the Hand (ASSH) as the sum of active MCP, PIP and DIP arc of motion in degrees of an individual digit. This calculation compared to the TAM of the contralateral hand or the norm of 260 degrees. While passive motion was useful to record changes resulting from surgery, active motion may illustrated the functional gain. Total motion measured both active and passive motion [10].
After calculation of the sum of active flexion ranges in MCP, PIP, DIP minus the extension deficit, the percentage of total active motion (TAM score) was calculated in the affected digit of every patient by dividing the recorded result with that of the contralateral non injured digit. Normal skin considered excellent score, percent more than 75% considered good score, fair score rated from 50% to 75%, poor score represented below 50% and worse score obtained when percent came less than pre operative [11].

Therapeutic procedures
For laser therapy group
The therapeutic procedures was done by using low intensity laser therapy device after 24 hours post surgery and continued as three times a week, for four weeks for 12 sessions with the wrist 20° flexion, metacarpophalangeal (MCP) joints of 2nd to 5th digits in 50 degrees flexion and Interphalangeal (IP) joints of 2nd to 5th digits in full extension (0° flexion). Both therapists and patients wore protective goggles during application of laser therapy. An 830-nm diode laser was used to irradiate the incisions. Its continuous power output was 40 mW, its energy per point was 1.04 J and its energy density was 13 J/cm2. The contact laser probe positioned perpendicularly above the repair location [1].

For both groups
Post surgical medical care
Following surgery, edema was initially controlled by hand elevation, neck, shoulder and elbow motion and light wound bandaging. If necessary, the patient or significant other may safely place a self-adhesive circumferential wrap over the damaged digit at night to reduce swelling. Antibiotics and analgesics were described for at least 7 days. Sutures were removed after healing of the wound and the median was 12 days.
The Saint John protocol of rehabilitation started at first 3 to 5 days by immobilizing the affected hand through a dorsal block splint with the wrist slightly flexed (20 to 30) degree, MCP joints slightly flexed and the IP joints in extension (or minimal flexion). In the initial days following surgery, the hand was ra-

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ised at all times to prevent bleeding in the wound, decrease edema and reduce work of flexion and friction. Internal bleeding causes hematoma formation, and increase adhesions. Immobilization lets the swelling, work of flexion and friction to lessen the danger of rupture. Edema control from day five to week two involves elevating the hand and applying a soft finger compression wrap. Before engaging in active flexion, patients were asked to passively flex each digit. Actively extend the IP joint while blocking the MP joint in flexion (10 times every waking hour) to avoid IP joint flexion contractures. True active flexion beginning at the distal IP joint and extending to around one third to one half of a fist (active hook fist). Next 2 weeks, dorsal block splint was shortened. Patients worked to extend their wrists up to 45 degrees and achieve a half to full active fist position. Keep the MP fully flexed while maintaining full IP joint extension. Focus on completing the full fist position by six weeks. From 4th to 6th week, patients started to use the hand for light activity. At 6th week splint was discontinued. The patient started the last six weeks of the rehabilitation protocol with active exercises for the radio-carpal joint, finger abduction and adduction and opposition of the pollicis division to the other fingers. Patients carried out the previously mentioned exercises in addition to starting ball based forearm and hand muscle strengthening activities [12].

Statistical analysis

To compare the two groups, an unpaired t-test was applied. The injured hand, number of operated fingers and operated fingers distribution was compared using the Chi-squared test. Paired t test was conducted for comparison of VSS and TAM between post I and post II in each group. All statistical tests had a significance threshold of $p < 0.05$. The statistical software for social studies (SPSS) version 22 for Windows was used for all statistical calculations.

Results

Subject characteristics

Thirty patients with 43 injured fingers with flexor tendon repairs participated in this study. Table (2) showed the subject features of the group A and B. Age, affected hand, number of operated fingers and distribution of operated fingers did not significantly differ between groups ($p > 0.05$).

Table 2. Essential features of participants

	Group A Mean ± SD	Group B Mean ± SD	p-value
Age [years]	27.53 ± 5.62	27.6 ± 4.74	0.97
Affected hand, n(%)			
Dominant hand	8 (53%)	11 (73%)	0.25
Non dominant hand	7 (47%)	4 (27%)	
Number of operated fingers, n (%)			
4	1 (6.7%)	0 (0%)	0.25
3	1 (6.7%)	1 (6.7%)	
2	1 (6.7%)	5 (33.3%)	
1	12 (80%)	9 (60%)	
Operated fingers			
Little	6 (28.6%)	4 (18.2%)	0.57
Ring	5 (23.8%)	4 (18.2%)	
Middle	4 (19%)	8 (36.4%)	
Index	5 (23.8%)	6 (27.3%)	
Thumb	1 (4.8%)	0 (0%)	

SD: standard deviation; p-value: level of significance

Effect of treatment on VSS and TAM

Within group comparison

In group A and B, the VSS significantly decreased and the TAM significantly increased at post II compared to post I ($p < 0.001$). The percentages of change in VSS and TAM in group A were 15.71 and 12.57, respectively and 13.56 and 24.49, respectively, in group B (Table 3).

Between groups comparison

At post I and post II, there was a significantly lower VSS and a significantly higher TAM in group A compared to group B ($p < 0.01$) (Table 2).

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Table 3. Mean VSS and TAM post I and II of the group A and B

		Group A Mean ± SD	Group B Mean ± SD	MD	t-value	p-value
VSS	Post I	4.52 ± 1.75	5.68 ± 1	−1.16	−2.68	0.01
	Post II	3.81 ± 1.56	4.91 ± 0.86	−1.1	−2.86	0.007
	MD	0.71	0.77			
	% of change	15.71	13.56			
	t-value	7.07	8.45			
		p = 0.001	**p = 0.001**			
TAM [degrees]	Post I	126.9 ± 30.83	95.77 ± 30.48	31.13	3.32	0.002
	Post II	142.85 ± 27.27	119.22 ± 27.18	23.63	2.48	0.007
	MD	−15.95	−23.45			
	% of change	12.57	24.49			
	t-value	−12.87	−15.02			
		p = 0.001	**p = 0.001**			

SD: standard deviation; MD: mean difference; p-value: level of significance

Discussion

Flexor tendon injuries are frequent and a robust low friction repair that facilitates initial movement without impairing the tendon's vascularity or causing adhesions is essential for a favourable functional outcome [13].

Following surgical intervention, where the regular skin is replaced with a fibrous tissue, scarring is an expected side effect of wound healing. Unlike healthy, uninjured skin, this scar tissue is devoid of those traits. Functionally, a scar that restricts mobility is undesirable [14].

Patients with flexor tendon injuries may benefit from low level laser therapy as a parallel treatment because it can improve ROM, reduce pain and foster greater patient participation [15].

The goal of this study was to assess effect of early intervention of low level laser therapy on surgical wound scar prevention after hand unilateral zone II flexor tendon repair. Thirty male patients with age from 20 to 40 years were split into two clusters equal in number, each with 15 patients.

In this study VSS was used to measure degree of scar maturity which is significantly decreased at its all values after 4 weeks and after 12 weeks with probability degree of 0.01 and 0.007 respectively which referred to improvement in both microscopic and functional outcomes and to measure indirect effect on active range of motion of flexor tendons.

Total active motion was considered the representative target in functional results needed to move finger functionally during ADL activities, finger goniometer was used to assess active range of motion of injured finger as it was a valid and reliable method in measuring MCP, PIP and DIP joints ROM and it was an easy method to be used in clinical practise and it wasn't an expensive method.

It has been established that active testing (reproduction of joint position) is more precise and functional than passive testing (reproduction) [16].

In this study there was a significant elevation in TAM of low level laser cluster compared with that of the control cluster after 4 weeks and after 12 weeks with probability of 0.002 and 0.007 respectively.

The incidence rate of tendon rupture occurred after flexor tendon repair as active ROM prevents adhesion but increases the rate of rupture. Also, some surgeons decided to increase number of strands to provide more tendon tensile strength aiming to avoid tendon rupture however, it could affect the gliding mechanism of repaired tendon.

As LLLT proved previously its effect on improving tendons tensile strength it would be helpful in intrinsic healing and decreasing ischemic reaction occurred to repaired tendon which cause adhesion formation.

Additionally, LLLT is helpful in reducing collagen concentration, oxidation and histological abnormalities in a research trial regarding tendoachilles damage. The improvement in the oxidant/antioxidant balance may operate as a mediating factor that decrease fibrosis.

Acceleration of wound healing, improving repaired tendon tensile strength and modifying morphology of scar tissue in skin wound occurred after LLLT application give chance to decrease surgical strand which improves gliding mechanism and minimises the formation of internal adhesion and scar tissue formation.

The trial outcomes showed that early application of low level laser therapy has a beneficial impact on minimizing creation of incisional scar and restoring range of motion (ROM) of interphalangeal (IP) joints post surgical repair of hand flexor tendon laceration are supported by the works reported by: Avci et al., [17], Ayad et al., [18], Badawy et al., [19], Calin et al., [20], Carvalho et al., [1] and Karmisholt et al., [21].

Avci et al., [17] reported that low level laser (light) treatment (LLLT) has been demonstrated to facilitate tissue healing. LLLT helps in the repair of burns, hypertrophic scars, wrinkles and acne scars.

Ayad et al., [18] compared results between the two study clusters; patients in the first cluster underwent low degree laser therapy in addition to the identical therapeutic training plan as those in the other group. The results confirmed a highly statistically significant difference in most hand grip strength at 3 weeks and 3 months ($P < 0.05$) and a more considerable diffe-

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rence (P < 0.01) respectively as well as an extremely statistically significant difference in TAM at 3 weeks and 3 months (P < 0.01) both favoring laser treated group.

Badawy et al., [19] elicited the treatment with laser therapy of doses 1 or 4 J/cm2 in addition to conventional treatment had a positive effect at 2 months after commencement of treatment on primary repaired hand flexor tendon and showed that treatment with LLLT is more effective than conventional treatment, which included TENS in addition to early therapeutic exercises following Duran protocol. The best results were shown at 2 and 3 months after treatment only in group using the laser dose of 4 J/cm2.

Calin et al., [20] discovered that the essential healing was enhanced when surgical wounds were treated with low power laser radiation that was standardised in compliance and that the process ended in the 10th day after surgery. The biomechanical blood test revealed that all commonly known groups' normal enzyme levels, with the exception of alkaline phosphatase, extend by about double or triple of the physiological limits of the research group, with figures that are two to three times greater than the moderate levels in the control group. The erythrocyte indices displayed increased erythrocyte numbers and mean erythrocyte aggregation in the research group in contrast to the controls, which indicates that, the tissues received more oxygen as achieved by biostimulation. Additionally, it was determined histologically that the treated group's epithelial synthesis and dermis healing are expedited. The dynamics of the leukocytes numbers point to an activation of the immunological control and regenerative processes, which is apparent in monocytosis (a trait shared by both groups) and lymphocytosis (which is greater in the treated group). All of those facts have demonstrated that LLLT is successful in treating wounds.

Carvalho et al., [1] found that regarding the frequency of low level laser application to surgical incision, they discovered that there has been no distinction among the frequencies in terms of the development of the wound restoration. Their study supports previous findings, showing that using the programme every day for a week encouraged positive treatment outcomes. The properties of LLLT, as tested in this and other researches, would aid many patients to enjoy a quicker healing and enhance the best in their surgical scars. In addition to speeding up the healing process, they also made wound closure quicker whilst growing the tensile power of the scar.

Karmisholt et al., [21] embarked on a study on modifying the wound healing process to lessen the creation of scar tissues. Laser exposure that is used after wounding and hence targets the initial stages of wound healing has been tested to enhance later scar development. To evaluate laser treatment applied in the beginning of wound healing, they only included trials introducing laser within 3 months of injury in this systematic review. This extensive study discovered that the inflammatory phase of wound healing is ideal to begin using lasers to lessen scarring.

The conclusion of this study that low level laser therapy has a beneficial impact on incisional scar formation and range of motion (ROM) of injured digits post surgical repair of hand flexor tendon laceration disagreed with the works done by: Allendorf et al., [22], Freitas et al., [23], Gammel et al., [24], Hopkins et al., [25], Lagan et al., [26], Lucas et al., [27] and schlager et al., [28].

Allendorf et al., [22] also showed that there isn't any proof that low intensity laser ray has any discernible impact on how quickly wounds heal. At the same time, low intensity laser biostimulation excisional and incisional models were being constructed. At fluencies of 1, 2, and 4 J/cm2, the rate of wound contracture in the treatment groups was practically the same as the controls. Furthermore, at the two postoperative time periods, there was no change in the tensile strengths of incisional wounds between the treatment (2 J/cm2) and control groups. Power analysis shows that changes of 40–50% would have been discovered, whilst tiny differences would have gone undetected. Assessment was done very early during inflammatory stage without any follow up or reassessment which took into consideration during current study.

Freitas et al., [23] analysed the impact of LLLT 5weeks treatment on scar's thickness, macroscopic aspect, length, width, tingling, pain tolerance and pain recognition. In reality, there were no considerable differences between the test and fake groups, primarily because of the small sample size. So they reported that LLLT intervention shows up to have a great impact on the plainly visible appearance of scars as well as the thickness of old scars. However, it is impossible to say with certainty whether LLLT has an effect on scar tissue. But this work misfortune analyst unbiasedness as well as the limited sample which did not happen in current study.

Gammel et al., [24] found with the methodology described in their study, LLLT did not seem to have an impact on closure of operatively produced wounds. LLLT did not consider the impact of healing duration, the size of the incision or microscopic evaluation of collagen and epithelial synthesis occur in open wounds and incisions. Despite the fact that there were only minor variations in the appearance and microscopic evaluations, no group consistently outperformed the others throughout all study period. This study limited by the fact that the incisions and open wounds in the control group were surgically caused and systemic effects of the LLLT were no longer ruled out. These limitations were treated in current study.

Hopkins et al., [25] wrote that the effect of the laser could be minimal or non-existent on fresh injuries as cell proliferation is active. Laser response could be observed in old wounds. It is apparent that the issue of optimum dosage for LLLT is far from clear. This study was constrained by the fact that the researcher did not position the probe head specifically in contact with the open wound by using neoprene format that surrounds wound during treatment, resulting in a 2 mm space between the probe head and the wound and a few expected dissimilarity of the laser light and diminishment of light escalated to the tissue.

Lagan et al., [26] came to the conclusion that LLLT provides no advantages over existing practise in the treatment of minor postoperative wounds. Despite the infrared laser's apparent ineffectiveness in treating acute stage wounds at some dosages, more research is required to see whether it might be useful in treating other wound types. Researcher investigate the possible practical effectiveness of low dosage of LLLT in the therapy of uncomplicated post operative wound following minor surgery which replaced with higher dosage in current study.

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Lucas et al., [27] did not find any evidence to support the use of low level laser therapy as an adjunct to the agreed upon ulcer treatment. Considerations showed that surgical skin injuries treated with a 904 nm infrared laser at a pulse frequency of 700 to 800 Hz as opposed to 1200 Hz showed significantly more pronounced wound contraction, more pronounced cellular substance of granulation tissue, more fibroblast generation, and more organised fibroblasts. Detail was also provided on vein and lymph vessel recovery. Additionally, they stated that there is some doubt regarding the effectiveness of LLLT in advancing wound healing due to final studies' results being compromised due to factors like very small sample sizes, insufficiently blinded result appraisal, differences in the prognosis of groups at baseline, retreat from sessions and specific dropouts, numerous co-interventions, and lost information. Finally, researcher overrepresented women in this study reflecting a nursing home population. Their consider did not uncover the adequacy of LLLT on ulcers healing in spite of particular consideration paid to sample size, prognostic comparability at baseline level, and observer blinding.

Schlager et al., [28] revealed any appreciable alterations neither a macroscopic nor histologic evaluation of the wound following low level laser treatment. A minor but not appreciably faster epithelization was seen when the epithelization of the laser treated wounds was examined under the microscope. On day 6 following damage, peripheral epithelization started in both groups. All wounds had fully epithelized in both groups 30 days after damage. Both groups experienced a reduction in redness and edema simultaneously. Ratings for redness and edema in the control group were barely higher than in the treated group. The macroscopic assessment and the histologic information are consistent. After exposure to a low power 670 nm laser beam, the wound's vascularization, granulation tissue development or epithelization were unaffected. They draw the conclusion that 670 nm low power laser treatment does not improve wound healing.

The study was limited by selection of male patients only as the difference in muscle power between male patients and female patients might affect the results of this study and individual differences of the patients during periods of evaluation. Also, the chosen method of application which is contact method which may had side effects as it might spread infection from one finger to the other so sterilisation was needed several times in the same session. Also, the contact between the probe and the sutures caused slight movement in skin sutures which caused pain and discomfort to the patient during application. In addition, surgical techniques and number of strands used for tendon repair, physiological state of the patients during time of treatment and possible human errors also might limit this study. Finally, the site of suture in some patients might extend to the side of the selected zone.

Conclusion

Within the limitation of the present study, the notable conclusions were:

1. There was improvement in total active motion and decreasing in scar formation in the operated fingers post surgical repair of flexor tendon laceration in group of patients treated with low level laser therapy as evidenced by VSS and goniometric measurements of current study.
2. For the treatment of incisional scars left over from flexor tendon repair, low level laser therapy was regarded as a secure and efficient therapy form.

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