Low-level laser therapy versus neural mobilization on shoulder dysfunction post liver donation

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ABSTRACT

Background: Postoperative liver donors face shoulder dysfunction, which might be explained by brachial plexus compression during surgery and intraoperative malposition.

Aim of the work: To compare the therapeutic impact of low-level laser therapy (LLLT) and neural mobilization techniques on shoulder dysfunction post-liver donation.

Patients and methods: The study comprised 66 patients of both sexes who had been clinically diagnosed with shoulder dysfunction following liver donation. They were between thirty and fifty years old. They were randomized and equally split into three groups (A, B, and C). Alongside a traditional physical therapy program, Group (A) received LLLT, and Group (B) underwent neural mobilization treatments. Group (C) received only a traditional physical therapy program. The study outcomes were evaluated prior to and after the intervention. For four weeks consecutively, patients underwent intervention three times a week. A digital goniometer to test joint range of motion (ROM) (flexion, abduction, and lateral rotation); a handheld dynamometer to assess shoulder abductor strength; and an Arabic version of the Shoulder Pain and Disability Index to evaluate shoulder functions.

Results: A statistically significant reduction was observed across all groups, favoring group A.

Conclusion: Laser therapy improved shoulder ROM, abductor muscular strength, and functions in patients post-liver donation. This treatment may help the effective rehabilitation of these patients.

Keywords: liver donation, low-level laser therapy, neural mobilization, shoulder dysfunction.

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INTRODUCTION

Since the liver is an internal organ that interacts with every human system, recipients or donors of liver grafts experience significant physiological alterations [1]. It is widely recognized that hepatocellular cancer, hilar cholangiocarcinoma, acute fulminant hepatocyte defect, end-stage liver illness, and many metabolic diseases can only be treated with liver transplantation [2].

After major liver surgery, compressed nerves in the subclavian region brought on by rib cage retraction in response to surgical exposure may result in pressure on the brachial plexus (BP) [3]. Shoulder dysfunction in postoperative donors may be caused by intraoperative improper positioning or compression of the brachial plexus throughout the surgery [4]. Shoulder dysfunction in liver donors has been identified as a significant musculoskeletal problem that necessitates multidisciplinary care, including the availability of physiotherapy, analgesics, and self-advice **[5].** The upper trunk is the most frequently impacted among the three trunks. In the latter instance, injuries to the mid and lower trunks recover rapidly, while upper trunk involvement does not. Long-term arm malposition or extended use of Thompson retractors has been linked to BP injury during prolonged liver operations. The use of the Thompson retractor to improve exposure may have resulted in divisions between the mid-clavicle and the first rib, as well as undue pressure on the right BP trunks. The axillary nerve, which emerges from the brachial plexus, is primarily affected by affection of the upper trunk of the BP (upper trunk, posterior division, and posterior cord) **[6].**

Low-level laser therapy (LLLT) has been proven as an efficient physical method for pain relief. It also speeds up the recovery in numerous clinical illnesses, including shoulder pain, which is mediated by biostimulation with light energy, boosting the homeostasis level [7]. Neural mobilization is a complicated therapeutic approach that includes patient education techniques, several neural mobilization techniques, and conservative treatment for nerve interface correction. Neural mobilization is a conventional method of treating neural tissue disorders. **[8].**

Aim of the work

To compare the therapeutic impact of LLLT and neural mobilization techniques on shoulder dysfunction following liver donation.

PATIENTS AND METHODS

Sixty-six patients of both sexes were recruited randomly using the folded paper from the National Liver Institute, Menoufia University, according to the inclusion criteria. This trial was authorized by the research ethics committee of the Faculty of Physical Therapy, Cairo

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University. All patients were given thorough information regarding the test methods and trained to do the required tests.

This randomized controlled trial (RCT) followed the 1975 Helsinki Declaration's ethical guidelines. The study was registered under the number P.T.REC/012/005253. There were 66 participants in the pretest-posttest design. Every participant in this study gave their informed consent. They were split up into three groups, with twenty-two subjects in each group; besides a traditional physiotherapy program, Group A received LLLT, and Group B gained neural mobilization treatments. while Group (C) was only given a traditional physical therapy program.

Inclusion Criteria

Patients of both sexes were involved. They were between the ages of thirty and fifty. Patients experienced unilateral shoulder pain (right shoulder). The training protocol was started by patients one week after surgery. Every patient had a VAS score of more than 4, indicating moderate to severe pain.

Exclusion criteria

A history of high cancer or spinal cord injuries; diabetes; displacement or fracture; uncontrolled pulmonary or cardiovascular conditions; upper limb circulation problems; rotator cuff tendinitis, impingement syndrome, or lymphedema.

Methodology

A: Measurement instrumentation

The measurements were taken at the study's beginning and after the treatment procedures (after 4 weeks).

1. Digital goniometer

The digital goniometer, a device designed for measuring the human body's angles of motion with 1° resolution, is an excellent alternative to conventional goniometers, which typically depend on a scale of 5 incremental degrees [9]. To measure the most affected shoulder movements in liver donors (flexion, abduction, and lateral rotation) [5], the patient was told to assume a supine position. Shoulder ROM was evaluated prior to and after treatment (4 weeks) [10].

For shoulder flexion

The participant's arm was first positioned beside his torso with the thumb directed upward and the elbow extended. The lateral portion of the greater tubercle served as the measurement axis, and the lateral epicondyles served as a baseline point. The movable arm was positioned parallel to the lateral side of the upper arm, with the fixed arm placed parallel to the ground.

For shoulder abduction

The subject began with his arm laterally rotated adjacent to his body, elbow extended, palm pointing upward, with no shoulder flexion or extension. The medial epicondyle was represented as the reference point, while the anterior side of the acromion process served as the axis of measurement. The mobile arm was positioned parallel to the front side of the upper arm, while the fixed arm was adjusted parallel to the ground.

For shoulder external rotation

The participant began with his arm abducted 90 degrees, his elbow bent 90 degrees, his forearm perpendicular to the plinth, his palm pointing to his feet with no pronation or supination of the forearm, and his elbow outside the plinth. A small cushion was positioned beneath the humerus to ensure that it was level with the acromion. The clavicle, thorax, and distal humeral end were all stabilized. The ulnar styloid process served as the reference point, while the olecranon process served as the measurement axis.

1. **Hand-Held Dynamometer (HHD)**

The maximum isometric shoulder abductor muscle strength was objectively measured via the Lafayette Manual Muscle Tester, Model # 01163 (Lafayette Instrument Inc., Indiana). It provides a quantitative force measurement, in contrast to manual muscle testing. Compared with an isokinetic apparatus, HHD is an accurate and reliable tool for assessing muscular strength in a clinical context due to its portability, affordability, simplicity, and small size [11]. Lafayette HHD was used to assess the shoulder abductors' maximum isometric force (MIF) prior to and following the treatment procedure. An adaptive isometric "make" test was used to measure the MIF. Participants applied their maximum force against the examiner while maintaining a stable position. Each muscle group was subjected to three 5-second contractions by the participants, with a 30-second pause following each trial and a 5-minute interval in between. Each muscle's average force from the three measured trials was calculated.

2. Arabic Version of Shoulder Pain and Disability Index (SPADI)

The significance of the SPADI is recognized by its translation, cultural adaptation, and validation into various languages [12]. The 13 items on this self-administered index are split into two subscales: 8 points for impairments and 5 points for pain. To evaluate shoulder impairments, SPADI has demonstrated excellent construct validity and reliability, primarily in patients presenting with shoulder pain at the primary healthcare level (Venturin et al., 2022). Arabic version of SPADI: For the feasibility of assessors and the local public, the SPADI was translated into several languages [13]. The 13 items on the SPADI, a self-reported scale, are split into two sections: the pain domain and the disability domain. Five questions describing the level of pain at its highest point, when lying on the affected side, grabbing an object on a higher shelf, feeling the neck pain, and pressing with the affected arm are included in the pain subscale. The disability subscale comprised eight questions about how difficult it is to wash your hair, wash your back, put on a sweater or undershirt, put on a front-button shirt, put on your trousers, place an item on a higher shelf, carry an item weighing ten pounds (4.5 kilograms), and take an object out of your back pouch. Eleven numerical values, ranging from 0 to 10, were assigned to each question on the pain and disability subscales. The summation of each score was transferred into a percentage. Lastly, SPADI will be assessed before and after therapy (6 weeks), with the mean result of the pain and disability subscales comprising the overall SPADI scores, which range from zero (the best) to one-hundred (the worst)**[13].**

Intervention instrumentation

1. **Low level laser**

The low-level laser (LLT) model (Fisioline, Lumix 2; Italy) was utilized. Clinical uses of LLLT have mostly relied on earlier research on the effects of LLT, such as boosting the synthesis of adenosine triphosphate while simultaneously having a positive impact on collagen and fibroblast production at the molecular-cellular level [14]. Besides the traditional physical therapy, Group (A) received LLLT (Fisioline Lumix 2, Italy).

The patients were seated comfortably with assistance. To avoid retinal injury, patients and the physiotherapist were advised to wear eyeglasses. At least two to four painful sites were exposed to LLLT (GaAs type 1-10 mW, and 904 nm) every three to four minutes, with a maximum duration of 15 minutes [15]. The upper trapezius and deltoid muscles were the most painful regions **[5].**

2. Neural mobilization techniques

A professional physiotherapist uses nerve mobilization (NM), a physiotherapy technique that includes pulling, vibrating, or manipulating nerve tissue to enhance nervous system efficiency. This method is primarily used to treat neuropathy, nerve discomfort, tense muscles, and other neurological issues [15]. NMT was administered to Group (B) in addition to traditional physical therapy.

To begin the NMT application, the patient assumed a sitting position with the arm initially at the side and the elbow bent at 90 degrees. The procedure began with gently extending the patient's shoulder (moving the arm backward) while keeping the elbow bent. This movement creates tension on the axillary nerve. Hold the tension for a few seconds, ensuring it is within the patient's tolerance level and not causing discomfort or pain. Next, slowly return the shoulder to the initial position, releasing the tension on the nerve. The movement should be controlled and gentle. Repeat this sequence of tension and release, gradually increasing the ROM as tolerated by the patient.

Dosage: Ten repetitions in three sets, with a one-minute rest in between.

Frequency: 3 sessions/week

Total treatment period: 4 weeks **[8].**

Group C: received traditional physical therapy

Conventional exercise plan

The patients in three groups completed the following exercises. Pendulum exercises, rotator cuff, wall creeping, isometric scapular retraction, active-assisted ROM, and Codman. Every exercise, including bending extension and abduction-adduction, was done in one set of ten to fifteen repetitions within a free pain limit, and participants were told to complete their ADLs [16]. Upper limb active ROM: Chin tucks, shoulder shrugging, shoulder circular motion, scapular retraction, and shoulder ROM exercises include shoulder extension and adduction with moderate resistance and shoulder flexion and abduction to enhance glenohumeral and scapulothoracic mobility and shoulder medial/lateral rotation with roughly two sets of 15 repetitions [17].

Data analysis

ANOVA and Chi-squared tests were utilized to compare age and sex distribution across groups, respectively. Normality was assessed by the Shapiro-Wilk test, and Levene's test verified homogeneity of variances. Mixed MANOVA analyzed the effects on shoulder ROM, abductor strength, and SPADI. For post-hoc comparisons, Bonferroni correction was employed, with a significance level of $p < 0.05$. Analyses were performed utilizing SPSS version 27 (IBM SPSS, Chicago, IL, USA).

RESULTS

- Subject demographics

The participant demographics of all groups are displayed in Table (1). The distribution of age and sex did not change significantly among groups ($p > 0.05$).

Table 1. The participant basic demographics

	Group A	**Group B**	**Group C**	**p-value**
	mean ± SD	**mean ± SD**	**mean ± SD**	
Age (years)	41.05 ± 6.75	40.68 ± 7.12	41.14 ± 7.29	0.97
Sex, n (%)				
Females	17 (77%)	16 (73%)	18 (82%)	0.77
Males	5 (23%)	6 (27%)	4 (18%)	

SD, standard deviation; p-value, probability value

Impact of treatment on shoulder ROM, shoulder abductor strength, and SPADI

Table 2. *Mean shoulder flexion, abduction and external rotation ROM before and after treatment of all groups:*

ROM (degrees)	Group A	Group B	Group C
	mean ± SD	**mean ± SD**	**mean ± SD**
Flexion			
Pre treatment	148.59 ± 5.36	146.64 ± 3.89	147.82 ± 4.40
Post treatment	164.64 ± 3.93	160.41 ± 4.69	156.55 ± 4.67
MD (% of change)	-16.05 (10.80%)	-13.77 (9.39%)	-8.73 (5.91%)
95% CI	-16.99: -15.10	-14.71: -12.83	-9.67: -7.79
	p = 0.001	***p = 0.001***	***p = 0.001***
Abduction			
Pre treatment	154.64 ± 6.30	156.86 ± 5.12	155.73 ± 5.47
Post treatment	171.36 ± 5.61	166.18 ± 4.64	160.23 ± 5.46
MD (% of change)	-16.72 (10.81%)	-9.32 (5.94%)	-4.50 (2.89%)
95% CI	-18.26: -15.19	-10.86: -7.78	-6.04: -2.96
	p = 0.001	***p = 0.001***	***p = 0.001***
External rotation			
Pre treatment	70.32 ± 4.69	71.36 ± 5.17	71.55 ± 4.90
Post treatment	84.27 ± 4.51	79.82 ± 5.77	75.41 ± 5.11
MD (% of change)	-13.95 (19.84%)	-8.46 (11.86%)	-3.86 (5.39%)
95% CI	-15.27: -12.64	-9.77: -7.14	-5.18: -2.55
	p = 0.001	***p = 0.001***	***p = 0.001***

MD, Mean difference; CI, Confidence interval; p value, Probability value

Table 3. *Mean shoulder abductor strength and SPADI before and after treatment of all groups:*

	Group A	Group B	Group C
	mean ± SD	**mean ± SD**	**mean ± SD**
Shoulder abductors strength (kg)			
Pre treatment	10.17 ± 0.78	10.05 ± 0.71	10.03 ± 0.58
Post treatment	13.50 ± 1.23	11.90 ± 0.95	10.75 ± 0.78
MD (% of change)	-3.33 (32.74%)	-1.85 (18.41%)	-0.72 (7.18%)
95% CI	-3.79: -2.87	-2.31: -1.39	-1.18: -0.26
	p = 0.001	***p = 0.001***	***p = 0.001***
SPADI			
Pre treatment	75.36 ± 6.74	76.45 ± 6.44	75.86 ± 7.29
Post treatment	42.50 ± 5.85	53.73 ± 6.09	58.82 ± 6.29
MD (% of change)	32.86 (43.60%)	22.72 (29.72%)	17.04 (22.46%)
95% CI	30.20: 35.53	20.06: 25.39	14.38: 19.71
	p = 0.001	***p = 0.001***	***p = 0.001***

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p value, Probability value

Table 4. Comparison of shoulder ROM, shoulder abductor strength, and SPADI across all *groups after treatment.*

Outcome	Group A vs B		Group A vs C		Group B vs C		ηp²
	MD (95% CI)	p value	MD (95% CI)	p value	MD (95% CI)	p value	
Flexion ROM (degrees)	4.23 (1.01: 7.44)	0.007	8.09 (4.88: 11.31)	0.001	3.86 (0.65: 7.08)	0.01	0.37
Abduction ROM (degrees)	5.18 (1.38: 8.98)	0.005	11.14 (7.33: 14.94)	0.001	5.95 (2.15: 9.76)	0.001	0.44
External rotation ROM (degrees)	4.45 (0.73: 8.18)	0.01	8.86 (5.13: 12.59)	0.001	4.41 (0.68: 8.14)	0.01	0.34
Shoulder abductors strength (kg)	1.60 (0.87: 2.32)	0.001	2.75 (2.02: 3.48)	0.001	1.15 (0.43: 1.88)	0.001	0.57
SPADI	-11.23 (-15.63: -6.83)	0.001	-16.32 (-20.72: -11.92)	0.001	-5.09 (-9.49: -0.69)	0.01	0.57

CI, Confidence interval; p value, Probability value; ηp², Partial Eta Squared.

DISCUSSION

Regarding shoulder ROM, the current results revealed that LLLT statistically increased shoulder ROM compared with neural mobilization. This aligns with **[18],** who stated that LLLT enhances mitochondrial ATP production, reduces inflammatory cytokines, improves microcirculation, promotes nerve regeneration, and reduces neuropathic pain. **Abrisham et al. (2011) [19]** carried out a double-blind RCT in patients with subacromial syndrome and demonstrated that LLLT combined with exercise provided significantly increased ROM in shoulder flexion, abduction, and lateral rotation relative to exercise alone. The authors attributed these improvements to the anti-inflammatory and biostimulatory impacts of photobiomodulation, which may lessen pain and allow greater active movement. Similarly, **Ordahan et al. (2023) [20]** reported significant gains in shoulder ROM following LLLT in cases with adhesive capsulitis, with clinically meaningful improvements in abduction and external rotation compared with baseline values.

In contrast, while mobilization techniques, including joint mobilization and neurodynamic approaches, have demonstrated effectiveness in improving shoulder ROM, superiority over other modalities is not consistently established. **Vermeulen et al. (2006) [21]**, an RCT comparing high-grade and low-grade mobilization procedures in individuals with adhesive capsulitis, indicated ROM improvements in the two groups, with superior results in the higher-grade mobilization group. However, the gains reported were gradual and mostly dependent on mechanical capsular stretching rather than neuromodulatory effects.

Regarding shoulder muscle strength, current evidence indicates that LLLT can produce measurable improvements in shoulder muscle strength, particularly when combined with exercise-based rehabilitation, whereas neural mobilization primarily targets neural mechanosensitivity and pain rather than direct muscle performance. In a double-blind RCT, **Abrisham et al. (2011) [19]** investigated the further impact of LLLT with therapeutic exercise in cases with subacromial impingement syndrome. They indicated better shoulder functional capacity and pain relief in the LLLT group relative to the exercise group only. Because strength recovery in impingement syndrome is strongly influenced by pain inhibition, the superior functional gains observed in the laser group suggest enhanced restoration of muscle performance secondary to reduced inflammatory and nociceptive processes. These findings support the concept that photobiomodulation may indirectly enhance shoulder muscle strength by allowing more effective voluntary contraction.

In a prospective RCT with hemiplegic shoulder discomfort, **Korkmaz et al. (2022) [22]** discovered that high-power laser therapy considerably enhanced upper limb motor functioning as compared to traditional rehabilitation alone. Improvements in functional motor scores reflect enhanced muscle activation and strength performance in the shoulder complex.

Systematic review evidence further supports the functional benefits of LLLT. In a meta-analysis of RCTs on shoulder tendinopathy**, Haslerud et al. (2015) [23]** found that when LLLT is utilized at appropriate dosages, it dramatically reduces pain and shoulder functioning. The trials' improvements in functional scores indicate an enhanced capacity for daily activities and shoulder performance.

In contrast, evidence for neural mobilization in shoulder conditions primarily demonstrates improvements in pain and neural mechanosensitivity, with more limited data on global shoulder function scores. Studies examining neurodynamic mobilization in upper limb neuropathies report functional improvements; however, these are often modest and gradual **(Sharaf et al., 2020) [24]**. Neural mobilization primarily addresses neural tension and does not directly target inflammatory or degenerative tissue changes within the shoulder joint complex. Therefore, while neural mobilization is beneficial, particularly in cases with neural involvement, its impact on comprehensive shoulder function outcomes may be less pronounced compared to modalities that directly modulate inflammation and tissue healing.

CONCLUSION

Laser therapy improved shoulder ROM, abductor muscle strength, and function in patients post-liver donation. This may help the effective rehabilitation of these patients.

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Conflicts of interest

No conflicts of interest.

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