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# Effect of proprioceptive neuromuscular facilitation versus low level laser therapy on shoulder adhesive capsulitis post-neck dissection surgery

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**Abstract**

**Introduction.** Neck dissection (ND) operations are performed to treat known metastatic neck illness. These operations have been associated with chronic neck and shoulder problems. In patients who have had a ND, adhesive capsulitis (AC) is one of the causes of shoulder dysfunction.

**Methods.** Forty patients with AC following modified radical neck dissection (MRND) surgeries were chosen at random and divided into two groups of equal size. The low-level laser therapy (LLLT) group (group A) received LLLT with: wavelength – 830 nm, output – 50 mw, maximum frequency – 5000 Hz, pulse duration – 50 ns, and average dose – 9 J/cm$^2$ for 20 min, plus traditional physical therapy (mobilisation technique, myofascial release, range of motion (ROM), and strengthening exercises) for 30 min. The proprioceptive neuromuscular facilitation (PNF) group (group B) received PNF for 25–30 min in addition to traditional physical therapy. The treatment period was 3 times each week and lasted for eight weeks. The discomfort in the shoulder was measured using the visual analogue scale (VAS). Shoulder impairment and pain were assessed by the SPADI scale and the shoulder ranges of motion were assessed using the universal goniometer technique. All measures were taken before and after the intervention.

**Results.** The findings reveal that there was a significant enhancement in all variables in both groups A and B after therapy compared to before the treatment ($p < 0.001$). After therapy, there were no obvious changes in the VAS and SPADI values among the groups ($p > 0.05$). However, statistical analysis showed significant improvement in the PNF group (group B) in shoulder flexion, abduction and external rotation in comparison to that of the LLLT group (group A) after treatment ($p < 0.001$).

**Conclusions.** PNF proved to be more effective than LLLT in increasing ROM but was as effective as LLLT in decreasing shoulder pain and dysfunction in AC post ND surgery.

**Key words:** pneck dissection surgery, adhesive capsulitis, proprioceptive neuro muscular facilitation, low-level laser therapy

## Introduction

Neck dissection (ND) is a common procedure for treating malignant growth of the head and neck caused by squamous cell carcinoma [1]. Neck dissections (NDs) are classified according to the structures removed [2]. Radical neck dissection (RND) is one of these categories, which requires the removal of lymph nodes from one region of the neck, and also sternocleidomastoid muscle, major vein (internal jugular vein), as well as a nerve that governs the movement of the arm and shoulder, the spinal accessory nerve (SAN), whereas modified radical neck dissection (MRND) entails the removal of structures similar to classical selective neck dissection (SND), but with the preservation of one or more of the key extra nodal structures (SAN, sternocleidomastoid muscle, and internal jugular vein) [3,4]. SND also describes any sort of cervical lymphadenectomy in which one or more lymph node groups are preserved after RND [4]. During NDs, it has been demonstrated that sacrificing the SAN causes shoulder illness plus common shoulder disease, which is identified by limitation in motion and discomfort in the shoulder and neck; preserving SAN reduces the above and resolves the shoulder disease [5]. The risks and benefits of lateral neck dissection (LND) must be considered and reevaluated by considering both the oncologic outcomes and complication rates [6]. Shoulder and neck pain may influence patients' condition of living for at least one year after the neck surgery, according to van Wilgen et al. [7]. Infection, thrombosis, chyle leak, and heart issues are common early postoperative consequences. The most prevalent symptoms are neck discomfort and tightness, reduced shoulder and cervical ranges, lymphedema, a decrease in mouth opening, and swallowing issues. In relation to severity RND results in the most significant modifications to neck and shoulder movement, whereas SND results in the least. Adequate exposure needs extensive manipulation of the SAN, resulting in its injury, which may explain why trapezius muscle dysfunction occurs in only a small fraction of patients after a SND. During ND, the nerve is tractioned in the neck along its whole length, even though the nerve is intact. If the SAN is not cut, the dysfunction may be reversible; however, it may take a few months for adhesive capsulitis (AC) to return to normal function. Shoulder joint function improves with MRND and SND compared to RND [8, 9]. As a result of this procedure, long-term shoulder difficulties have emerged following surgery [10]. Shoulder dysfunction or AC and pain occur in 20–60% of patients after various types of NDs [8]. Shoulder pain, droop, and impairment of active shoulder range of motion (ROM) were the most frequently reported consequences of ND. Shoulder pain was slightly more common following RND than after MRND, and much more common than after SND (9–25%). Shoulder droop was shown to be more common in RND (44–100%) and MRND (0–30%) than in SND (13%). Furthermore, shoulder abduction was decreased in RND of one neck side (92–94%), RND of both

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sides of the neck (100%), and MRND (23%) [11], due to fibrosis and eventual rigidity of the glenohumeral joint capsule, causing AC, which is defined as a painful disorder causing a gradual loss of active and passive glenohumeral motion [12]. The pain is described as a dull, poorly localised aching that can migrate to the biceps, which can cause stiffness and pain. Reduced ROM in forward flexion, abduction and external rotation is the most common symptom of AC. In severe disease, observing a patient's stride indicates a lack of the normal arm motion that happens when walking [13].

AC can be managed pharmacologically by medication, such as oral steroid treatment and intra-articular steroid injections, non-pharmacologically using cryotherapy, transcutaneous electrical nerve stimulation (TENS), low-level laser therapy (LLLT), activity modification, moderate ROM exercises and proprioceptive neuromuscular facilitation (PNF) or it can be managed by surgical treatment using arthroscopy capsulotomy, which is performed on patients for whom non-operative treatment has failed [14, 15]. LLLT is a non-invasive, non-thermal treatment option for a variety of musculoskeletal disorders [16]. The capacity of photoreceptors on the subcellular level to react to visible red as well as near-infrared wavelengths is crucial to the mechanism of action. Stimulating such receptors affects the electron transport chain, the respiratory chain, and oxidation, resulting in an increase in cellular metabolic activities [17]. By lowering oxidative stress or limiting axonal transit, laser has been shown to alleviate muscle discomfort. Furthermore, the laser aids tendon mending and collagen formation found in the ligaments of the glenohumeral joint as well as the synovia, which is greatly reduced in AC, resulting in mobility restriction [18]. PNF is a technique that uses intrinsic receptors to stimulate and improve neuromuscular structures. This stretching method was created to decrease muscle stretching encouragement while boosting inhibition. It is a therapeutic strategy that uses four theoretical mechanisms to improve ROM and muscle activation: autogenic inhibition, reciprocal inhibition, stress relaxation, and the gate control theory. PNF techniques, particularly those that combine reciprocal activation of the agonist and antagonist to the intended motion, offer the most promise for improving muscle function, joint coordination, and movement control. This is performed through therapist monitoring and rotational diagonal movement patterns caused by a variety of stimuli. Autogenic inhibition (post-isometric relaxation) activates the Golgi tendon organs, which transmit an inhibitory signal towards the inhibitory interneurons in the spinal cord through Ib afferent nerve fibres when PNF procedures are used. These inhibitory interneurons also inhibit the alpha motor neuron in the same muscle, allowing the muscle to be in a resting position. The need for this research arose from a deficiency of quantitative data and information in previous studies evaluating the influence of LLLT on frozen shoulder following ND operations versus PNF. This study may help in planning appropriate treatments for decreasing the consequences of AC following ND operations by providing instructions on the treatment modalities of LLLT and the effect of PNF on shoulder AC symptoms.

## Subjects and methods

Forty patients suffering from shoulder AC after neck dissection surgeries participated in this study. The individuals were sent to our outpatient clinic at Damanhour Medical National Institute by the Damanhour Oncology Center and were divided into two groups of similar size. The study included patients who involved the following requirements: (1) Both sexes with age ranging from 25 to 65 years old with shoulder AC after MRND procedures, (2) All the patients had shoulder pain and impairment after MRND surgery, (3) All the patients had moderate-to-severe pain (VAS > 4), and (4) Informed consent was obtained from all patients enrolled in the trial. The following were the criteria for exclusion: (1) There is a wound in the affected area, (2) A lesion in the cervical disc, (3) Spondylolisthesis or a fracture in the cervical spine, (4) Chronic inflammatory disease that affects the joints, and (5) Epilepsy or any psychological disorders.

### Design

Using the envelope approach, the patients in this study were randomised into two groups of equal size. The full nature of the investigation was given, and informed consent was obtained. Patients who agreed to participate in the study were given cards with the words 'LLLT' or 'PNF' written on them, which were sealed in envelopes and given to a blinded physical therapist to choose one of the envelopes. Based on the selected card, patients were assigned to the appropriate group. The start dates for the allocated therapy were set, and treatment began. The examiner was not informed which therapy each patient was assigned. Patients were requested not to tell the physical therapist their therapy assignment during the evaluation. The participants were instructed to report any undesirable effects at any time during the treatment period.

### Assessment methods

#### *Visual Analogue Scale* (*VAS*)

The VAS is a subjective, validated measure of acute and chronic pain. Handwritten marks on a 10-cm line representing a continuum between 'no pain' and 'worst pain' are used to record scores. Patients are then asked to mark that line to show their pain level. The final score might range from '0' to '10' points (no pain to the worst pain) [22].

#### *Universal goniometer assessment*

Universal Goniometer is a technique used by physical therapists to quantify passive and active (ROM). The measurements are commonly used to detect ROM restrictions, determine relevant therapies, and track therapy success (The assessments for shoulder flexion, abduction, and external rotation were recorded from a supine lying position) [23].

#### *SPADI scale assessment*

The SPADI scale consists of 13 tasks, each of which is assessed on a visual analogue scale ranging from 0 (no pain/no difficulty) to 10 (worst agony imaginable/so difficult that aid was required). The final score might range from 0 to 10 points (best to worst) [24]. All patients were assessed at baseline and eight weeks after starting treatment.

### Treatment

Both groups received a traditional physical therapy program for 30 min in the form of: (1) Mobilisation technique, specifically distraction, caudal glide, and posterior glide of the glenohumeral joint, (2) Myofascial release by releasing the underlying connective tissue and fascia, and then rebalancing the affected muscles and stabilising the bone of the arm within the joint, (3) Strengthening exercises for shoulder abductors, flexors and external rotators, and (4) ROM exercises, such as Codman/pendulum exercise, wall climbing exercise and shoulder wheel exercise. Group A received LLLT (PR999, Medical Italia, Italy) with the following parameters: wavelength – 830 nm, output – 50 mw, maximum frequency – 5000 Hz, pulse duration – 50 ns, and average dose – 9 J/cm$^2$ for 20 min. Group B received PNF for 25–30 min; this exercise was performed while the patient was sitting in a comfortable position, then diagonal pattern 2 was performed as follows: First, the flexion pattern: the patient was asked to adduct and internally rotate his or her arm with the forearm crossing the umbilicus; then the extension pattern: the patient was asked to open his or her hand and turn it toward the face lifting their arm up and out while pointing the thumb outwards. diagonal pattern 1 was performed as follows: First, the flexion pattern; the patient was asked to move his or her arm backwards, away from the body with the palm facing the ceiling and wrist and finger flexion; then the extension pattern: the patient was asked to turn his or her palm up, with the elbow partially flexed, pulling their arm up, crossing the face. The treatment was conducted three times per week for eight weeks. During the therapy time, all patients were told not to take any additional AC medications.

### Statistical analysis

An unpaired *t*-test was used to compare the age of the groups. To compare the sex distribution between the two groups, the chi-squared test was used. To make sure the data had a normal distribution, the Shapiro–Wilk test was utilised. The Levene's test for value similarity was employed to determine group homogeneity. An unpaired *t*-test was utilised to compare the group mean values of VAS, SPADI, and shoulder ROM. To compare before and after therapy in each group, a paired *t*-test was utilised. All statistical tests were performed with a significance threshold of 0.05. All statistical analyses were conducted using the Statistical Program for Social Studies (SPSS) version 22 for Windows (IBM SPSS, Chicago, IL, USA).

## Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by ethical committee at Faculty of Physical Therapy Cairo University (approval No.: P.T.REC/012/003499).

## Informed consent

Informed consent has been obtained from all individuals included in this study.

## Results

### Effect of treatment on VAS, SPADI and shoulder ROM

#### *Within-group comparison*

There was a significant decrease in VAS and SPADI post-treatment compared with that of pre-treatment in both groups A and B ($p > 0.001$). There was also a significant increase in shoulder flexion, abduction and external rotation post-treatment compared with that of pre-treatment in both groups ($p < 0.001$).

#### Between-groups comparison

There was a significant increase in shoulder flexion, abduction and external rotation of group B compared with that of group A post-treatment ($p < 0.001$). However, there was no significant difference between groups pre-treatment ($p > 0.05$). Comparison between groups post-treatment revealed non-significant differences in VAS and SPADI ($p > 0.05$).

Table 1 shows patients' characteristics within both groups. There was no notable variation in age or sex distribution across groups ($p > 0.05$).

Table 1. Differences in patients' characteristics between groups

| | Group A mean ± *SD* | Group B mean ± *SD* | *t*-value | *p*-value |
|---|---|---|---|---|
| Age (years) | 39 ± 14.09 | 42.7 ± 13.88 | –0.83 | 0.41 |
| Sex, *n* (%) | | | | |
| Females | 12 (60%) | 11 (55%) | ($\chi^2$ = 0.1) | 0.74 |
| Males | 8 (40%) | 9 (45%) | | |

Before starting therapy, there was no statistical difference between groups ($p > 0.05$).

Table 2. Mean VAS and SPADI before and after treatment

| | Group A mean ± *SD* | Group B mean ± *SD* | MD | *t*-value | *p*-value |
|---|---|---|---|---|---|
| VAS | | | | | |
| Pre-treatment | 7.45 ± 1.35 | 7.1 ± 1.25 | 0.35 | 0.84 | 0.4 |
| Post-treatment | 2.1 ± 0.78 | 2.2 ± 0.95 | –0.1 | –0.36 | 0.71 |
| MD | 5.35 | 4.9 | | | |
| % of change | 71.81 | 69.01 | | | |
| *t*-value | 23.01 | 25.71 | | | |
| | *p* = 0.001 | *p* = 0.001 | | | |
| SPADI | | | | | |
| Pre-treatment | 95.75 ± 11.33 | 91.55 ± 11.18 | 4.2 | 1.18 | 0.24 |
| Post-treatment | 21.2 ± 8.54 | 19.05 ± 10.29 | 2.15 | 0.72 | 0.47 |
| MD | 74.55 | 72.5 | | | |
| % of change | 77.86 | 79.19 | | | |
| *t*-value | 45.26 | 62.27 | | | |
| | *p* = 00.001 | *p* = 00.001 | | | |

Table 3. Mean shoulder ROM before as well as after treatment

| ROM (degrees) | Group A mean ± *SD* | Group B mean ± *SD* | MD | *t*-value | *p*-value |
|---|---|---|---|---|---|
| Flexion | | | | | |
| Pre-treatment | 68.85 ± 16.33 | 72.75 ± 12.54 | –3.9 | –0.84 | 0.4 |
| Post-treatment | 156.25 ± 7.04 | 170.5 ± 7.76 | –14.25 | –6.07 | 0.001 |
| MD | –87.4 | –97.75 | | | |
| % of change | 126.94 | 134.36 | | | |
| *t*-value | –33.1 | –60.2 | | | |
| | $p = 0.001$ | $p = 0.001$ | | | |
| Abduction | | | | | |
| Pre-treatment | 55 ± 14.95 | 57 ± 16.17 | –2 | –0.41 | 0.68 |
| Post-treatment | 94.5 ± 13.36 | 111 ± 16.82 | –16.5 | –3.43 | 0.001 |
| MD | –39.5 | –54 | | | |
| % of change | 71.82 | 94.74 | | | |
| *t*-value | –41.45 | –29.42 | | | |
| | $p = 0.001$ | $p = 0.001$ | | | |
| External rotation | | | | | |
| Pre-treatment | 39.75 ± 6.33 | 38.25 ± 5.24 | 1.5 | 0.81 | 0.41 |
| Post-treatment | 48.75 ± 7.23 | 64.75 ± 8.34 | –16 | –6.47 | 0.001 |
| MD | –9 | –26.5 | | | |
| % of change | 22.64 | 69.28 | | | |
| *t*-value | –12.46 | –17.79 | | | |
| | $p = 0.001$ | $p = 0.001$ | | | |

## Discussion

The main objective of this research was to compare between the effects of LLLT and PNF on shoulder pain and ROM in AC to find the ideal treatment for reducing the complications of AC after MRND surgeries. The SPADI and VAS score evaluations demonstrated considerable improvements, as the percentage of improvement was 71.81% and 77.86%, respectively, in the LLL group, and 69.01% and 79.19%, respectively, in the PNF group. There was a significant increase in shoulder flexion, abduction and external rotation post-treatment. The changes in shoulder flexion, abduction and external rotation in the LLL group were 126.94%, 71.82% and 22.64%, respectively, and that in the PNF group, 134.36%, 94.74% and 69.28%, respectively. The VAS and SPADI scores were not significantly different between groups after therapy ($p > 0.05$). However, there was a significant increase in shoulder flexion, abduction and external rotation in the PNF group compared with that of the LLL group post-treatment ($p < 0.001$).

These findings suggest that the involvement of exercise in PNF is significant in improving ROM as the diagonal movement patterns of PNF can improve mobility, joint synchronisation, and movement control. Single-session therapy using PNF methods and patterns, according to Olędzka et al. [25], can enhance both the active and passive range of shoulder mobility, while a single session of local cryotherapy, laser therapy and magnetic field therapy did not enhance the ROM or the reduce pain immediately following an intervention in research assessing the effectiveness of PNF in improving shoulder ROM using the DASH questionnaire in patients with subacromial impingement syndrome. The experimental group received PNF-based therapy, whereas the control group received local cryotherapy, laser therapy and magnetic field therapy, followed by single-session PNF therapy. The average active shoulder flexion, abduction, and external rotation were all enhanced in the PNF group by 15 degrees, 13 degrees, and 8 degrees, respectively, while passive shoulder flexion, abduction, and external rotation were raised by 14 degrees, 18 degrees, and 7 degrees, respectively. The pain was decreased in 73% of cases receiving local cryotherapy, laser therapy and magnetic field therapy, but there was no significant ROM improvement. Akbaş et al. [26] undertook similar comparative research where patients with AC received upper extremity and scapular PNF treatment 5 times a week for a total of fifteen sessions. The severity of pain during activity decreased in both groups, whereas shoulder flexion and abduction ROM increased significantly in the PNF group ($p < 0.05$). Moreover, in the research group, pain was greatly reduced ($p < 0.05$), while remaining unchanged in the control group ($p > 0.05$). Both groups' SPADI scores dropped significantly ($p < 0.05$). The findings revealed that PNF patterns contribute significantly to an improvement of pain and flexion and abduction ROM in patients with shoulder problems, suggesting that including PNF applications into an AC therapy protocol might improve the outcomes. Recently, Lin et al. [27] evaluated the effect of PNF on the treatment of frozen shoulder through a pilot randomised controlled trial using magnetic resonance imaging (MRI) observation to assess the improvement of the local structure of the shoulder joint, and reported that the PNF technique was more helpful in relieving the pain and restoring the joint structure of patients with frozen shoulder compared to traditional manual therapy. Because scapular kinematics is disrupted in AC patients, PNF therapy has been shown to be more effective in repairing abnormal modifications in the shoulder joint's anatomy. The PNF technique also emphasises diagonal movements that activate the body's proprioceptors, encourage appropriate neuromuscular responses, and improve muscle contraction capacity. Previous research reinforces the findings of this study, showing substantial shoulder ROM improvements in the PNF group compared to the LLLT group post-treatment [20, 27].

In this study, both techniques reduced shoulder discomfort. The gate control hypothesis could explain one possible mechanism for pain reduction in PNF approaches, as afferent inputs from muscle spindles, joints, tendons, and capsules throughout PNF movements might impede pain conduction at the dorsal grey horn laminae of the spinal cord [19–21]. The capacity of LLLT to enhance capillary permeability may explain its analgesic and anti-inflammatory benefits on AC. The analgesic effect of LLLT is attributed to an increase in endogenous opioids, such as endorphins, which function to block pain centrally [28]. Some studies presented consent, and others indicated contrary findings with the effect of LLLT on pain. Recently, Ezzati et al. [29] approved that the LLLT showed better analgesic effects than normal physical therapy. However, the effects on ROM, muscle thickness, and function were insignificant in the short term and one-month follow-up. Furthermore, according to Ip et al. [30], LLLT seems to be a realistic solution for the conservative management of shoulder discomfort in the elderly, caused by AC of the shoulder, with a clinical efficacy in the short and medium term, with a good clinical result of more than 90%. Also, Baireddy et al. [31] concluded that using LLLT along with Maitland's mobilisation therapy achieved significant improvement in the glenohumeral ROM, VAS and SPADI score.

## Limitations

There were no side effects or adverse effects of the treatment in this study, however, the study was limited by the small sample size and absence of follow-up, which could provide a more robust statistical analysis. Variations in skills and experience among oncology surgeons, possible human errors in measurement or therapeutic procedures, and patients' co-operation during the treatment were all factors that could limit this study.

## Conclusions

PNF was more effective than LLLT in increasing ROM but was as effective as LLLT in decreasing pain and improving function of the shoulder joint in patients with AC post-ND surgery.

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## Conflict of interest

The authors state no conflict of interest.

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