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Original Research Article

Effect of neural mobilization of musculocutaneous nerve on spasticity of elbow flexors in post-stroke patients: a pilot study

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ABSTRACT

Background: While neural mobilization shows promise, its effect on the musculocutaneous nerve remains underexplored. This pilot study evaluated the clinical effectiveness of musculocutaneous nerve mobilization on elbow flexor spasticity in chronic post-stroke individuals.
Methods: Eighteen chronic stroke survivors with elbow flexor spasticity were randomly assigned to Group A (experimental, n=9) or Group B (control, n=9). Group A received musculocutaneous nerve mobilization plus concurrent physiotherapy; Group B received structured elbow flexor stretching plus concurrent physiotherapy. Both interventions were delivered 5 times weekly for 6 weeks (45 minutes/ session). Outcome measures included surface electromyography (sEMG) root mean square difference (RMSD) of the biceps and brachialis, the Modified Ashworth Scale (MAS), and goniometric range of motion (ROM) for elbow flexion and extension lags.
Results: Both groups demonstrated statistically significant within-group improvements across all clinical and objective metrics ($p<0.05$ for MAS; $p<0.001$ for sEMG and ROM). Between-group analyses did not reach statistical significance for any outcome measure ($p>0.05$). However, Group A demonstrated a distinct clinical trend toward superior outcomes, achieving greater mean reductions in Biceps sEMG (7.57 µV to 4.80 µV vs. Group B: 8.36 µV to 6.68 µV) and greater decreases in flexion (15.22)^∘ with 15.22° and (7.33)^∘ with 7.33°.
Conclusion: Musculocutaneous nerve mobilization is a safe, clinically valuable intervention for post-stroke elbow spasticity. Though between-group statistical significance was limited by the pilot sample size, the technique showed superior descriptive clinical trends compared to stretching.

Keywords: Stroke rehabilitation, Spasticity, Musculocutaneous nerve, Neural mobilization, Surface electromyography, Range of motion

INTRODUCTION

Stroke is a major cause of neurological disability in India, where annual incidence is estimated between 105 and 152 cases per 100,000 individuals.[1] Pathogenesis is governed by multifactorial demographic, metabolic, and environmental determinants.[2-4] Advanced age and male sex represent key vulnerability factors.[5] Distinct demographic, clinical, and coagulation profiles between ischemic and hemorrhagic subtypes provide crucial guidance for targeted clinical management.[6] Following upper motor neuron damage, loss of descending inhibitory control leads to reticulospinal hyperactivity and spindle hypersensitivity, resulting in velocity dependent spastic

hypertonia.[7,8] Post stroke spasticity develops progressively, affecting up to 43% of patients by six months and emerging early in the elbow flexors before progressing distally.[9,10]

Because the nervous system functions as an integrated mechanical continuum, excessive tension along peripheral nerve trunks directly increases distal muscle stiffness and restricts mobility.[11] In stroke survivors, persistent hypertonia of the biceps brachii and brachialis limits functional reaching and daily activities, imposes mechanical stress across neural pathways, and impairs overall quality of life.[12] Conventional management employs stretching, range of motion exercises, dry needling, and functional electrical stimulation to alleviate muscular stiffness and preserve joint integrity.[13,14] Furthermore, orthotic positioning and active caregiver participation are essential to prevent secondary contractures during stroke rehabilitation.[15,16]

Neural mobilization techniques, established in peripheral entrapment neuropathies and gait rehabilitation, restore longitudinal nerve excursion, disperse intraneural edema, and modulate hyperactive spinal reflex loops.[17-19] Surface electromyography root mean square values and the Modified Ashworth Scale provide objective and clinical quantification of muscle overactivity and resistance to passive movement. While general neurodynamic protocols show clinical benefit, targeted mobilization of the musculocutaneous nerve supplying primary motor innervation to the spastic elbow flexors remains insufficiently investigated. Therefore, this pilot study evaluated the effect of musculocutaneous nerve mobilization on elbow flexor spasticity, electromyographic activity, and joint range of motion in chronic post stroke patients.[20]

METHODS

The study was designed as a randomized controlled pilot study and was conducted from February 2026 to April 2026 at Jaya College of Physiotherapy, Chennai, Tamil Nadu. The intervention was administered over a period of six weeks. Participants were screened and selected based on the predefined inclusion and exclusion criteria.

Inclusion criteria

Participants with hemorrhagic or ischemic strokes. Participants with chronic stroke. Participants who are oriented. Both male and female participants. Participants aged between 45 and 60 years.

Exclusion criteria

Participants with a Modified Ashworth Scale (MAS) score of 3 or greater. Participants with upper limb deformities. Participants who have had recent surgeries on the upper limb. Participants with visual impairments. Participants with cognitive problems.

The study protocol received Institutional Ethical Committee approval. Following voluntary written informed consent and baseline medical evaluation, 18 eligible chronic stroke participants were enrolled via convenience sampling. Participants were allocated into two equal groups using computerized randomization, with allocation concealment maintained through sealed envelopes. Group A, which is an experimental group, received Neural Mobilization targeting musculocutaneous nerve, combined with Concurrent Physiotherapy. Group B, which is a control group, received the stretching of elbow flexors along with Concurrent Physiotherapy.

Group A

Participants in Group A underwent a structured neural mobilization protocol targeting the musculocutaneous nerve along with conventional physiotherapy. Each session was conducted with the participant positioned supine, maintaining the head and neck in a neutral alignment. The mobilization sequence included the following steps: Application of shoulder girdle depression to pre-tension the nerve bed. Full extension of the elbow to elongate the nerve pathway. Shoulder extension to further stretch the musculocutaneous nerve. Ulnar deviation of the wrist combined with thumb flexion to increase distal neural tension. Medial or lateral rotation of the arm, as needed, to selectively enhance nerve sensitization based on participant tolerance Figure 1.

Figure 1: Neural mobilization of musculocutaneous nerve on post stroke spasticity.

The mobilization protocol consisted of 3 sets of 20 repetitions (9-second hold per repetition, 1-minute rest between sets; 12 minutes total session), administered 5 days weekly for 6 weeks. Each session was followed by 30 minutes of concurrent conventional physiotherapy to optimize functional motor recovery.

Group B

Participants in Group B received structured stretching exercises, each session was conducted with the participant

positioned supine on a plinth, ensuring the scapula was free from the bed to allow optimal shoulder positioning. The stretching sequence included the following positioning elements: Shoulder positioned in abduction. Elbow fully extended to elongate the flexor muscles. Wrist held in dorsiflexion. Fingers extended to complete the stretch through the upper extremity. The stretching protocol consisted of 3 sets of 3 repetitions (60-second hold per repetition, 1-minute rest between sets; 12 minutes total), administered 5 days weekly for 6 weeks. Each session was delivered alongside 30 minutes of concurrent conventional physiotherapy.

Concurrent treatment

Along with neural mobilization or stretching both the groups underwent 30 minutes of standard physiotherapy rehabilitation which included: Strengthening exercises targeting the triceps to promote reciprocal inhibition. Functional tasks, such as reaching, grasping, and releasing, were incorporated to enhance voluntary motor control. Weight-bearing activities through the affected limb were utilized to reduce spastic muscle tone. These interventions aimed to improve overall functional movement and reduce the impact of spasticity on daily activities.

Outcome measures

Outcome measures included surface electromyography (sEMG), the Modified Ashworth Scale (MAS), and goniometric range of motion (ROM). All the outcome measures were administered by a licensed physiotherapist at pre- and post- intervention. The participants' attendance was consistently monitored and recorded throughout the intervention period.

Surface Electromyography (sEMG): Muscle overactivity of the biceps brachii and brachialis was recorded using a Natus Synergy Elite system. The Root Mean Square Difference (RMSD, µ"V") between baseline and stretch reflex onset served as the primary neurophysiological indicator.

Modified Ashworth Scale (MAS): Evaluated resistance to passive elbow extension, with score 1+ recorded as 1.5 for statistical computation.

Goniometry: A standard universal goniometer measured elbow joint extension lag and flexion lag ((_^∘)).

Data analysis

Statistical analysis was performed using IBM SPSS software (version 30.0). For continuous parametric variables (sEMG and ROM), paired samples t-tests were used for within-group comparisons, and unpaired t-tests were utilized for between-group comparisons. For ordinal non-parametric data (MAS scores), the Wilcoxon Signed-Rank test evaluated within-group differences, and the Mann-Whitney U test compared post-test values between groups. Significance was set at $p < 0.05$.

RESULTS

All 18 participants successfully completed the 6-week intervention without any dropouts. Results showed significant within-group improvements in both groups from pre- to post-intervention. MAS scores decreased significantly within both Group A and Group B (p=0.043) (Table 1); however, the Mann–Whitney U test for between-group comparisons of post-test MAS revealed no statistically significant difference (p=0.59) (Table 2). EMG analysis revealed a greater descriptive reduction in Biceps RMSD for Group A (7.57 µV to 4.80 µV) (Table 3) compared to Group B (8.36 µV to 6.68 µV), and a similar trend in the brachialis muscle (Table 4). Goniometric findings showed a more pronounced mean decrease in elbow flexion lag in Group A ([37.78]^∘ to [22.56] ^∘) than in Group B ([33.89]^∘ to [26.56]^∘) (Table 5), while extensor lag also decreased more sharply in Group A ([18.00]^∘ to [8.00]^∘) than in Group B ([16.00]^∘ to [10.22]^∘) (Table 6). While within-group changes were highly significant (p<0.001), between-group T-tests for all post-test sEMG and ROM values (Table 7 and Figure 2) did not reach statistical significance (p>0.05), representing a superior clinical trend rather than statistical differentiation.

Table 1: MAS Score-Wilcoxon Signed-Rank test results of pre and post intervention.

Group	Pre-test median (IQR)	Post-test median (IQR)	Z value	P value	Significance
Group A	1.5 (1 – 2)	1 (1 – 1)	-2.023	0.043*	Significant
Group B	1.5 (1 – 2)	1 (1 – 1.5)	-2.023	0.043*	Significant

Notes: MAS = Modified Ashworth Scale; IQR = Interquartile Range. * Indicates statistical significance (p < 0.05)

Table 2: MAS Score - Mann–Whitney U Test – group comparison (post-test).

Comparison	Group A (Post)	Group B (Post)	U Value	Z Value	P value	Significance
Post-test MAS	Median = 1 (IQR 1–1)	Median = 1 (IQR 1–1.5)	34.5	0.53	0.59	Not Significant (p>0.05)

Notes: MAS = Modified Ashworth Scale; IQR = Interquartile Range. * Indicates statistical significance (p < 0.05).

Table 3: Pre and post-test values of biceps RMSD on sEMG.

Group	Pre-test, Mean±SD (µV)	Post-test, Mean±SD (µV)	t value	P value
Group A	7.5667±3.3908	4.8000±2.7532	7.2000	<0.001
Group B	8.3622±4.0540	6.6778±3.4932	5.8875	<0.001

Notes: sEMG = Surface Electromyography; RMSD = Root Mean Square Deviation; SD = Standard Deviation; µV = Microvolts. Statistical significance is defined as p<0.05

Table 4: Pre and post-test values of Brachialis RMSD on sEMG.

Group	Pre-test, Mean±SD (µV)	Post-test, Mean±SD (µV)	t value	P value
Group A	6.1344±3.3525	3.7444±2.5183	6.9386	<0.001
Group B	7.4378±3.6042	5.8911±3.1213	7.5761	<0.001

Notes: sEMG = Surface Electromyography; RMSD = Root Mean Square Deviation; SD = Standard Deviation; µV = Microvolts. Statistical significance is defined as p<0.05.

Table 5: Pre and post-test goniometeric values of elbow flexor lag.

Group	Pre-Test, Mean±SD (°)	Post-Test, Mean±SD (°)	t value	P value
Group A	37.78±11.58	22.56 ±8.97	8.1764	<0.001
Group B	33.89±11.26	26.56±9.99	8.1706	<0.001

Notes: SD = Standard Deviation; ° = Degrees. Statistical significance is defined as p<0.05.

Table 6: Pre and post-test goniometeric values of elbow extensor lag.

Group	Pre-test, Mean±SD (°)	Post-test, Mean±SD (°)	t value	P value
Group A	18.00±6.48	8.00±5.43	13.4164	<0.001
Group B	16.00±7.87	10.22±7.34	5.3003	<0.001

Notes: SD = Standard Deviation; ° = Degrees. Statistical significance is defined as p<0.05.

Table 7: Post test comparison of sEMG and elbow ROM lag between groups.

Outcome Measure	Group A (Mean±SD)	Group B (Mean±SD)	t value	P value
sEMG – Biceps RMSD (µV)	4.8000±2.7532	6.6778±3.4932	1.2665	0.2234
sEMG – Brachialis RMSD (µV)	3.7444±2.5183	5.8911±3.1213	1.6058	0.1279
Elbow Flexor Lag (°)	22.56±8.97	26.56±9.99	0.8937	0.3847
Elbow Extensor Lag (°)	8.00±5.43	10.22±7.34	0.7298	0.4761

Notes: sEMG = Surface Electromyography; RMSD = Root Mean Square Deviation; SD = Standard Deviation; µV = Microvolts; ° = Degrees. Statistical significance is defined as p<0.05.

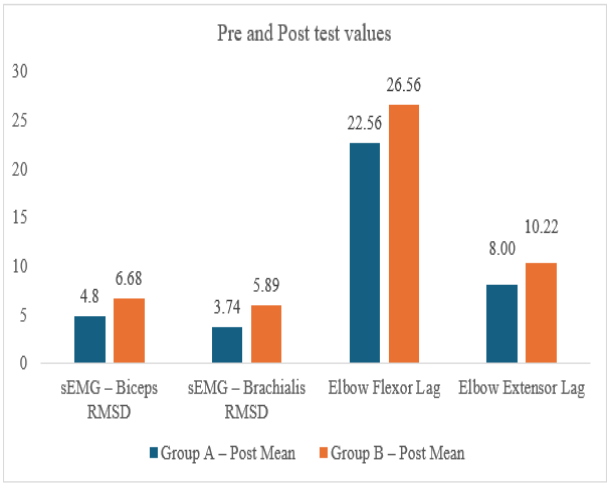

Figure 2: Comparison of post-test values of sEMG and elbow ROM lag between groups.

DISCUSSION

This pilot study demonstrates that structured neural mobilization targeting the musculocutaneous nerve effectively reduces elbow flexor spasticity, lowers neuromuscular hyperexcitability, and improves joint range of motion in chronic post stroke individuals. Spasticity disproportionately affects the upper extremity, impeding voluntary motor control and rehabilitation progress.[21] While underlying comorbidities such as hypertension require sustained medical management early physical interventions targeting hypertonia are vital to prevent progressive contractures, pain, and functional decline.[22-25]

The notable reduction in biceps brachii and brachialis surface electromyography (sEMG) activity in Group A reflects a significant decrease in abnormal motor unit firing and stretch reflex excitability. These findings corroborate the work of Castilho et al who reported electrophysiological improvements following neural

mobilization in hemiplegic patients.[26] The pronounced neuromuscular gains observed in our trial likely stem from the six-week duration, standardized neural mobilization parameters, and concurrent functional training. Furthermore, these results parallel findings by Saxena et al who demonstrated superior spasticity reduction and functional recovery with neurodynamic mobilization in upper motor neuron lesions.[27]

While prior studies emphasized combining neurodynamic with pharmacological agents such as botulinum toxin A, our findings highlight that musculocutaneous nerve mobilization alone provides significant therapeutic value as a non-invasive manual modality.[28] Targeting the primary motor innervation of the biceps brachii and brachialis directly addresses the principal anatomical contributors to elbow flexor hypertonia, consistent with evidence from Yu et al. Mechanically, restoring neural gliding relieves tension across the nerve trunk and modulates hyperactive spinal reflex circuits.

Limitations

The primary limitations of this study include the small pilot sample size and the absence of extended post intervention follow up. Although descriptive clinical trends favored neural mobilization, larger multi center randomized trials with long term follow up are warranted to confirm treatment retention and optimize clinical dosing protocols.

CONCLUSION

Musculocutaneous nerve mobilization combined with concurrent physiotherapy produced significant improvements in elbow flexor spasticity, neuromuscular activity, and elbow range of motion in chronic post-stroke patients. The neural mobilization group demonstrated greater descriptive improvements; however, these findings did not establish its superiority over stretching in this pilot study.

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