DOI:10.55735/thjprs.v2i1.51

THE HEALER
Journal of Physiotherapy & Rehabilitation Sciences

Original Article

Effects of Scapular Proprioceptive Neuromuscular Facilitation Techniques in Addition to Routine Physical Therapy on Clinical Outcomes in Patients with Adhesive Capsulitis: A Randomized Controlled Trial

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Abstract

Background: Adhesive capsulitis is a painful condition comprises of reduced glenohumeral joint movement and the scapular neuromuscular facilitation techniques is considered effective, non-invasive approach for treating this condition. **Objective:** To compare the effects of neuromuscular facilitation techniques on clinical outcomes in patients with adhesive capsulitis. **Methods:** This trial was registered in ClinicaTrials.gov (ref: NCT05151783) and approval was taken (IRB No. 818-II). This single-blinded randomized controlled trial was conducted on patients (n=96) having adhesive capsulitis in six months. Non-probability purposive sampling technique was used for randomization via sealed envelope method. Conventional group received routine physiotherapy including ultrasound, hot packs, shoulder range of motion, stretching exercises, and joint mobilization five times per week for four weeks with 40 minutes' duration of each session. Glenohumeral joint distraction, caudal, dorsal, and ventral glides were given at a rate of 2-3/second oscillations for 1-2 minutes to patients. Visual analogue scale, functional activity was calculated at baseline, 2nd and 4th week. The descriptive statistics (continuous variables) values for each variable in form of means and standard deviations were calculated and their p-values were also calculated using an independent sample t-test. For the qualitative data (categorical variables), frequency and percentage were estimated. Frequencies and percentages of different variables like gender had also been calculated. Repeated measure analysis of variance (ANOVA) was calculated to calculate within-group differences in the mean of each variable between the assessment points. **Results:** Test of within subject effects showed significant difference for all variables at follow-up and difference between groups also showed significant difference at different follow-ups (p-value≤0.001). Both groups showed statistically significant results (p≤0.001), but scores were higher in experimental group. **Conclusion:** Scapular proprioceptive neuromuscular facilitation technique along with routine physical therapy are more effective as compared to routine physical therapy alone in patients with adhesive capsulitis.

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Keywords: adhesive capsulitis, proprioceptive neuromuscular facilitation technique, shoulder range of motion, VAS	**Citation:** Butt MS. 2022. Effects of scapular proprioceptive neuromuscular facilitation techniques in addition to routine physical therapy on clinical outcomes in patients with adhesive capsulitis: a randomized controlled trial. *The Healer Journal of Physiotherapy and Rehabilitation Sciences, 2(1):78-87*

DOI:10.55735/thjprs.v2i1.51

Introduction

Adhesive capsulitis (AC) or frozen shoulder is painful condition comprises of reduced glenohumeral joint movement like abduction and external rotation. Adhesive capsulitis is defined as capsular thickening and dense adhesions that leads to restriction in active and passive range of motion (ROM) with development of scapular dyskinesis.[1] There is progressive stiffness with sudden onset of symptoms and slower recovery phase.[2] The prevalence of AC is approximately 2-5% in general population.[3] A study performed on randomly selected 9696 individuals reveals that 8.2% men and 10.1% women of working age are affected by AC.[4]

Women are often four times more prone to AC than men.[5] Onset of this disease is common in 50s and 60s while the peak age is mid-fifties. The non-dominant hand's shoulder is more commonly affected.[6] Data showed that 40% of patients showed persistent but mild symptoms after three years while 15% patients have long-term disability.[7] The patients developing AC in early stages usually suffer from sudden pain in anterior aspect of shoulder unilaterally.[8] The typical symptoms of AC are restriction in active and passive ROM with limitation in external rotation and abduction.[9] Overall period of AC varied between 1 to 3.5 years. It has also seen that contralateral shoulder develop AC within five years in about 15% of patients.[10] AC also accompanies several complications including residual pain and stiffness, rupture of bicep tendon while manipulation and fracture of humerus as well.[11] Clinical diagnosis of AC includes several components such as medical history, imaging, and physical examination.

There is no specific test or imaging that promises the confirmation for diagnosis of AC.[12] The imaging is often done to rule out concurrent shoulder pathologies such as tear of rotator cuff or shoulder joint arthritis. The most common imaging performed on patients with suspected AC is musculoskeletal ultrasound (MUS) which is now recognized as the first line imaging technique to scrutinize shoulder pathologies. Despite of the fact that there is sufficient evidence on frozen shoulder, consistent consensus for management of AC is still lacking. The management options include conservative management through physical therapy (PT) and pharmacological treatment.[13,14] In the early stages of AC, inflammation is an important concern to be addressed while in later advanced stages, restriction in ROM becomes dominant and point of concern. The treatment plan for AC patients is designed according to the severity of disease. The exact recognition of disease stage is vitally important while tailoring the treatment plan.[15] The plan of early stages focuses on patient education, pain management, inflammation control and its reduction. Nonsteroidal anti-inflammatory drugs (NSAID) along with PT is prescribed in early stages.

PT plays vital role in pain management and restoration of shoulder movement to normal.[16] Electrotherapeutic agents such as hot packs,[17] transcutaneous electrical nerve stimulation (TENS),[18] cryotherapy,[19] and ultrasound[20] can be engaged for pain management regimen. Physical therapy comprises of manual therapies such as gentle stretching and soft tissue mobilization, therapeutic exercises such as mobilization and proprioceptive neuromuscular facilitation (PNF) techniques.[21] Along with clinical treatment, home exercise plans are also prescribed for better outcomes.[22,23] In later stages when disease progresses to advance levels, PT focuses on restoration of ROM of shoulder joint.[24] In case of moderate to severe AC, especially when patient becomes unresponsive to conservative management, intraarticular corticosteroid injection can be considered as alternate treatment option.

After the injection, physical therapy is mandatory to maintain ROM and improved strength and endurance.[25] Prolonged immobilization of shoulder leads to scapular dyskinesia and ankylosed joint. This study aimed to find the effects of this non-invasive, and cost-effective approach of scapular PNF techniques. The effects of other upper extremity PNF techniques on shoulder joint have been investigated in some studies. However, very little evidence is available on investigating the effects of scapular PNF techniques in AC rehabilitation. The studies conducted for showing

DOI:10.55735/thjprs.v2i1.51

effects of different therapies on adhesive capsulitis reported the efficacy of PNF techniques as compared to other studies. While there is still a lack of quality-based randomized trials with adequate sample size and proper methodology to define more supreme treatment options for the management of adhesive capsulitis. No study reported the supremacy of one technique over another. The purpose of the study was to investigate the effects of proprioceptive neuromuscular techniques with and without routine PT on pain, functionality and shoulder range of motion in patients with adhesive capsulitis.

Methods

This trial was registered in ClinicaTrials.gov (ref: NCT05151783) and approval was taken from ethical review board committee (IRB No. 818-II). Patients were recruited from Janjua Physical Therapy and Rehabilitation Clinic, Gujranwala. This single-blinded randomized controlled trial was conducted on patients (n=96) having adhesive capsulitis in six months. Sample size was calculated through this formula, Where $Z_{1-\alpha/2}$ confidence interval (2-sided) is 80%, $Z_{1-\beta}$ power of study 80%, μ_1 Mean score in Group A 3, μ_2 mean score in Group B 3.4, δ_1 standard deviation in Group A 0.85, δ_2 standard deviation in Group B 0.9, the sample size calculated was 40 in each group and by adding 20% dropout, it became 48 in each group. All methods were performed following the relevant CONSORT guidelines and regulations.

$$n = \frac{2\sigma^2(z_{1-\alpha/2} + z_{1-\beta})^2}{(\mu_1 - \mu_2)^2}$$

The assessor was unaware of the treatment given to both groups. Non-probability purposive sampling technique was used for randomization via sealed envelope method. Patients were screened to meet inclusion criteria and written consent form was taken from patients after that they were randomly allocated to two groups (48 in each group). Diagnosed cases of stage II & III adhesive capsulitis, with duration of 1 month, both male and female and aged: between 40 to 70 years[22] were included in study. However, subjects with recent history of trauma, surgery, diabetes and hypertension, dislocation or fractures of shoulder, congenital shoulder deformity, or having cardiovascular disease were excluded from trial. Baseline data was collected and then at 2nd and 4th week of treatment. Conventional group received routine PT including ultrasound (1.5 w/cm^2, 3 MHz continuous type, duration 10 minutes), hot packs (on affected region of shoulder for 10 minutes), shoulder ROM, stretching exercises, and joint mobilization five times per week for four weeks with 40 minutes' duration of each session. Maitland mobilization was given in supine position.

After giving glenohumeral (GH) joint distraction, caudal, dorsal, and ventral glides were given at a rate of 2-3/second oscillations for 1-2 minutes to patients. Grade I or II rhythmic oscillations applied in pain free range. While the experimental group received scapular PNF techniques with routine PT (same as above). In this group, 20 repetitions of diagonal scapular pattern (anterior elevation and posterior depression, posterior elevation and anterior depression) with 20 seconds rest period were given to subjects. PNF techniques of rhythmic initiation and repeated contractions were used in all patterns, applied for 50 minutes. Outcome was measured by visual analogue scale (VAS) for pain intensity, shoulder ROM through universal goniometer, shoulder functional activities by simple shoulder function test (SST) and scapular mobility through lateral scapular slide test (LSST).

Data were tabulated and analyzed by statistical package for social sciences (SPSS) version 26. The descriptive statistics (continuous variables) values for each variable in form of means and standard deviations were calculated (Table-I) and their p-values were also calculated using an independent sample t-test. For the qualitative data (categorical variables), frequency and percentage were estimated. Frequencies and percentages of different variables like gender had also been calculated. Shapiro-Wilk test was used to assess normality and after fulfilling the parametric assumptions, an independent sample t-test was applied to compare both groups at baseline, at the 2nd and 4th week. Repeated measure analysis of variance (ANOVA)

DOI:10.55735/thjprs.v2i1.51

was calculated to calculate within-group differences in the mean of each variable between the assessment points (at baseline, 2nd and 4th week after commencement of treatment). The p-value less than or equal to 0.05 is considered significant.

Results

The total number of enrolled male patients were 26 (30.96%) and female patients were 58 (69.04%). Socio-economic status of patients showed that 32 (38.1%) were from upper class, 35 (41.67%) from middle class and17 (20.23%) from lower class. Most of the subjects were left-handed having frequency 72 (85.72%) and most were having their left shoulder affected (81, 96.43%). Total number of patients with stage II were 39 (46.43%) and stage III were 45 (53.57%). There were two dropouts as two patients discontinue treatment after 2nd week follow up so average values were considered, and data of all patients were analyzed (n=96). Multivariate test (Table-II) showed significant differences for pain, external rotation, abduction, internal rotation, SST and LSST at different time points within groups (p-value≤0.001). Test of within subject effects in Table-III showed significant difference for all variables at follow-up points and difference between groups also showed significant difference at different follow-ups (p≤0.001). The between subjects' effects showed significant difference for all variables except for LSST-2 which showed non-significant difference (Table-IV). Multiple comparison test showed that significant difference in scores of different variables across different follow-up points (Table-V). Both groups showed statistically significant results (p≤0.001), but scores were higher in experimental group.

Table-I: Descriptive statistics for all variables

Variables	Follow-up	Experimental group	Conventional group
VAS (Pain)	Baseline	6.40±1.71	6.45±1.97
	2nd week	4.69±1.78	4.69±1.78
	4th week	2.64±1.44	3.88±1.77
External Rotation	Baseline	43.86±2.85	44.38±2.273
	2nd week	59.38±4.018	56.86±3.049
	4th week	83.69±4.561	77.95±3.819
Internal Rotation	Baseline	52.90±7.22	53.21±6.40
	2nd week	60.60±4.35	59.57±3.99
	4th week	73.71±4.76	65.00±5.19
Abduction	Baseline	154.43±6.021	153.81±4.441
	2nd week	163.45±4.198	159.52±3.915
	4th week	170.31±2.300	164.86±2.992
SST	Baseline	4.52±1.95	5.98±3.22
	2nd week	7.81±2.09	7.45±2.54
	4th week	10.43±1.17	8.45±1.94
LSST-1	Baseline	.829±.340	1.107±.323
	2nd week	.374±.235	.531±.224
	4th week	.407±.164	.502±.238
LSST-2	Baseline	1.88±.251	1.81±.242
	2nd week	.838±.337	.876±.393
	4th week	.583±.291	.445±.227
LSST-3	Baseline	2.37±.197	2.32±.254
	2nd week	.545±.221	.900±.350
	4th week	.829±.340	.531±.224

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Table-II: Multivariate test for all variables

Effect (Wilk's Lambda)	Value	F	p-value
Pain	0.110	329.33	.000
Pain*Group	0.769	12.194	.000
External rotation	0.012	3269.700	.000
External rotation*Group	0.654	21.432	.000
Abduction	.073	512.566	.000
Abduction*Group	.715	16.147	.000
Internal rotation	.067	565.238	.000
Internal rotation *Group	.388	63.894	.000
SST	.118	303.595	.000
SST *Group	.436	52.409	.000
LSST-1	.307	91.493	.000
LSST-1 *Group	.945	2.365	.100
LSST-2	.072	525.728	.000
LSST-2*Group	.958	1.759	.000
LSST-3	.028	1420.095	.000
LSST-3*Group	.666	20.349	.000

Table-III: Tests of within-subjects' effects of all variables

Source (Greenhouse-Geisser)	Type III Sum of Squares	df	Mean Square	F	p-value	Partial Eta Square
Pain	421.675	1.650	255.486	485.918	.000	.856
	15.167	1.650	9.189	17.477	.000	.176
External rotation	57636.960	1.624	35493.473	4302.223	.000	.981
	411.817	1.624	253.602	30.739	.000	.273
Abduction	7636.770	1.709	4469.560	682.069	.000	.893
	256.452	1.709	150.093	22.905	.000	.218
Internal rotation	11226.595	1.747	6427.924	692.712	.000	.894
	996.452	1.747	570.531	61.484	.000	.429
SST	742.095	1.708	434.500	379.496	.000	.822
	123.556	1.708	72.342	63.184	.000	.435
LSST-1	14.812	1.8	8.145	120.935	.000	.596
	.365	1.8	.201	2.983	.059	.035
LSST-2	81.159	1.8	43.600	435.496	.000	.842
	.332	1.8	.179	1.784	.174	.021
LSST-3	152.977	1.7	89.725	859.936	.000	.913
	4.555	1.7	2.67	25.606	.000	.238

DOI:10.55735/thjprs.v2i1.51

Table-IV: Tests of between-subjects' effects for all variables

Source		Type III Sum of Squares	df	Mean Square	F	P-value	Partial Eta Square
Pain	Intercept	5993.813	1	5993.813	697.286	.000	.895
	Group	22.321	1	22.321	2.597	.111	.031
External rotation	Intercept	938302.009	1	938302.009	39651.594	.000	.998
	Group	419.147	1	419.147	17.713	.000	.178
Abduction	Intercept	6537245.016	1	6537245.016	161.869.148	.000	.999
	Group	700.000	1	700.000	17.333	.000	.174
Internal rotation	Intercept	932575.000	1	932575.000	12829.192	.000	.994
	Group	622.286	1	622.286	8.561	.004	.095
SST	Intercept	13950.893	1	13950.893	1060.536	.000	.928
	Group	5.433	1	5.433	.413	.522	.005
LSST-1	Intercept	98.438	1	98.438	1187.193	.000	.935
	Group	1.973	1	1.973	23.800	.000	.225
LSST-2	Intercept	291.003	1	291.003	3776.614	.000	.979
	Group	.206	1	.206	2.670	.106	.032
LSST-3	Intercept	395.001	1	395.001	9179.169	.000	.991
	Group	.000	1	.000	.008	.928	.000

Discussion

The current study aimed to find the effects of scapular PNF techniques in addition to routine PT on clinical outcomes in patients with AC. About 84 patients were randomly allocated to routine PT and experimental groups. Treatment protocol was applied for four weeks, and measurements were taken at baseline, end of 2nd and 4th week. Literature showed no supremacy of treatment protocols over one another when it comes to adhesive capsulitis. However, different studies showed better results when routine physical therapy is combined with PNF techniques. Myeungsik Hwang et al. (2021) did comparison of scapular stabilization technique and movement control exercises on office workers who have scapular dysfunction.

This randomized controlled trial consisted of 18 sessions, 3 days per week for 6 weeks and 25min/session. At the end of protocol, movement control group showed statistically significant results in improving pain, functional ability, and scapular position. The study concluded that PNF technique can be used for improving scapular position, ROM and functional activities.[26] The results of their study are consistent with current study where the group performing PNF technique along with routine PT showed more statistically significant results for pain management, and improving shoulder ROM and overall functional status of subjects. Jaya Shanker Tedla and Devika Rani Sangadala in 2019 conducted a systemic review and meta-analysis to find out the effectiveness of PNF techniques in patients with AC for managing pain, improving disability, increasing function and ROM. They included 10 full articles and nine studies showed more significant results in improving outcome measures. Meta-analysis reported that PNF technique is more effective as compared to routine PT.[27] The results of current study is also in accordance with these findings where the group performing PNF showed more improvement as compared to routine PT group. In 2021, Gisele Oltramari Meneghini evaluated the effects of PNF technique on volleyball players with scapular dyskinesis. They performed quasi experimental study on 32 patients aged between 14 to 17 years, both gender and having scapular dyskinesis. This study concluded that PNF techniques showed positive results in initial phases.[28] The results of their study are consistent with current study as this

DOI:10.55735/thjprs.v2i1.51

Table-V: Pairwise Comparisons of lateral scapular slide test (LSST) position 1, 2 and 3

Variables			Mean Difference (I – J)	Std. Error	Sig.	95% confidence interval for difference	
						Lower bound	Upper bound
VAS (pain)	1	2	1.488*	.089	.000	1.270	1.706
		3	3.167*	.123	.000	2.866	3.467
	2	1	-1.488*	.089	.000	-1.706	-1.270
		3	1.679*	.089	.000	1.460	1.897
	3	1	-3.167*	.123	.000	-3.467	-2.866
		2	-1.679*	.089	.000	-1.897	-1.460
SST	1	2	-2.381*	.161	.000	-2.775	-1.987
		3	-4.190*	.173	.000	-4.613	-3.768
	2	1	2.381*	.161	.000	1.987	2.775
		3	-1.810*	.118	.000	-2.098	-1.521
	3	1	4.190*	.173	.000	3.768	4.613
		2	1.810*	.118	.000	1.521	2.098
LSST-1	1	2	.515*	.040	.000	.417	.614
		3	.513*	.042	.000	.411	.615
	2	1	-515*	.040	.000	-.614	-.417
		3	-.002*	.032	1.000	-.080	.075
	3	1	-513*	.042	.000	-.615	-.411
		2	.002*	.032	1.000	-.075	.080
LSST-2	1	2	.995*	.052	.000	.867	1.123
		3	1.338*	.041	.000	1.238	1.439
	2	1	-.995*	.052	.000	-1.123	-.867
		3	.343*	.047	.000	.228	.458
	3	1	-1.338*	.041	.000	-1.439	-1.238
		2	-.343*	.047	.000	.458	-.228
LSST-3	1	2	1.631*	.038	.000	1.538	1.724
		3	1.674*	.044	.000	1.565	1.782
	2	1	-1.631*	.038	.000	-1.724	-1.538
		3	.043*	.054	1.000	-.090	.175
	3	1	-1.674*	.044	.000	-1.782	-1.565
		2	-.043*	.054	1.000	-.175	.090

also reported statistically significant results of PNF techniques on scapular dyskinesis and improving ROM.

Nilay Comuk Balc et al. in 2016 did a study to compare the effects scapular PNF techniques with traditional physiotherapy interventions for AC patients. This trial involved fifty-three patients and allocated them in three groups i-e PNF techniques with modalities, classic exercises with modalities and only modality group. Their results showed significant improvement in pain, ranges, and functional abilities but there was no difference between group analysis. They concluded that PNF techniques, classic exercises and modalities alone have immediate effects on pain, ROM and functional abilities of patients.[29] However, the result of their study is in contrast with current study where

DOI:10.55735/thjprs.v2i1.51

both groups showed significant differences and interventional group with scapular PNF techniques performed well as compared to conventional routine physical therapy protocol.

Hariharasudhan Ravichandran and Janakiraman Balamurugan (2015) worked on efficacy of PNF compared with muscle energy techniques for pain management and disability in patients with AC. They performed single-centered experimental study with 132 male subjects with mean age of 46 to 50 years showing that PNF technique is more effective in pain management, improving ROM and functional ability in AC patients.[30] Their results are also in accordance with current study. Eda Akbaş et al. in 2015 conducted a study to investigate the effects of PNF on scapula and upper extremity in patients with adhesive capsulitis. They performed randomized trial with conventional PT techniques in control group and PNF techniques in experimental group. This study measured the outcomes using goniometer, lateral scapular slide test and SPADI questionnaire.

The results showed equal significance in terms of reducing pain while ROM in flexion and abduction and night pain was significantly more improved in PNF techniques groups.[31] The results of this study also match with the current study where PNF techniques accounts for more promising results and showed significant results. Scapular proprioceptive neuromuscular facilitation technique combined with routine physical therapy are found to be more effective as compared to routine physical therapy alone in patients with adhesive capsulitis. PNF techniques should be compared with more treatment options to find a better treatment option for management of adhesive capsulitis. The limitation of the study was that it was single-centered study, sample size included was limited due to pandemic conditions.

Conclusion

Scapular proprioceptive neuromuscular facilitation technique along with routine physical therapy are more effective as compared to routine physical therapy alone in patients with adhesive capsulitis. It accounts for more effective results in reducing pain, improving range on motion and improving shoulder dyskinesis, all of which leads to better functional status and quality of life.

Declarations

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.
Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.
Competing interests: None
Funding: No funding source involved.
Authors' contributions: All authors read and approved the final manuscript.
CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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