

Effectiveness of Gong's Mobilisation, Angular Joint Mobilisation and Maitland Mobilisation on Physical and Functional Outcomes among Patients with Frozen Shoulder: A Randomised Controlled Trial

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ABSTRACT

Introduction: Frozen shoulder is a prevalent shoulder condition marked by significant pain and reduced mobility, which substantially compromises good health and well-being frequently among the elderly. Manual therapy techniques such as Gong's Mobilisation (GM), Angular Joint Mobilisation (AJM), and Maitland Mobilisation (MM) are widely used to improve Range Of Motion (ROM), reduce pain, and restore function.

Aim: This study evaluated and compared the effectiveness of three manual therapy techniques GM, AJM, and MM on physical and functional improvements in individuals with Stage II frozen shoulder.

Materials and Methods: This study was a single-blinded, three- arm randomised controlled trial conducted at outpatient physiotherapy clinics affiliated with a University, Bengaluru, Karnataka, India, between March 2024 and August 2025. A total of 54 participants aged 40-60 years diagnosed with Stage II frozen shoulder were included based on primary inclusion criteria of shoulder pain and stiffness persisting for 3-9 months with a capsular pattern of restriction. Participants were randomly allocated into three groups (n=18 each): Group-A (GM), Group-B (AJM), and Group-C (MM). Each group received the respective manual therapy intervention along with standardised conventional physiotherapy for six weeks. Demographic parameters including age, sex, and duration of symptoms

were recorded at baseline. Outcome measures assessed pre- and post-intervention included Passive ROM (PROM) using goniometry, the PENN Shoulder Score (PSS) (pain, satisfaction, and function), and the Upper Extremity Functional Scale (UEFS). Statistical analysis was performed using appropriate parametric and non-parametric tests, including Kruskal-Wallis test, Wilcoxon signed-rank test and Dunnett's T3 post-hoc analysis with a p-value <0.05 considered statistically significant.

Results: All three interventions showed statistically significant improvements across all outcome measures (p<0.05). Between-group analysis revealed significant differences in post-intervention PENN Total Score, PENN Satisfaction, UEFS, ROM flexion, abduction, and Internal Rotation (IR). Post-hoc comparisons showed AJM provided the greatest pain relief and patient satisfaction. GM demonstrated significantly greater improvement than MM in upper-limb functional ability (UEFS), while AJM demonstrated greater improvements in selected ROM outcomes.

Conclusion: GM, AJM, and MM are all effective techniques for treating frozen shoulder. However, AJM demonstrated superior outcomes in pain relief and satisfaction, while AJM and GM were superior in restoring mobility and function. Clinicians should tailor interventions based on individual patient needs and clinical presentation to optimise recovery.

Keywords: Angular joint mobilisation, Frozen shoulder, Gong's mobilisation, Maitland mobilisation, Manual therapy, Range of motion, Shoulder function

INTRODUCTION

Adhesive capsulitis is commonly referred to as frozen shoulder, and is one of the most common and debilitating musculoskeletal conditions that affects the glenohumeral joint. It is characterised primarily by a painful and gradual reduction in active and passive range of motion (ROM). Adhesive capsulitis is still one of the most prevalent issues seen in physicians' offices and an estimated 3-5% of the general public will experience this problem at some point in their lives [1]. Additionally, approximately 20% of patients diagnosed with diabetes may also suffer from this problem [2].

There are three distinct phases of development for adhesive capsulitis: "Freezing," or the initial stage where the individual experiences their greatest level of pain and their pain typically worsens during the nocturnal hours; "Frozen," or the second stage in which overhead movements or reaching behind are essentially completely impaired; and finally, the "Thawing" phase, or the third phase, where the individual's ability to move gradually improves, although they may

continue to experience some degree of functional impairment for several months to years [2,3].

Conservative management involves a combination of medications and physical therapy for a period of six to nine months. Pharmacological management, including corticosteroids and Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), provides temporary pain relief but does not influence the overall disease progression. Because of this limitation, physiotherapy remains the mainstay of treatment with the major focus on restoring shoulder mobility, reduce pain, and improve the ability to perform daily functional tasks [4,5].

Traditional physiotherapy approaches consist of a combination of stretching, strengthening, and various manual mobilisation techniques like the Maitland and Spencer techniques. Recently, other techniques like GM and AJM have emerged with a number of studies indicating that GM and AJM may be superior to traditional methods in restoring mobility. Each of the three techniques could possess technical and mechanical advantages over the others but to

date, there is little evidence-based recommendations available for the best course of treatment for patients as well as lack of comparative studies examining the efficacy of the three techniques [6,7].

This study aims to bridge the existing evidence gap by directly evaluating and comparing the effect of three distinct manual therapy techniques on pain, physical function, and ROM in patients with Stage II frozen shoulder.

The primary objective of the study was to compare GM, AJM, and MM with respect to their effects on pain, ROM, and functional outcomes in individuals with Stage II frozen shoulder. In addition, the study sought to assess which technique provided better improvement in patient satisfaction and upper-limb functional performance.

MATERIALS AND METHODS

This study was a single-blinded three-arm randomised controlled trial conducted over a duration of six months in outpatient clinics affiliated with a University in Bengaluru, Karnataka, India from March 2024 to August 2025. The research was approved by the Institutional Ethics Committee(IEC/IRB/DSU/MPT/2024/017)andregisteredprospectively with the Clinical Trials Registry of India (CTRI/2025/02/08038).

A total of 54 participants (aged 40-60 years) diagnosed with Stage II frozen shoulder based on Maitland criteria were recruited [1,8].

Inclusion criteria: Shoulder pain and stiffness persisting for 3-9 months, capsular pattern restriction, and $\geq 50\%$ reduction in PROM compared to the contralateral side.

Exclusion criteria: Stage I or III FS, history of shoulder trauma or surgery, dislocations, rotator cuff tear, inflammatory arthritis, or contraindications to manual therapy such as severe osteoporosis or recent intra-articular injections [8].

Sample size and Randomisation: The sample size was calculated using G*Power for repeated measures ANOVA (within-between interaction) with an effect size of 0.25, $\alpha=0.05$, and power=0.98, resulting in 54 participants. Block randomisation (block size=6) was used to ensure balanced allocation into three intervention groups (n=18 each). Participants were blinded to group allocation.

Intervention Protocols

Participants were divided into three groups:

Group-A (n=18): Gong's Mobilisation (GM)

Delivered using dynamic positioning and anterior-posterior glides in a side-lying position, followed by Maitland Grade III-IV oscillations and sustained stretches [9].

Group-B (n=18): Angular Joint Mobilisation (AJM)

Conducted in three stages: initial joint mobilisation (with passive or assisted overpressure), joint shift (involving multi-directional mobilisation), and combined movement techniques during later sessions [10].

Group-C (n=18): Maitland Mobilisation (MM)

Applied based on direction of restriction: posterior glide for flexion/IR, inferior for abduction, and anterior for ER. Grade III and IV oscillations were performed for 30-60 seconds [11].

The flow of participants through each stage of the trial is illustrated in [Table/Fig-1].

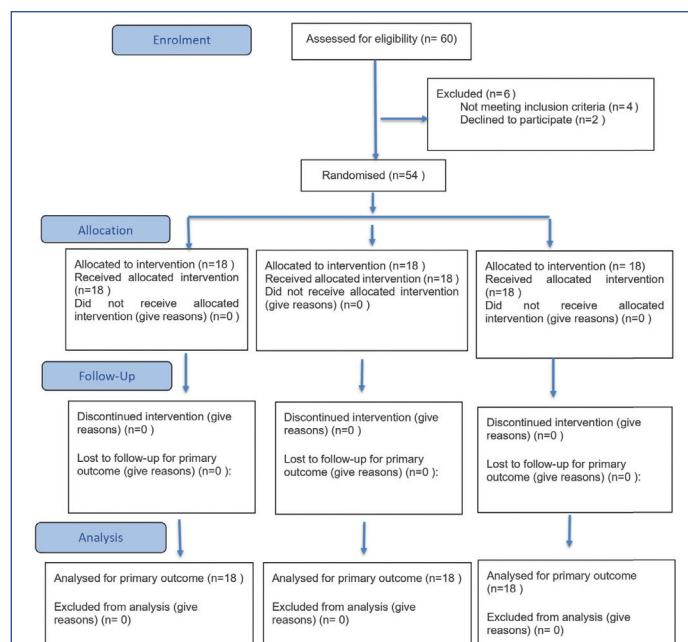
In addition to the group specific manual therapy interventions, all participants also received standardised conventional physiotherapy, which was prescribed according to the FITT principle as described below:

Frequency: Two supervised sessions per week

Intensity: Exercises and mobilisation techniques were performed within pain-free limits and progressed based on patient tolerance.

Time: Each session lasted approximately 20-30 minutes. Manual therapy techniques were applied for 30-60 seconds per set, with multiple repetitions as clinically indicated.

Type: Interventions included group-specific manual therapy techniques (GM, AJM, or MM), pulsed ultrasound (1.5 W/cm² for 8



[Table/Fig-1]: CONSORT flow diagram showing participant recruitment, allocation, follow-up, and analysis across the three intervention groups: Gong's Mobilisation (GM), Angular Joint Mobilisation (AJM), and Maitland Mobilisation (MM). Adapted from Hopewell et al., CONSORT 2025 Statement: BMJ 2025;388:e081123 (Creative Commons Attribution License 4.0).

minutes per session) [12], Codman's pendular exercises [13], and wand-assisted active ROM exercises for shoulder flexion, extension, abduction, and IR [8].

The intervention program was administered for a total duration of six weeks under supervised physiotherapy.

Outcome Measures

Baseline and post-intervention outcomes were assessed using:

Passive Range of Motion (PROM): measured with goniometry for flexion, extension, abduction, IR and External Rotation (ER).

PENN Shoulder Score (PSS): The PSS assesses pain (30 points), satisfaction (10 points), and function (60 points), with a total score of 100, where higher scores indicate better shoulder function, lower pain levels, and greater patient satisfaction [14].

Upper Extremity Functional Scale (UEFS): The UEFS is a 20-item self-reported questionnaire assessing upper limb functional ability, with scores ranging from 0 to 80, where higher scores indicate better functional performance [15].

All tools used are validated and demonstrate high reliability and responsiveness. Minimal Clinically Important Differences (MCID) were considered during interpretation.

STATISTICAL ANALYSIS

Data were analysed using IBM SPSS Statistics v29.0. Between-group comparisons for non-normally distributed variables were performed using the Kruskal-Wallis test applied to post-intervention scores; the H statistic (Kruskal-Wallis H) and associated p-value are reported. Where the Kruskal-Wallis test indicated a statistically significant overall difference, pairwise post-hoc comparisons were performed using Dunnett's T3 test. For normally distributed variables (confirmed by normality testing), between-group comparisons at baseline and post-intervention were performed using one-way ANOVA. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 54 participants diagnosed with Stage II frozen shoulder were randomised into three intervention groups: GM, AJM, and MM, with 18 participants in each group. There were no statistically significant differences in the baseline demographic characteristics, including age, sex, or duration of symptoms, among the three groups [Table/Fig-2].

Variable	GM (n=18)	AJM (n=18)	MM (n=18)
Age (years, mean±SD)	52.0±4.2	51.4±4.5	51.9±3.8
Sex (M/F)	8/10	6/12	6/12
Duration of symptoms (mo)	6.3±1.2	6.4±1.1	6.2±1.3

[Table/Fig-2]: Baseline characteristics of participants (n=54).

Values are presented as mean±Standard Deviation (SD) unless otherwise specified. GM: Gong's mobilisation; AJM: Angular joint mobilisation; MM: Maitland mobilisation; M: Male; F: Female.

The MM group demonstrated higher baseline values for both extension (25.4±5.5° vs 19.9±4.9° in GM) and abduction (102.83±7.67° vs 94.61±9.19° in GM). These baseline imbalances likely occurred by chance despite random allocation, particularly

given the relatively small sample size per group (n=18). The potential influence of these baseline differences on post-intervention comparisons is acknowledged in the limitations section [Table/Fig-3].

Within-Group Analysis

All three treatment protocols were found to be effective. A Wilcoxon Signed-Rank Test was performed to compare pre- and post-intervention scores within each group. Overall pre- and post-intervention changes within each group are summarised in [Table/Fig-4].

The results indicated that all three groups (GM, AJM, and MM) demonstrated statistically significant improvements across all

Outcome measure	GM Pre (Mean±SD)	AJM Pre (Mean±SD)	MM Pre (Mean±SD)	Test Statistic	p-value	Interpretation
PENN Pain	22.8±2.8	22.8±2.4	23.2±3.0	H=0.17	0.917	No baseline difference
PENN Satisfaction	2.6±1.2	2.1±1.0	2.4±1.0	H=0.93	0.627	No baseline difference
PENN Function	21.6±2.5	22.0±2.5	22.1±2.7	H=0.97	0.616	No baseline difference
PENN Total Score	46.56±3.54	46.94±4.05	48.00±3.93	F=0.68	0.511	No baseline difference
UEFS	22.4±3.4	23.1±3.4	22.8±3.1	H=1.05	0.593	No baseline difference
Flexion (°)	104.9±9.9	101.4±7.9	104.9±8.4	H=1.25	0.536	No baseline difference
Extension (°)	19.9±4.9	22.8±3.5	25.4±5.5	H=10.83	0.004*	Significant baseline difference
Abduction (°)	94.61±9.19	95.44±6.09	102.83±7.67	F=6.13	0.004*	Significant baseline difference
Internal Rotation (IR) (°)	27.4±6.5	28.1±8.1	31.3±5.9	H=2.40	0.302	No baseline difference
External Rotation (ER) (°)	33.50±6.51	36.17±7.56	35.83±8.56	F=0.66	0.521	No baseline difference

[Table/Fig-3]: Baseline comparisons of outcome measures between groups.

Values are mean±SD. GM: Gong's mobilisation; AJM: Angular joint mobilisation; MM: Maitland mobilisation. For non-normally distributed variables, Kruskal-Wallis H test was used. For normally distributed variables (PENN Total Score, Abduction, External Rotation), One-way ANOVA (F statistic) was applied. * p<0.05 indicates significant baseline difference

Outcome measure	Group	Pre (Mean±SD)	Post (Mean±SD)	Test Statistic	p-value
PENN pain	GM	22.8±2.8	4.9±1.5	Z=-3.73	<0.001*
	AJM	22.8±2.4	4.1±1.1	Z=-3.73	<0.001*
	MM	23.2±3.0	5.4±1.1	Z=-3.73	<0.001*
PENN satisfaction	GM	2.6±1.2	8.7±0.8	Z=-3.74	<0.001*
	AJM	2.1±1.0	9.1±0.8	Z=-3.74	<0.001*
	MM	2.4±1.0	7.9±0.8	Z=-3.76	<0.001*
PENN function	GM	21.6±2.5	54.2±4.2	Z=-3.73	<0.001*
	AJM	22.0±2.5	56.1±2.9	Z=-3.73	<0.001*
	MM	22.1±2.7	51.5±5.6	Z=-3.73	<0.001*
PENN total score	GM	46.56±3.54	66.78±5.08	t=-14.22	<0.001*
	AJM	46.94±4.05	69.28±2.35	t=-20.88	<0.001*
	MM	48.00±3.93	64.78±5.61	t=-12.15	<0.001*
UEFS	GM	22.4±3.4	73.1±4.8	Z=-3.73	<0.001*
	AJM	23.1±3.4	69.9±4.2	Z=-3.73	<0.001*
	MM	22.8±3.1	68.8±5.1	Z=-3.73	<0.001*
Flexion (°)	GM	104.9±9.9	159.3±10.9	Z=-3.73	<0.001*
	AJM	101.4±7.9	161.4±5.4	Z=-3.74	<0.001*
	MM	104.9±8.4	152.5±9.6	Z=-3.72	<0.001*
Extension (°)	GM	19.9±4.9	41.8±6.2	Z=-3.73	<0.001*
	AJM	22.8±3.5	45.4±4.7	Z=-3.73	<0.001*
	MM	25.4±5.5	37.8±5.1	Z=-3.53	<0.001*
Abduction (°)	GM	94.61±9.19	165.61±7.13	t=-46.42	<0.001*
	AJM	95.44±6.09	167.94±6.91	t=-41.18	<0.001*
	MM	102.83±7.67	161.17±6.91	t=-24.56	<0.001*
Internal Rotation (IR) (°)	GM	27.4±6.5	59.1±4.1	Z=-3.73	<0.001*
	AJM	28.1±8.1	60.3±3.8	Z=-3.73	<0.001*
	MM	31.3±5.9	56.8±2.8	Z=-3.73	<0.001*
External Rotation (ER) (°)	GM	33.50±6.51	68.94±5.43	t=-21.92	<0.001*
	AJM	36.17±7.56	71.44±5.31	t=-18.03	<0.001*
	MM	35.83±8.56	64.61±5.17	t=-14.14	<0.001*

[Table/Fig-4]: Within-group comparisons of pre- and post-intervention outcomes.

Values are mean±SD. GM: Gong's mobilisation; AJM: Angular joint mobilisation; MM: Maitland mobilisation. For non-normally distributed variables, Wilcoxon Signed-Rank test (Z statistic) was used. For normally distributed variables (PENN Total Score, Abduction, External Rotation), Paired t-test (t statistic) was applied. * p<0.05 considered statistically significant. All groups showed significant improvements from pre- to post-intervention

Outcome measure	GM Post (Mean±SD)	AJM Post (Mean±SD)	MM Post (Mean±SD)	Test Statistic	p-value	Interpretation
PENN pain	4.9±1.5	4.1±1.1	5.4±1.1	H=6.92	0.032*	Significant difference
PENN satisfaction	8.7±0.8	9.1±0.8	7.9±0.8	H=14.36	0.001*	Significant difference
PENN function	54.2±4.2	56.1±2.9	51.5±5.6	H=7.36	0.025*	Significant difference
PENN total score	66.78±5.08	69.28±2.35	64.78±5.61	F=4.37	0.018*	Significant difference
UEFS	73.1±4.8	69.9±4.2	68.8±5.1	H=7.09	0.029*	Significant difference
Flexion (°)	159.3±10.9	161.4±5.4	152.5±9.6	H=7.02	0.030*	Significant difference
Extension (°)	41.8±6.2	45.4±4.7	37.8±5.1	H=9.33	0.009*	Significant difference
Abduction (°)	165.61±7.13	167.94±6.91	161.17±6.91	F=4.38	0.018*	Significant difference
Internal Rotation (IR) (°)	59.1±4.1	60.3±3.8	56.8±2.8	H=9.28	0.010*	Significant difference
External rotation (ER) (°)	68.94±5.43	71.44±5.31	64.61±5.17	F=7.65	0.001*	Significant difference

[Table/Fig-5]: Post-intervention comparisons of outcome measures between groups.

Values are mean±SD. GM: Gong's mobilisation; AJM: Angular joint mobilisation; MM: Maitland mobilisation. For non-normally distributed variables, Kruskal-Wallis H test was used. For normally distributed variables (PENN Total Score, Abduction, External Rotation), One-way ANOVA (F statistic) was applied; *p<0.05 considered statistically significant

outcome measures, including all subscales of the PSS, the UEFS, and all passive ranges of motion (p<0.001 for all comparisons).

Between-Group Analysis

To compare post-intervention outcomes among the three intervention groups, the Kruskal-Wallis test was applied to post-intervention scores. Statistically significant intergroup differences were observed for: PENN Pain (H=6.92, p=0.032), PENN Satisfaction (H=14.36, p=0.001), PENN Function (H=7.36, p=0.025), UEFS (H=7.09, p=0.029), Flexion (H=7.02, p=0.030), Extension (H=9.33, p=0.009), and IR (H=9.28, p=0.010). Pre-intervention scores were comparable between groups for most outcomes (p > 0.05), except for Extension (H=10.83, p=0.004) and Abduction (F=6.13, p=0.004), which showed baseline differences. Post-hoc pairwise comparisons were conducted using Dunnett's T3 test.

Post-intervention between-group comparisons are presented in [Table/Fig-5]. Post-hoc pairwise comparisons are detailed in [Table/Fig-6].

Post-hoc comparisons (Dunnett's T3 test, post-intervention):

PENN Pain (H=6.92, p=0.032): No significant difference between GM and AJM (p=0.473) or GM and MM (p=0.478). AJM showed a significantly greater reduction in pain compared with MM (p=0.008).

PENN Satisfaction (H=14.36, p=0.001): No significant difference between GM and AJM (p=0.373). GM showed significantly higher satisfaction than MM (p=0.008). AJM showed significantly higher satisfaction than MM (p < 0.001).

PENN Function (H=7.36, p=0.025): No significant difference between GM and AJM (p=0.199) or GM and MM (p=0.400). AJM showed significantly greater functional improvement compared with MM (p=0.009).

UEFS (H=7.09, p=0.029): No significant difference between GM and AJM (p=0.949) or AJM and MM (p=0.097). GM showed significantly greater improvement than MM (p=0.042).

Flexion (H=7.02, p=0.030): No significant difference between GM and AJM (p=0.443) or GM and MM (p=0.413). AJM showed significantly greater flexion gains compared with MM (p=0.009).

Extension (H=9.33, p=0.009): No significant post-intervention pairwise difference between GM and AJM (p=0.382) or GM and MM (p=0.266). AJM showed significantly greater extension gains compared with MM (p=0.004). Note: a significant pre-intervention baseline difference existed between GM and MM (p=0.004), which should be acknowledged as a study limitation.

Internal Rotation (IR) (H=9.28, p=0.010): No significant difference between GM and AJM (p=0.479) or GM and MM (p=0.154). AJM showed significantly greater IR gains compared with MM (p=0.004). Abduction (AJM vs MM, p=0.014) and ER (GM vs MM, p=0.046; AJM vs MM, p=0.001) also showed significant differences.

Outcome Measure	Comparison	Adjusted p-value	Significant?
PENN Pain	GM vs AJM	0.473	No
	GM vs MM	0.478	No
	AJM vs MM	0.008	Yes*
PENN satisfaction	GM vs AJM	0.373	No
	GM vs MM	0.008	Yes*
	AJM vs MM	<0.001	Yes*
PENN function	GM vs AJM	0.199	No
	GM vs MM	0.400	No
	AJM vs MM	0.009	Yes*
UEFS	GM vs AJM	0.949	No
	GM vs MM	0.042	Yes*
	AJM vs MM	0.097	No
Flexion	GM vs AJM	0.443	No
	GM vs MM	0.413	No
	AJM vs MM	0.009	Yes*
Extension	GM vs AJM	0.382	No
	GM vs MM	0.266	No
	AJM vs MM	0.004	Yes*
Abduction	GM vs AJM	0.579	No
	GM vs MM	0.146	No
	AJM vs MM	0.014	Yes*
Internal Rotation (IR)	GM vs AJM	0.479	No
	GM vs MM	0.154	No
	AJM vs MM	0.004	Yes*
External Rotation (ER)	GM vs AJM	0.341	No
	GM vs MM	0.046	Yes*
	AJM vs MM	0.001	Yes*

[Table/Fig-6]: Post-Hoc pairwise comparisons of post-intervention outcomes.

Post-hoc pairwise comparisons of post-intervention scores. For non-normally distributed variables (PENN Pain, Satisfaction, Function, UEFS, Flexion, Extension, Internal Rotation), Dunnett's T3 test was used. For normally distributed variables (Abduction, External Rotation), Tukey HSD test was used. * p < 0.05 considered statistically significant. GM: Gong's mobilisation; AJM: Angular joint mobilisation; MM: Maitland mobilisation

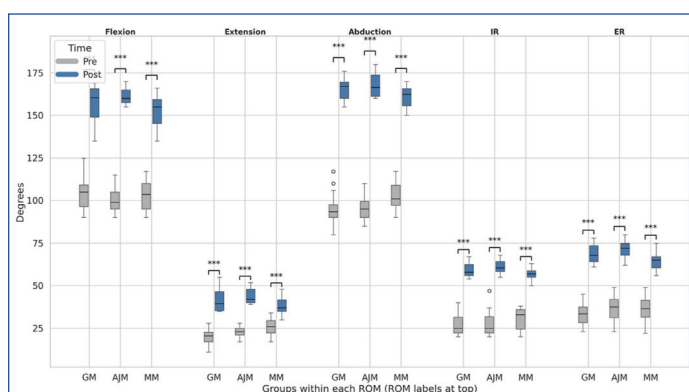
No other pairwise comparisons reached statistical significance.

[Table/Fig-7] illustrates the comparison of pre- and post-intervention shoulder ROM across the three treatment groups.

[Table/Fig-8] depicts the comparison of pre- and post-intervention PSS subscales (pain, satisfaction, and function) among the groups.

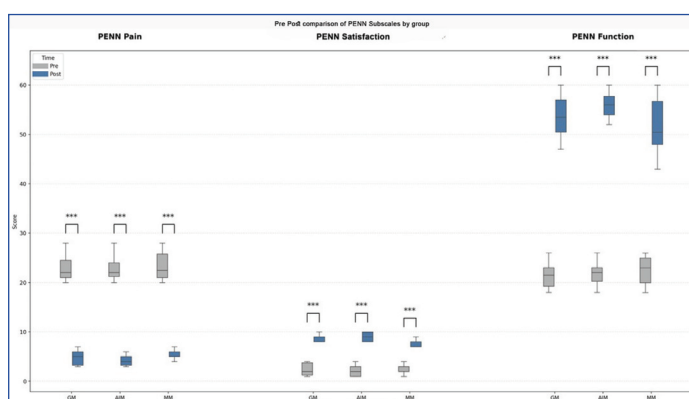
DISCUSSION

This study aimed to compare the effectiveness of GM, AJM, and MM on pain, ROM, and functional outcomes in individuals with Stage II frozen shoulder. The results of the current study indicated



[Table/Fig-7]: Comparison of pre- and post-intervention Range of Motion (ROM) by treatment group.

(Boxplots illustrate the distribution of scores for flexion, extension, abduction, Internal Rotation (IR), and external rotation (ER) before (Pre) and after (Post) a six-week intervention. The three treatment groups are Gong's Mobilisation (GM), Angular Joint Mobilisation (AJM), and Maitland Mobilisation (MM). The line within each box represents the median, the box represents the interquartile range, and the whiskers represent the full range of the data. *** indicates a statistically significant within-group difference ($p < 0.001$) based on the Wilcoxon Signed-Rank test)



[Table/Fig-8]: Comparison of pre- and post-intervention PENN subscale scores by treatment group.

(Boxplots illustrate the distribution of scores for PENN Pain, PENN Satisfaction, and PENN Function before (Pre) and after (Post) a six-week intervention. The three treatment groups are Gong's Mobilisation (GM), Angular Joint Mobilisation (AJM), and Maitland Mobilisation (MM). The line within each box represents the median, the box represents the interquartile range, and the whiskers represent the full range of the data. *** indicates a statistically significant within-group difference ($p < 0.001$) based on the Wilcoxon Signed-Rank test)

that all of the different mobilisations produced a significant improvement in pain levels, shoulder mobility and upper extremity functionality. However, as noted previously, the magnitude of the improvement demonstrated by each of the mobilisations varied; and AJM demonstrated significantly better outcomes than MM in pain, satisfaction, ROM, and function. GM also showed significantly better satisfaction and upper limb function compared with MM.

These findings align with previous systematic reviews reporting that different mobilisation techniques can be effective in adhesive capsulitis, although no single technique has been identified as universally superior [16].

One of the key observations of this study was that patient-reported outcomes seemed to improve more with AJM. Although pain reduction was noted across all three groups, this effect can be explained by established neurophysiological mechanisms associated with manual therapy, such as the gate control theory of pain [17]. When compared with MM, AJM showed more favourable changes in overall shoulder function and patient satisfaction. This suggests that the manner in which the joint is loaded and positioned may play a role in treatment response. Similar findings have been reported by Nouraeen R et al., and Ramteke J et al., who observed better pain relief and functional outcomes with angular and end-range mobilisation techniques in individuals with adhesive capsulitis [18,19].

The enhanced effect of the AJM may be due to biomechanical and neurophysiological mechanisms. Biomechanically, the continuous,

multi-planar method of AJM allows for more effective stretching of the fibrotic joint capsule [20]. Neurophysiologically, this prolonged end range stretch gives a strong afferent input that may more effectively change the sensation of pain and lessen the protective muscle guarding by activating mechanoreceptors like Golgi tendon organs. The combined biomechanical stretching and sustained afferent input may act synergistically, allowing improvements in mobility while simultaneously reducing pain-related movement inhibition [17,18].

In Stage II frozen shoulder, where capsular fibrosis and pain co-exist, mobilisation techniques that combine sustained end-range loading with controlled movement may be particularly effective [3].

Regarding physical recovery and functional ability, AJM appeared to result in greater improvements than both GM and MM. Improvements in shoulder abduction were more pronounced with AJM compared with MM. Both GM and AJM demonstrated greater IR gains, with AJM showing a statistically significant advantage over MM. These differences may be attributed to the emphasis on sustained end-range loading and dynamic, multi-directional movement in these techniques.

Although GM showed a trend towards improved IR, the between-group difference versus MM did not reach statistical significance ($p=0.154$). This contrasts with findings reported by Ramteke J et al., which may reflect differences in sample size or intervention protocols [19]. Similar improvements in pain, ROM, and disability following GM have also been reported in earlier pilot studies and randomised trials [21-23]. The side-lying positioning used in GM may reduce gravitational compression and allow more selective capsular engagement, which could explain its particular effectiveness in improving IR and functional movement patterns. In addition, GM demonstrated favourable outcomes in upper extremity functional performance as assessed using the UEFS [15]. As this scale reflects a patient's ability to perform activities of daily living, the dynamic and multi-planar application of GM, which facilitates coordinated scapulohumeral movement, may contribute to improved functional use of the upper limb [23].

Although MM was associated with pain relief and functional improvement, its predominantly oscillatory approach may be less effective in addressing capsular stiffness during the frozen stage of adhesive capsulitis [17]. Previous studies evaluating MM have similarly reported improvements in pain and function, while suggesting that outcomes may depend on disease stage and treatment dosage [11,24]. In contrast, the sustained end-range stretching applied in AJM and GM may be more suitable for promoting capsular extensibility and tissue adaptation during this stage [23].

The clinical implications of these discoveries are very important as they go against the idea of a "one-size-fits-all" manual therapy approach for frozen shoulder. Instead, they support the selection of mobilisation techniques based on the patient's predominant impairments. For patients presenting primarily with pain and reduced satisfaction, AJM may be a more appropriate initial option. Conversely, in individuals with marked stiffness and functional limitation, GM or AJM may be more suitable choices. For restoring shoulder ROM specifically, AJM demonstrated the most consistent advantages. Future studies should involve larger, multi-centre samples with longer follow-up periods to better understand long-term outcomes. Given the high prevalence of frozen shoulder among individuals with diabetes, further research focusing on this population may also help clarify whether specific mobilisation techniques offer greater benefit.

Limitation(s)

Significant baseline differences were observed in extension and abduction, with the MM group showing higher baseline ROM for both parameters. While randomisation should theoretically balance groups, such imbalances can occur by chance, and these

baseline differences may have influenced the post-intervention comparisons. Readers should interpret these specific findings with appropriate caution, and future studies may benefit from analysis of covariance (ANCOVA) to adjust for baseline differences when they occur. The sample size was relatively small (n=18 per group) and the study was conducted at a single centre, which may limit the generalisability of the findings. In addition, the absence of long-term follow-up restricts conclusions regarding the sustainability of treatment effects beyond the intervention period. Furthermore, as the study included only individuals with Stage II frozen shoulder, the findings may not be generalisable to patients in other stages of the condition.

CONCLUSION(S)

In conclusion, this randomised controlled trial demonstrated that GM, AJM, and MM are all effective interventions for improving pain, ROM, and functional ability in patients with Stage II frozen shoulder. However, the techniques are not interchangeable. AJM is the superior choice for pain reduction and patient satisfaction, while GM and AJM are most effective for restoring shoulder mobility and function. These findings support a shift towards a more personalised treatment strategy, allowing clinicians to select the most appropriate manual therapy technique to optimise patient outcomes. By identifying more effective and personalised non-invasive treatments for adhesive capsulitis, this research not only offers clinicians better tools to improve patient outcomes but also contributes to the broader global effort to promote good health and well-being.

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AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

PLAGIARISM CHECKING METHODS: [Joan H et al.]

- Plagiarism X-checker: Nov 04, 2025
- Manual Googling: Jun 13, 2026
- iThenticate Software: Jun 16, 2026 (3%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

Date of Submission: Nov 02, 2025

Date of Peer Review: Jan 10, 2026

Date of Acceptance: Jun 18, 2026

Date of Publishing: Nov 01, 2026