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Clinical outcomes and cost-effectiveness of manipulation under brachial plexus block versus physiotherapy for refractory frozen shoulder: a prospective observational study

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Background: Frozen shoulder (FS) is a pathological condition that involves a painful and stiff shoulder joint, most commonly in people aged 40-60 years. Most literature supports treatment with physical therapy (PT), although some studies have demonstrated years of continuing pain and functional deficits. Manipulation under anesthesia is effective at eliminating the contracture of intra-articular lesions for refractory FS. This study aimed to compare whether manipulation under anesthesia or PT is a more effective treatment in refractory FS.

Methods: This study was a prospective observational study. A total of 102 patients with refractory FS were enrolled in this study in the medical records, all of whom had severe and multidirectional loss of motion and thickening of the joint capsule and coracohumeral ligament on magnetic resonance imaging. Fifty-one patients were in the manipulation under brachial plexus block (MUB) group (34 females, median age: 57 years), and 51 patients were in the PT group (34 females, median age: 59 years). The MUB procedure consisted of the conventional method with additional adduction manipulation, in which one examiner initially abducted the shoulder joint as much as possible. We recorded the visual analog scale, shoulder range of motion, and American Shoulder and Elbow Surgeons and Constant Scores at the initial baseline visit and at the 1-, 3-, 6-, and 12-month follow-ups. The total cost was calculated from the medical records, and cost-effectiveness was evaluated using quality-adjusted life year and incremental cost-effectiveness ratio.

Results: Visual analog scale ($P < .001$), range of motion ($P < .001$), and American Shoulder and Elbow Surgeons and Constant Scores ($P < .001$) in the MUB group were significantly superior to those in the PT group at 1, 3, 6, and 12 months after treatment. The median cost and total quality-adjusted life year in the MUB and PT groups were $1375 versus $2751 and 2.95 versus 2.68, respectively, and the cost-effectiveness ratio between the MUB and PT groups was calculated as -$560.

Conclusions: The new MUB procedure provides a shorter treatment period, better clinical outcomes, and higher cost-effectiveness in patients with refractory FS compared to PT.

Frozen shoulder (FS) is a common disorder characterized by shoulder pain and progressive loss of shoulder movement. It affects approximately 2%-5% of the general population aged 40-60 years, up to 20% in individuals with diabetes, and is more frequent in women than men.[3,19] The disorder is characterized by a gradual onset of shoulder pain and progressive restriction in global range of passive and active movement. The etiology and pathophysiology have not been well understood. The natural history of FS is documented to be a self-limited disease and described in three phases: a freezing phase that is a result of inflammation, a frozen phase characterized by stiffness, followed by a thawing phase over a duration of 2-3 years.[9,23] Although a

The Kuwano Kyoritsu Hospital Institutional Review Board approved this study: K-2017-02.

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long-term follow-up study showed that 94% of patients without treatment recovered to the normal level of function and motion, other studies reported that 40%-50% of patients treated conservatively still had pain or stiffness in the shoulder after a mean follow-up of 5-11 years.[2,28,33]

Treatment options are nonsteroidal anti-inflammatory drugs, intra-articular (IA) injections of corticosteroid, physiotherapy (PT), hydrodistension, manipulation under anesthesia (MUA), and arthroscopic capsular release (ACR). Conservative treatment, including IA corticosteroid injections and PT, is considered an appropriate treatment option for the majority of patients.[4] A systematic review showed that the administration of IA corticosteroid resulted in clinical superiority when compared with other interventions for pain in 3 months; additionally, home exercise with simple exercises, stretches, and PT with IA corticosteroid added benefits in 6 months.[5] Among these regimens, MUA and ACR have been long-standing treatments for refractory FS. Many studies regarding MUA have reported that the treatment, as a relatively simple procedure, has the potential to rapidly reduce symptoms and restore the range of motion (ROM) for refractory FS.[6,8,13,30,32] A multicenter and randomized control study in which ACR and MUA were compared with early structured PT revealed that none of the three interventions were clinically superior after 12 months; ACR carried a higher risk; and MUA was the most cost-effective.[22] However, other studies reported that MUA had no advantage when compared with conservative treatment, documenting the potential complications associated with this procedure such as dislocation, fractures, brachial plexus injury, bone bruise, labral detachment, and rotator cuff tears.[11,14,17,18,21,26]

MUA was commonly performed under general anesthesia, and an ultrasound-guided cervical nerve root or brachial plexus block (MUB) has become a recent trend for shoulder manipulation in the outpatient setting.[1,6,8,13,15,25,30,32] This anesthesia method makes it convenient for the physician to change the patient's position and facilitate the manipulation procedure without general anesthesia tools and hospitalization. Both MUA and PT appear to be effective treatments in patients with refractory FS, although it is unclear whether there are differences in the clinical outcomes and cost-effectiveness between the two treatment options. The purpose of this study was to evaluate the clinical outcomes, complications, and cost-effectiveness of manipulation under MUB compared with structured PT for refractory FS, which means unsuccessful conservative therapy for 3 months. We hypothesized that MUB and structured PT would have equivalent clinical outcomes and cost-effectiveness.

Materials and methods

Patients

This was a prospective observational study conducted between April 2017 and March 2021. The protocol of this study was reviewed and approved by the institutional review board of Kuwano Kyoritsu Hospital (No. K-2017-02). Written informed consent was obtained from all of the patients included in this study. The data on patients with refractory FS were prospectively retrieved from the medical data and analyzed. Inclusion criteria comprised painfully restricted passive ROM of the shoulder (forward flexion [FF] < 110°, abduction [Abd] < 90°, external rotation [ER] at the side < 50% of the unaffected shoulder, and internal rotation [IR] to the back < the 4th lumber vertebra), absence of intrinsic and extrinsic shoulder disease confirmed by X-ray and magnetic resonance imaging (MRI), and unsuccessful conservative treatments such as administration of nonsteroidal anti-inflammatory drugs and IA corticosteroid injection for 3 months. Patients with osteoarthritis, full-thickness rotator cuff tears, calcific tendinitis, inflammatory arthritis, and a history of trauma and previous surgery around the shoulder were excluded. All of the patients underwent MRI (Echelon RX, 1.5T; Hitachi, Tokyo, Japan) before initiation of treatment to locate the thickening of the axillary joint capsule and coracohumeral ligament (CHL).[29] Patients with FS chose either PT or manipulation after unsuccessful conservative therapy for 3 months. A total of 102 patients who satisfied the inclusion and exclusion criteria were enrolled in this study; 51 patients underwent MUB, and 51 were treated with structured PT. The patients in the MUB group had an MRI within 2 weeks of the manipulation procedure to identify the rupture of the axillary joint capsule and the CHL and the bone and soft tissue injuries incurred in the procedure.

PT protocol

At the first visit, the PT group received 20 mg of triamcinolone and 10 mL of 1% xylocaine in the glenohumeral joint under ultrasound and then received structured PT for 30 minutes twice a week. Three physical therapists, specialists in shoulder disorders, treated the patients in the PT group. The rehabilitation programs started with patient education and assessment to provide information on FS and help patients recognize their malposture and painful motion. The physical therapists measured the ROM in the bilateral shoulders, examined which muscles were tight and presented with tenderness, investigated thorax movement including the thoracic spine, clavicle, and ribs, and evaluated passive scapular movements.[31] Based on the concept that movements of the bones (spine, ribs, clavicle, scapula, and humerus) are essential to shoulder motion, the movements of the bones were next improved using mobilization of the costovertebral, sternocostal, sternoclavicular, and acromioclavicular joints. Massage was employed to relax tight muscles in the shoulder including rotator cuff muscles, deltoid, pectorals major and minor, latissimus dorsi, teres major, and biceps and triceps brachii muscles. With increasing shoulder motion, passive and active ROM exercises such as FF, ER, IR, and horizontal flexion were started. Lastly, an isometric strengthening exercise of the rotator cuff muscles was initiated when every ROM reached 80% of those in the contralateral normal shoulder and there was no pain in activities of daily living.

Manipulation under brachial plexus block protocol

MUB was performed in an outpatient setting. An ultrasound-guided brachial plexus block was performed by an anesthesiologist using 20 mL of 1% mepivacaine hydrochloride. Before manipulation, 20 mg of triamcinolone and 10 mL of 1% lidocaine hydrochloride were injected into the glenohumeral joint under ultrasound. The manipulation procedure started with adduction manipulation of the glenohumeral joint to eliminate superior capsular tightness (Fig. 1 *A* and *B*).[34] The patient lay in the lateral position, and one examiner abducted the shoulder joint as much as possible. The first examiner pushed the upper arm toward the trunk with fixation of the upwardly rotated scapula by another examiner to completely adduct the glenohumeral joint, and the adduction procedure was repeated three times. Next, the patient changed their position from the lateral to the supine position. The examiner moved the affected extremity to maximal ER at the side (Fig. 1*C*), FF (Fig. 1*D*), and ER and IR at 90° of Abd (Fig. 1 *E* and *F*). The patients then changed their position from supine to lateral position. IR to the back was performed as the thumb reached up to the highest thoracic vertebral level (Fig. 1*G*), and lastly, the humeral head was pushed posteriorly and the elbow pushed anteriorly while keeping the IR position (Fig. 1*H*). After manipulation, patients

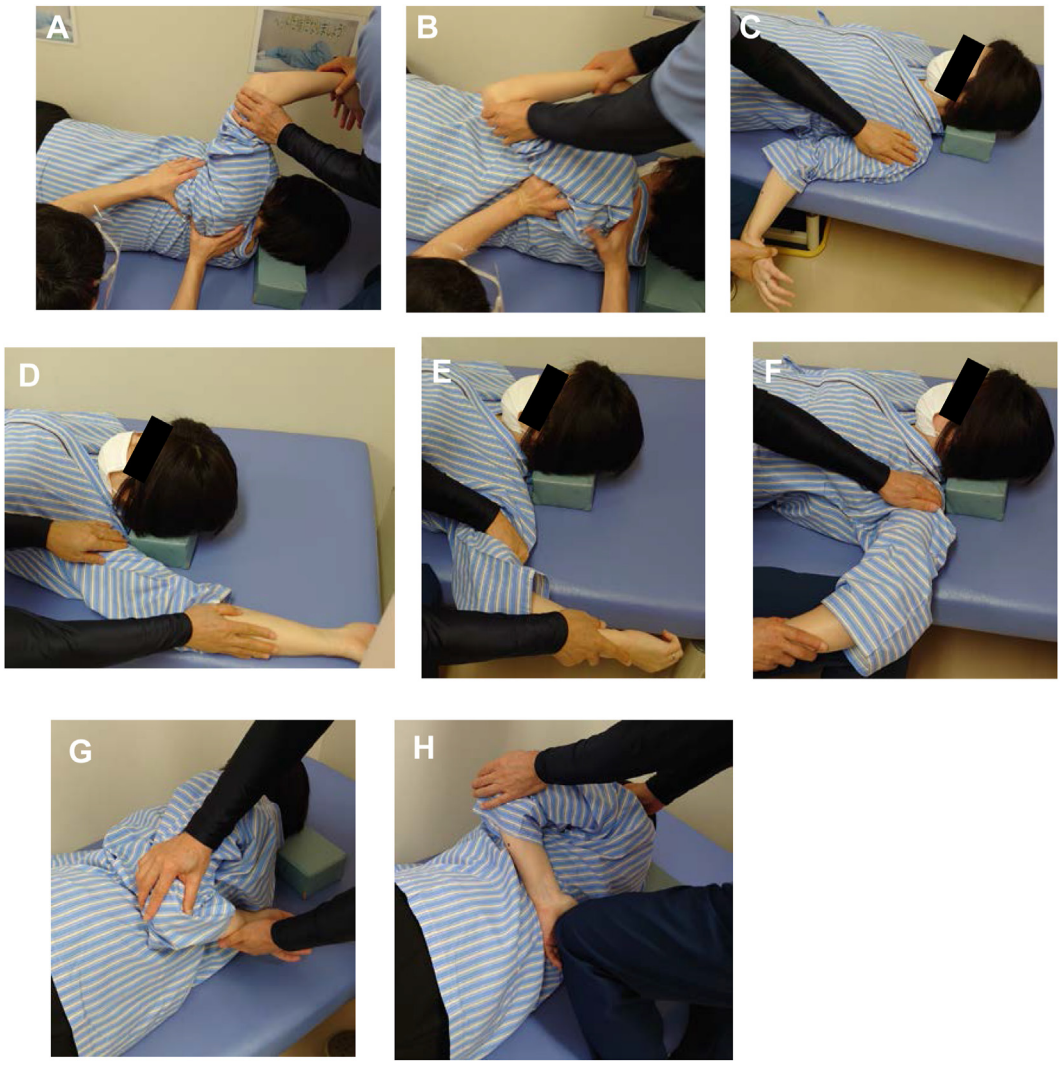


Figure 1 Manipulation procedures. **A.** Abduction (Abd) of the shoulder joint, **B.** Adduction of the glenohumeral joint in the coronal plane with fixation of the scapula, **C.** External rotation (ER) at the side, **D.** Forward flexion (FF), **E.** ER at 90° of Abd, **F.** Internal rotation (IR) at 90° of Abd, **G.** IR toward the back, **H.** The elbow is pushed forward in the position of IR.

Table 1
Demographic and clinical characteristics at the baseline of two treatment groups.

	MUB (n = 51)	PT (n = 51)	*P* value
Age, y	57 (51-63)	59 (53-64)	.183
Sex, male: female (%)	33:67	33:67	1
BMI (kg/m^2)	22 (19.3-25.1)	21.6 (20-25)	.576
Affected side right: left (%)	47:53	57:43	.322
DM	9	7	.379
Duration of symptoms, months	5 (4-7)	5 (4-7)	.93
VAS	8 (7.1-8.5)	6.9 (5.6-8.5)	.014
ROM, FF, degrees	90 (85-100)	100 (90-110)	.017
Abd, degrees	70 (65-80)	80 (75-90)	<.001
ER, degrees	5 (0-20)	15 (10-25)	.002
IR	Buttock	Sacrum	.028
ASES score	34.3 (26.2-43.2)	40.5 (26.2-47)	.176
Constant Score	37 (28-43)	40 (28-51)	.349

(): interquartile range.
BMI, body mass index; *DM*, diabetes mellitus; *VAS*, visual analog scale; *ROM*, range of shoulder motion; *FF*, forward flexion; *Abd*, abduction; *ER*, external rotation at the side; *IR*, internal rotation; *ASES*, American Shoulder and Elbow Surgeons.

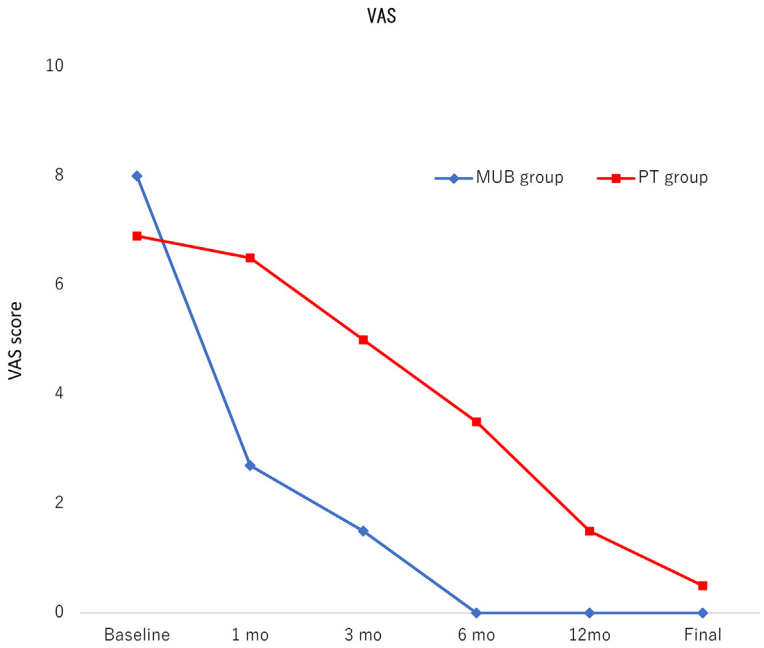
in the MUB group underwent PT for 20 minutes once a week and undertook self-exercise. The goal of the treatment was to treat the same conditions as described above.

Assessment of clinical outcomes

The baseline characteristics, including age, sex, body mass index, affected side, duration of symptoms, and treatment period, were recorded. The VAS pain score, ASES score, Constant Score, and EuroQol-visual analog scale (EQ-VAS) were assessed. ROM including FF, ER, and IR was also measured with a goniometer. For statistical analysis of IR, we numbered the IR ROM by assigning the number 1 to the first thoracic vertebra, with sequential numbering by vertebra until the fifth lumbar vertebra (number 17). IR to the sacrum was assigned the number 18, and IR to the buttock was assigned the number 19. All patients were evaluated at the baseline, 1, 3, 6, and 12 months after the treatment. Complications during MUB were investigated using MRI within 2 weeks of the procedure.

Cost-effectiveness of MUB and PT

Health care costs for the diagnosis and treatment of FS were derived from individual patient history data in the medical records. We conducted a phone survey at 2- and 3-year follow-ups to record the EQ-VAS for patients who completed the treatment and whose outpatient follow-up period was finished. All costs were converted



	Baseline	1 mo	3 mo	6 mo	12 mo	Final
MUB group(mm)	8 (7.2-8.5)	2.7 (2-4.2)	1.5 (0-3)	0 (0-1.6)	0 (0-0)	0 (0-0)
PT group(mm)	6.9 (5.7-8.3)	6.5 (5.1-7.7)	5 (4.2-6.7)	3.5 (2.6-5.1)	1.5 (1.6-2.6)	0.5 (0-1)
P value	0.014	<0.001	<0.001	<0.001	<0.001	<0.001

Figure 2 Comparison of VAS in two groups. *mo*, month; *MUB*, mobilization under brachial plexus block; *PT*, physiotherapy; *VAS*, visual analog scale. These results are reported as the median (25^{th}-75^{th} percentile).

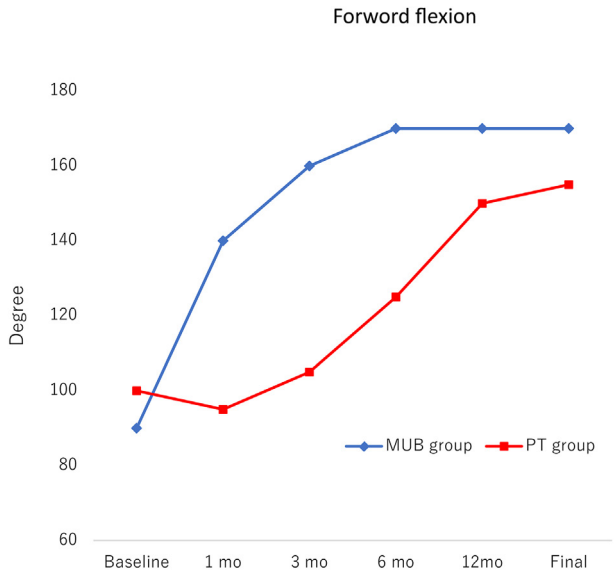
from Japanese yen to US dollars based on the Organization for Economic Cooperation and Development purchasing power parity in 2020 (1 dollar = 110 yen). Cost-effectiveness was evaluated with quality-adjusted life years (QALYs) gained using EQ-VAS and incremental cost-effectiveness ratios (ICERs). The mean duration of symptoms in refractory FS was considered to be 3 years, and QALY was calculated at 3, 6, 12, 24, and 36 months using the following formula: (EQ-VAS / 100) × 0.25 (at 3- and 6-month follow-up period), × 0.5 (at 1-year follow-up period), or × 1 (at 2- and 3-year follow-up period).[7] Total QALY was determined as the sum of every QALY at all evaluation periods, and ICER was calculated from the formula: total cost ÷ total QALY for 3 years.

Statistical analysis

All statistical analyses were performed using SPSS for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). The Mann–Whitney test was used to compare the two groups with respect to age, body mass index, duration of symptoms, treatment period, ROM, ASES score, Constant Score, health care cost, QALY, and ICER, while Pearson's chi-squared test was used to compare sex and the affected side. Friedman's test, Wilcoxon signed-rank test, and Bonferroni's multiple comparison test were used to assess the differences in VAS score, ROM, ASES score, and Constant Score between pretreatment and post-treatment. A P values < .05 was considered to represent statistical significance.

Results

A total of 102 patients were included in this analysis. The baseline characteristics of the patients are summarized in Table I. The PT group comprised 51 patients, with a median age of 59 years (range, 53–64 years); 66.7% of them were females, and the median duration of symptoms was 5 months (range, 4–7 months). The MUB group comprised 51 patients with a median age of 57 years (range, 51–63 years); 66.7% of them were female; and the median duration of symptoms was 5 months (range, 4–7 months). There were no significant differences in the baseline characteristics



	Baseline	1 mo	3 mo	6 mo	12 mo	Final
MUB group(degrees)	90 (87.5-100)	140 (125-152.5)	160 (150-170)	170 (155-175)	170 (165-180)	170 (165-180)
PT group(degrees)	100 (90-100)	95 (90-112.5)	105 (95-120)	125 (110-137.5)	150 (140-155)	155 (150-160)
P value	0.017	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Figure 3 Comparison of FF in two groups. *mo*, month; *MUB*, mobilization under brachial plexus block; *PT*, physiotherapy; *FF*, forward flexion. These results are reported as the median (25^{th}-75^{th} percentile).

between the two groups. The baseline VAS score, ROM, ASES score, and Constant Score are also shown in Table I. The VAS score in the MUB group was significantly higher (8.0 vs. 6.9, $P = .014$) and FF (90° vs. 100°, $P = .017$), ER (5° vs. 15°, $P = .002$), IR (buttock vs. sacrum, $P = .028$) were significantly lower compared with those in the PT group. There were no significant differences in the ASES and Constant Scores between the two groups. Pretreatment MRI findings revealed thickening of the axillary joint capsule and CHL, and no rotator cuff tears were identified in any patients.

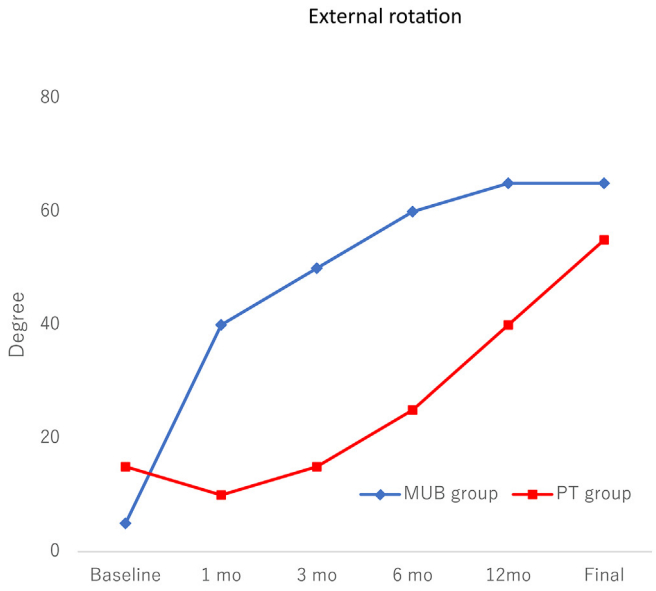
The period to achieve the goal of treatment (VAS < 1 and ASES score > 90 points) in the MUB group was significantly shorter than in the PT group (7.0 months vs 13.0 months), and the clinical follow-up period was 12.0 months in the MUB group and 15.0 months in the PT group. The VAS, ROM, ASES, and Constant Scores in the MUB group were superior at 1, 3, 6, and 12 months compared with those in the PT group (Figs. 2–7). VAS, ROM, and ASES, and Constant Scores in the MUB group 1 month after the procedure were greatly improved compared with those at baseline, and all clinical items continued to improve by the 6-month follow-up appointment. Conversely, in the PT group, VAS, ROM, ASES score, and Constant Score gradually improved up to the final follow-up.

Post-treatment MRI in the MUB group demonstrated ruptures of the axillary joint capsule in 51 patients (100%), the superior joint capsule in 41 (80.4%), the CHL in 48 (94%), and bone bruise of the humeral head in 12 (23.5%), a labral detachment in 1 (2%), and no dislocation or fracture in any patients. The bone bruise and labral detachment did not affect functional outcomes at any of the follow-up periods. No adverse events were reported in the PT group.

The median health care cost in the MUB group was statistically lower than that in the PT group ($1375 vs. $2751, $P < .001$). The QALYs of both groups (MUB vs. PT) for 3 years gradually increased as follows: 0.21 vs. 0.13 ($P < .001$) at 3 months, 0.25 vs. 0.16 ($P < .001$) at 6 months, 0.5 vs. 0.43 ($P < .001$) at 1 year, 1 vs. 1 ($P = .012$) at 2 years, and 1 vs. 1 ($P = .155$) at 3 years. As the total QALY was 2.95 in the MUB group and 2.68 in the PT group for 3 years, the MUB group spend of $466 and $1026 was required to reach 1 QALY. The ICER in the MUB group was calculated as −$560 compared with the PT group.

Discussion

The important findings of this study were that the period of treatment in the MUB group was shorter than that of the PT group, improvement of VAS, ROM, and ASES and Constant Scores in the MUB group were superior to those in the PT group at any follow-up time, and the PT group needed 6 months to catch up to the same level of clinical outcomes as the 1-month follow-up in the MUB group. Adverse events in the MUB group were less frequent than

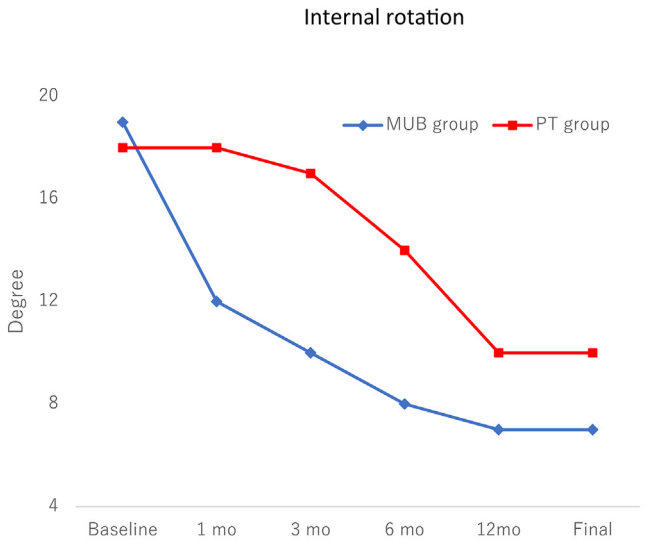


	Baseline	1 mo	3 mo	6 mo	12 mo	Final
MUB group(degrees)	5 (0-20)	40 (30-50)	50 (35-65)	60 (45-70)	65 (50-75)	65 (52.5-72.5)
PT group(degrees)	15 (10-25)	10 (5-25)	15 (10-25)	25 (20-35)	40 (35-50)	55 (40-60)
P value	0.002	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Figure 4 Comparison of ER in two groups. *mo*, month; *MUB*, mobilization under brachial plexus block; *PT*, physiotherapy; *ER*, external rotation. These results are reported as the median (25^{th}-75^{th} percentile).

those in the previous report of manipulation under cervical nerve root block for bone bruise (23.5% vs. 50%), labral detachment in 1 (2% vs. 13.3%), fractures (0% vs. 0%), brachial plexus injury (0% vs. 0%), and rotator cuff tears (0% vs. 0%).[27] Analysis of cost versus benefits between the two groups showed that MUB is a cost-effective treatment. Our manipulation procedure can thus be recommended as an appropriate conservative treatment option for refractory FS.

In the present study, the MUB group showed a shorter treatment period and superior effectiveness in clinical outcomes compared with the PT group; however, the findings are contradictory to outcomes in recent reports. The first randomized comparative study between MUA and home exercise with a 1-year follow-up reported that MUA did not add effectiveness to an exercise program carried out by the patients after instruction.[14] The second prospective randomized trial compared MUA and IA injections of corticosteroid with distension showed that no statistical differences in clinical outcomes were found between the two groups at the 2-year follow-up.[11] The third multicenter randomized control study, in which clinical outcomes for a 1-year follow-up period in ACR, MUA, and structured PT were compared with each group, concluded that none of the three interventions was clinically superior.[22] A systematic review of nine randomized trials comparing effectiveness among PT with IA injection of corticosteroid, MUA, and ACR concluded that neither PT with a steroid injection, MUA, nor ACR were clinically superior.[24] The patients enrolled in our study appear to provide contradictory results to those reported in recent reports. The inclusion criteria of our study, which were FF < 110°, Abd < 90°, ER at the side < 50% of the unaffected shoulder, IR to the back < the 5th lumbar vertebra, and the presence of thickened axillary joint capsule and CHL on MRI, were responsible for a conflict between the present study and three recent studies. In the first study, shoulder mobility of no more than 140° in elevation and 30° in ER was allowed; the patients in the second study were in the freezing phase of FS; and the inclusion criteria in the third study were only less than 50% of ER in the opposite shoulder.[11,14,22] ROM limitations in our study are global and severe compared with those in the other three studies; however, the inclusion of patients with mild restrictions of shoulder ROM in the other three studies led to negative conclusions about the MUA. We



	Baseline	1 mo	3 mo	6 mo	12 mo	Final
MUB group	19 (18–19)	12 (9. 5–15)	10 (7–13)	8 (7–10)	7 (6–8)	7 (6–9)
PT group	18 (16–19)	18 (16–19)	17 (15–18)	14 (12–16)	10 (9–13)	10 (9–11)
P value	0. 028	P<0. 001	P<0. 001	P<0. 001	P<0. 001	P<0. 001

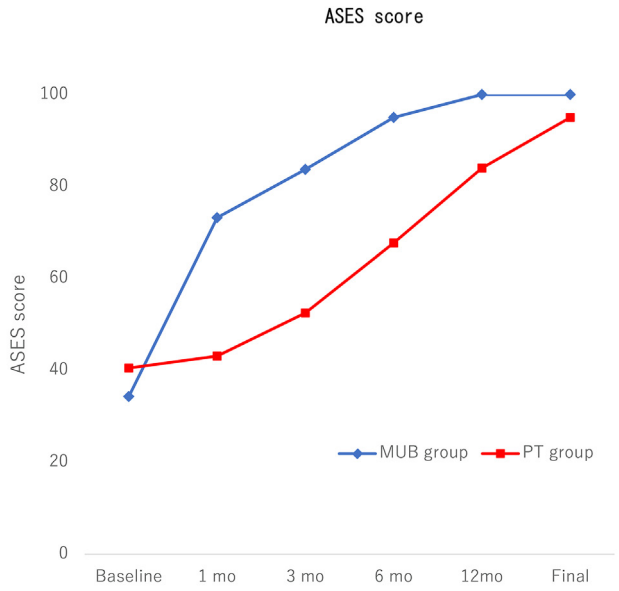
Figure 5 Comparison of IR in two groups. *mo*, month; *MUB*, mobilization under brachial plexus block; *PT*, physiotherapy; *IR*, internal rotation. These results are reported as the median (25^{th}-75^{th} percentile).

added MRI findings as inclusion criteria, as they are considered objective evidence of FS, but the other three studies did not assess MRI findings. Additionally, our criteria may influence the superior effectiveness of the MUB group compared with the PT group. As the main pathology in refractory FS is the thickening of the joint capsule, rotator interval, and CHL, MUB to eliminate these pathological conditions can add benefits by restoring ROM and improving severe pain for a shorter period of time.

A new manipulation procedure, adduction manipulation of the glenohumeral joint, to rupture the thickened upper part of the capsule, may affect the superior clinical outcomes in the MUB group compared with the PT group. Pan-capsular release, including resections of the superior capsule, rotator interval, and CHL during ACR, is a favorable procedure for refractory FS.[10] The conventional manipulation procedure is not able to eliminate the stiffness of the superior capsule. We used the conventional manipulation procedure in 25 patients with refractory FS; three patients did not have well-restored ROM, especially Abd, IR toward the back, and IR at 90° of shoulder Abd. They required ACR surgery, and arthroscopic findings showed that the inferior and posterior capsules had been ruptured, but that the thickened CHL and the superior capsule still remained in a thickened and fibrotic condition. After dissection of the soft tissues, the ROM was completely regained, most noticeably in the IR.[16] We reviewed the conventional method and added adduction manipulation to the glenohumeral joint as the new manipulation procedure that is used for the treatment of symptomatic rotator cuff tears.[34] Additionally, the maneuver to push the elbow forward in the position of the IR to the back is effective to rupture the CHL.[12] Our manipulation procedure started with adduction manipulation of the glenohumeral joint in rupturing the superior capsule and proceeded to stretch the posterior capsule and muscles to rupture the anterior capsule, the inferior capsule, and finally the CHL. After the new manipulation method became available, no patient who underwent MUB needed to have ACR.

General anesthesia has been a popular method of anesthesia for manipulation; however, regional anesthesia, such as cervical nerve block or brachial plexus block, has recently predominated. The advantages of transmission anesthesia are: less systemic effect; no hospitalization; no operation room; no anesthesia apparatus; and low cost. There are two options for regional anesthesia including under fluoroscopy or ultrasound. One study investigated the efficacy and safety of ultrasound-guided selective nerve root block versus fluoroscopy-guided interlaminar epidural block for the treatment of radicular pain in the lower cervical spine.[20] Although the clinical results in both groups had no significant difference, blood was aspirated before injection from 8% of patients in the fluoroscopy-guided group and 0% in the ultrasound-guided group. Furthermore, ultrasound-guided transmission anesthesia does not have exposure to radiation. Seven patients in the fluoroscopy-guided group demonstrated that intravascular contrast was noted during injection; therefore, an ultrasound-guided selective nerve root block is safer than a fluoroscopy-guided block. In our study, transmission anesthesia under ultrasound did not have any complications. Ultrasound-guided transmission anesthesia is recommended for the manipulation of refractory FS.

MUB may be associated with a risk of dislocation, fractures, bone bruises of the humeral head, labral detachment, and rotator cuff tears during the procedure.[17,18,26] One study reported that 1 week after the manipulation, 96% of patients had capsular tears, 40% had bone bruises, and 20% had labral tears.[26] The present study



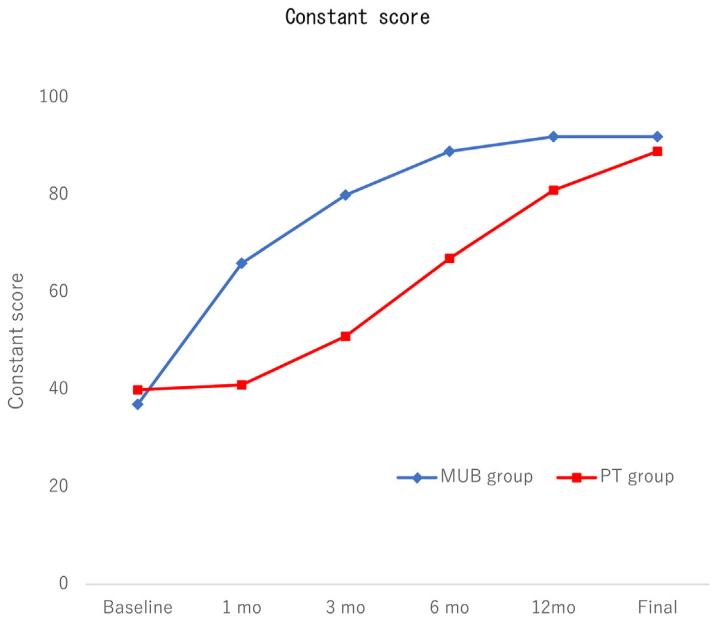
	Baseline	1 mo	3 mo	6 mo	12 mo	Final
MUB group	34.3 (26.8–42.5)	73.2 (60.1–78.8)	83.7 (73–92.5)	95 (85.3–100)	100 (96.7–100)	100 (97.9–100)
PT group	40.5 (27.9–46.9)	43.1 (32.7–58.4)	52.5 (46.8–63.4)	67.7 (57.1–74.7)	84 (76.5–89.9)	95 (91.4–100)
P value	0.176	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

Figure 6 Comparison of ASES score in two groups. *mo*, month; *MUB*, mobilization under brachial plexus block; *PT*, physiotherapy; *ASES*, American Shoulder and Elbow Surgeons. These results are reported as the median (25^{th}-75^{th} percentile).

demonstrated rupture of the inferior joint capsule in 51 patients (100%), the superior joint capsule in 41 (80.4%), the CHL in 48 (94%), bone bruise of the humeral head in 12 (23.5%), labral detachment in 1 (2%), and no dislocation or fracture in any patients. The percentage of complications such as bone bruises of the humeral head, and labral tears was less than those in the previous literature. Blocking the 5th and 6th cervical nerve roots paralyzes only the rotator cuff and deltoid muscles. In contrast, brachial plexus block from the 5th to 8th cervical nerve roots can paralyze the biceps and triceps brachii, serratus anterior, latissimus dorsi, and teres major muscles including the rotator cuff and deltoid muscles. Manipulation under the brachial plexus block appears to make the manipulation procedure easier, less painful, and with fewer complications due to flaccid paralysis in many muscles compared with the cervical nerve root block. Nevertheless, a gentle manipulation maneuver is required, and attention should be paid to inhibit complications such as dislocation or fracture during MUB.

The total health care cost of the MUB group was significantly lower than that of the PT group, and MUB was more cost-effective compared with PT. Medical expenses for treatment of FS are covered by national health insurance in many countries. The medical cost of ACR is $4242, MUB is $167, one-time is PT $23, (4 times in a month is $158 and 8 times in a month is $265) and additionally, patients need to pay 30% of the total medical fees in our country. There are two reasons why the cost of MUB is cheaper than that of PT; one is the low cost of MUB, and the second is the shorter treatment duration for MUB compared with PT. This result is supported by the study that concluded that MUA was the most cost-effective intervention among ACR, MUA, or structured PT.[22] Furthermore, another prospective randomized study that compared the cost-effectiveness between ACR and MUA also concluded that MUA was more cost-effective than ACR.[30] In the treatment of refractory FS, there is the possibility that MUB will contribute to the reduction of national health care costs.

There are some limitations to the current study. The first limitation of this nonrandomized study includes a selection bias. The second limitation is that a significant difference in VAS, FF, ER, and IR at baseline was found in the MUB and PT groups. The differences between the selection of patients in the PT group were not clinically significant and did not affect clinical outcomes because clinical outcomes in the MUB group were superior to those in the PT group at every follow-up period despite better VAS, FF, ER, and IR in the PT group at baseline. The third limitation is the short follow-up period. A 2-year follow-up period is appropriate for this study. The final limitation is that we did not investigate patient-reported outcome measures, for example, by seeking feedback using the Short Form 36. Recent research has recommended a quantitative approach to measuring aspects of health status by asking patients directly using a standardized questionnaire.



	Baseline	1 mo	3 mo	6 mo	12 mo	Final
MUB group	37 (29–43)	66 (60–75)	80 (69.5–89)	89 (80–92)	92 (89–95)	92 (89–95)
PT group	40 (28–51)	41 (34–56)	51 (42–58.5)	67 (54–73)	81 (73.5–89)	89 (86–95)
P value	0.349	P<0.001	P<0.001	P<0.001	P<0.001	0.026

Figure 7 Comparison of Constant Score in two groups. *mo*, month; *MUB*, mobilization under brachial plexus block; *PT*, physiotherapy. These results are reported as the median (25^{th}-75^{th} percentile).

Conclusion

The MUB can reduce pain, restore ROM, and obtain superior clinical outcomes for patients with refractory FS at 1 month after the procedure, and the improvements were maintained at the 12-month follow-up compared with those in the PT group. The clinical outcomes in the MUB group are superior to those in the PT group at every point in the follow-up period. The MUB procedure shows excellent clinical effectiveness, a low occurrence of adverse events, and low cost-effectiveness compared with PT. Therefore, MUB is a recommended treatment option for patients with refractory FS who hope to recover in a shorter period of time.

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