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Relationship between pain and range of motion in frozen shoulder

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Background: A frozen shoulder (FS) is characterized by pain and limited range of motion (ROM). Although physical assessment of ROM is important for diagnosing and staging FS, ROM cannot be accurately assessed in clinical practice because of pain and muscle contraction. This study aimed to measure changes in shoulder joint ROM before and after anesthesia (ΔROM) in patients with FS and investigate the factors affecting these changes.

Methods: This study included 54 patients (age, 55.6 ± 9.4 years; 17 males; disease duration, 6.6 ± 3.4 months) with FS before manipulation under transmission anesthesia. FS was defined as having a ROM in external rotation (ER) that was less than 50% of that in the unaffected shoulder. Pain at night and during motion was assessed using a numerical rating scale. Before anesthesia, the passive ROM of forward flexion (FF), abduction (AD), and ER were measured in the supine position. After confirming that the anesthesia was effective, passive ROM was measured again.

Results: The ROM in the FF, AD, and ER after anesthesia was significantly higher than that before anesthesia ($P < .001$). ΔROM in the FF, AD, and ER was significantly correlated with pain at night ($r = 0.51$, $P < .001$; $r = 0.45$, $P < .001$; and $r = 0.39$, $P = .004$, respectively). Furthermore, ΔROM in the ER was significantly correlated with pain during motion ($r = 0.31$, $P = .023$) and disease duration ($r = -0.31$, $P = .021$).

Conclusion: The ROM of the FS is susceptible to pain and muscle contraction. Interventions, such as physical therapy, may be recommended after pain relief.

Frozen shoulder (FS) is a common musculoskeletal disorder characterized by pain and limited range of motion (ROM), with a reported incidence of 3%-5% in the population.[18,22] The major causes of FS are synovitis and fibrosis around the glenohumeral joint, characterized by a multidirectional limited ROM.[7,11] A previous study with an average follow-up duration of 7 years showed that 50% of patients still had mild pain and 60% had some form of ongoing stiffness.[28] The chronicity of this problem is burdensome for the patients and reduces their quality of life.

FS has long been diagnosed based on shoulder joint ROM and radiographic and magnetic resonance imaging.[13] ROM and pain intensity assessment are important for unifying the diagnosis and stage of the condition.[22] The disease duration is also an essential factor that influences ROM.[35] Although FS has traditionally been classified into the freezing, frozen, and thawing stages based on ROM and pain intensity, these classifications remain controversial because the 3 stages progress with overlapping symptoms.[20] In addition, there are no uniform standards for evaluating the ROM based on various previous reports.[11,16,24] In clinical practice, we encounter cases in which active and passive shoulder joint ROMs vary widely or cannot be accurately measured because of pain or muscle contraction.[10,16,30] Assessing the relationship between pain and ROM in FS and investigating the factors affecting ROM are important for unifying the diagnosis and staging of FS.

In recent years, shoulder manipulation using ultrasound-guided cervical nerve root block in patients with FS has become widespread and good results have been reported.[26,27] This technique has made it possible to assess shoulder joint ROM in outpatients while eliminating shoulder joint pain and muscle contraction.

Institutional review board approval was obtained for this study from the Tochigi Medical Center Shimotsuga hospital (No.188).

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This study aimed to measure changes in shoulder joint ROM before and after anesthesia in patients with FS and investigate the factors affecting these changes.

Materials and methods

This study was approved by the Tochigi Medical Center Shimotsuga Institutional Review Board (no.188).

Participants

This was a cross-sectional, observational study. This study included 54 patients with FS, (17 men and 37 women). The average age was 55.6 (41-80) years. The mean disease duration was 6.6 (2-24) months. The inclusion criteria were age >30 years with a clinical diagnosis of unilateral FS and restricted external rotation (ER) at the shoulder joint on the affected side <50% of that in the contralateral shoulder.[24] Patients with osteoarthritis, rheumatoid arthritis, calcific tendinitis, rotator cuff tears, fractures, or dislocations were excluded. In addition, we excluded patients with a history of trauma to the affected shoulder within 4 weeks before surgery, history of surgery on the affected shoulder, shoulder pain due to spinal disease, or concurrent inflammatory and neurological disease involving the affected shoulder.[26] FS was diagnosed by a single orthopedic surgeon (H.S.) with more than 20 years of experience. The patients underwent shoulder manipulation under ultrasound-guided cervical nerve root block between April 2020 and August 2022. Informed consent for this study was obtained from all patients.

Measures

The ROMs (forward flexion [FF], abduction [AD], and ER) before anesthesia was measured in the supine position using a goniometer (GS11-002, OG Giken, Okayama, Japan).[14,16,17,21] To avoid pain induction, the ROMs were measured only once by a single leading physical therapist with over 15 years of experience and certification in the field of orthopedic rehabilitation.[29] Anesthesia was administered by a single orthopedic surgeon (H.S.) with more than 20 years of experience. The C5 and C6 nerve roots were identified using an ultrasound device (SONIMAGE HS; Konica Minolta, Tokyo, Japan), and 10 mL each of ropivacaine hydrochloride, normal saline, and 1% lidocaine were injected around the nerve roots.[12,26] Needle electromyography (MEB-2300 series Neuropac X1; Nihon Kohden, Tokyo, Japan) was performed on the deltoid and biceps brachii muscles of the first 10 patients to confirm whether muscle contraction at the C5 and C6 nerve root level had disappeared 15 minutes after anesthesia, and it was confirmed that the electromyography waveform during voluntary contraction was flat in all of these cases. The inability of shoulder and elbow joints to move spontaneously 15 minutes after anesthesia was verified in subsequent cases; ROMs were measured after anesthesia by the same physiotherapist with over 15 years of experience who measured ROMs before anesthesia (Fig. 1). For the first 5 patients, the ROMs were measured by 2 physical therapists with more than 15 years of experience and certification or leadership positions in orthopedic rehabilitation to assess the intra- and inter-rater reliabilities of the ROMs after anesthesia.

Other demographic data, such as age, sex, body mass index, affected side, employment status, presence of diabetes, and disease duration, were also collected. For shoulder pain and function assessment, the numeric rating scale, American Shoulder and Elbow Surgeons score, and Constant–Murley Score were used.[2,15,25]

Statistical analysis

G*Power 3.1 software (Heinrich Heine University, Düsseldorf, Germany) was used to evaluate ROM changes before and after anesthesia in patients with FS. A total of 54 participants were included to achieve the required sample size (effect size = 0.5 [large], α error = 0.05, and power = 0.95). Paired *t*-tests or Wilcoxon signed-rank tests were performed on the ROM data before and after anesthesia. If there was a significant difference in ROM before and after anesthesia, the correlation between the pre- and post-ROM difference (ΔROM) and factors affecting ROM were examined using Pearson's and Spearman's correlation coefficients, with a statistical significance level of $P < .05$. Statistical analyses were performed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA).

Results

Table I shows the patients' backgrounds and clinical characteristics (Table I). The FF, AD, and ER after anesthesia were significantly higher than those before anesthesia ($P < .001$). The ΔROM values were: FF, 21.8 ± 21.8; AD, 29.7 ± 28.4; and ER 12.1 ± 12.5 (Table II). ΔROM and pain at night were significantly correlated with FF, AD, and ER ($r = 0.51$, $P < .001$; $r = 0.45$, $P < .001$; and $r = 0.39$, $P = .004$, respectively). ΔROM in the ER was significantly correlated with pain during motion ($r = 0.31$, $P = .023$), whereas no significant correlation was found between pain during motion and ΔROM in the FF and AD (Fig. 2). ΔROM in the ER was significantly correlated with disease duration ($r = -0.31$, $P = .021$), whereas no significant correlation was found between disease duration and ΔROM in the FF and AD ($P > .05$) (Fig. 3). No significant correlation was found between ROM before and after anesthesia and pain intensity ($P > .05$) (Table III). The intra- and inter-rater reliabilities of the ROM in the FF, AD, and ER after anesthesia, as assessed by the 2 examiners, were satisfactory (intraclass correlation coefficient [1.1]: 0.99, 0.95, and 0.93; [2.1]: 0.97, 0.98, and 0.93, respectively).

Discussion

This study showed that ROM changes before and after the administration of anesthesia in patients with FS correlated with pain intensity, indicating that pain intensity directly impact ROM measurements.

Several studies have evaluated ROM under anesthesia in musculoskeletal disorders other than the shoulder joint.[5,9] Recently, Hollmann et al reported cases of patients with FS whose ROM significantly increased from 55° to 110° in AD and 15° to 40° in ER under general anesthesia.[10] In our study, the values of changes in ROM were 22°, 30°, and 12° for FF, AD, and ER, respectively, under transmission anesthesia. Thirteen shoulders (24%) showed an increase of >50° in the AD and 23 shoulders (43%) showed an increase of >15° in the ER. Although orthopedic surgeons with more than 20 years of experience judged FS based on ROM during outpatient visits in this study, more than a few patients had significant changes in ROM after transmission anesthesia. These previous studies and ours indicate that ROM with pain, muscle contraction, and ROM without pain have different clinical implications.

In this study, ΔROM correlated with pain intensity; however, ROM before and after anesthesia was not associated with pain intensity. There are few reports on the relationship between ROM and pain in patients with FS. De Baets et al found an association between passive ROM in FS and structural factors, such as the

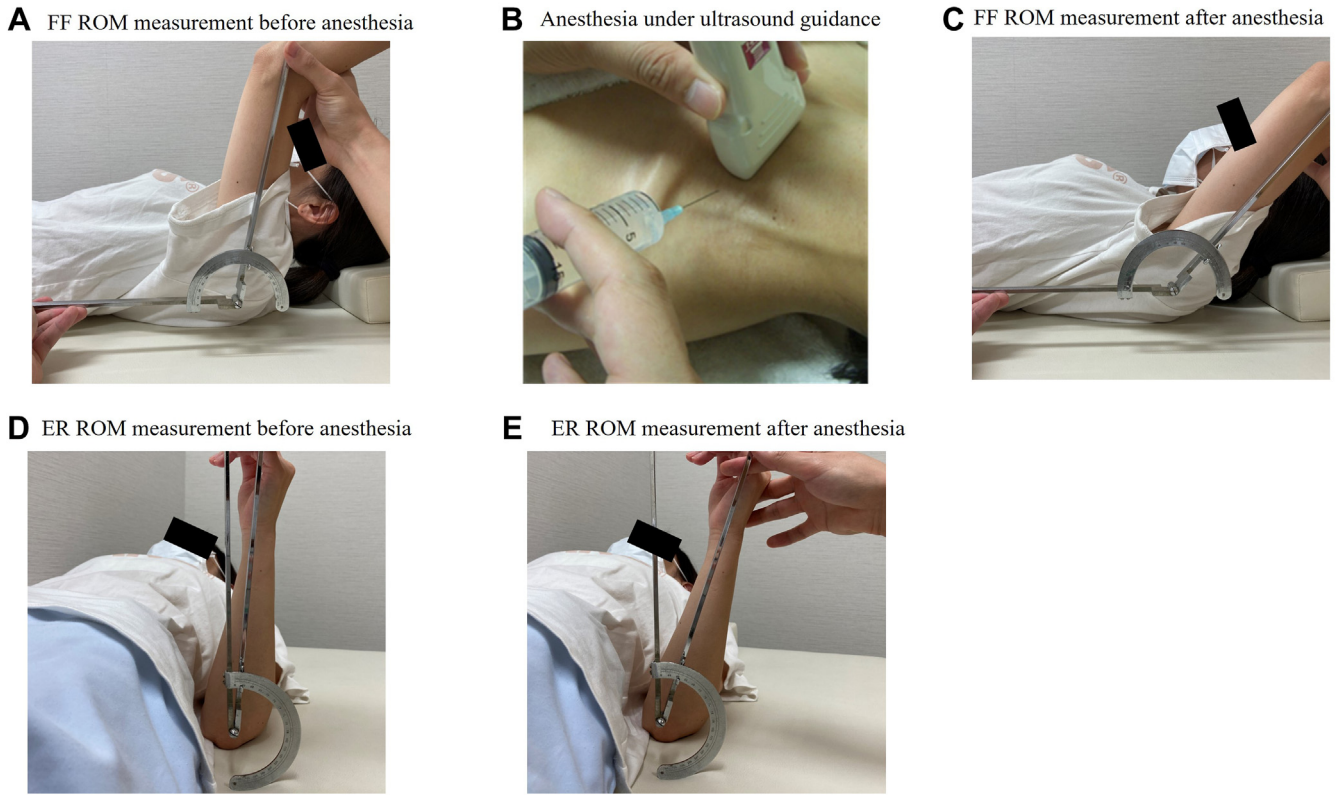

Figure 1 Measurement of ROM before and after anesthesia. The ROM was passively measured in the supine position. Anesthesia was administered under ultrasound guidance. After 15 minutes, ROM was passively remeasured. (A, D) ROM measurements before anesthesia, (B) anesthesia under ultrasound guidance, and (C, E) ROM measurements after anesthesia. *ROM*, range of motion; *FF*, forward flexion; *ER*, external rotation.

Table I
Patient demographic and clinical characteristics.

Variables (n = 54)		Values
Age (y)		55.6 ± 9.4
Sex (female/male)		37/17
BMI		21.7 ± 2.5
Affected side (right/left)		28/26
Disease duration (mo)		6.6 ± 3.4
DM		3/54
Employment status summary		
In paid work/not in paid work		38/16
NRS	Pain at night	6.4 ± 2.8
	Pain during motion	7.7 ± 2.8
ASES score		27.6 ± 17.9
Constant Score		27 ± 9.9

ASES, American Shoulder and Elbow Surgeons; *BMI*, body mass index; *DM*, diabetes mellitus; *NRS*, numerical rating scale.
Data are presented as means ± standard deviations.

coracohumeral ligament (CHL) and inferior glenohumeral ligament thickness, but they did not find a relationship with pain intensity, as in this study.[6] On the other hand, it was a new finding that ΔROM and pain intensity were correlated in this study. Fear or avoidance of pain leading to motor adaptation, such as muscle protection and ROM restriction, could be the reason for lower ROM before anesthesia than after anesthesia.[9,19,33] Accurate ROM evaluation is important for diagnosing and staging FS; however, accurate measurements cannot be obtained when severe pain is present. Itoi et al reported that an important feature of FS is that the reduction in ROM is fixed and not influenced by pain.[13] If ΔROM is small, muscle protection due to pain has little effect, which may indicate true ROM limitation. In this study, the relationship among pain at night, during motion, and ΔROM was not clear; in any case, it is desirable to evaluate patients in a state where ΔROM does not occur, and ROM evaluation should be performed after pain relief, even in an outpatient setting.

In this study, disease duration and ΔROM in the ER were significantly negatively correlated. Wu et al reported that disease duration was negatively correlated with ER ROM and positively correlated with CHL thickness.[35] Although this classification of the stage in FS remains controversial because of overlapping symptoms,[20] CHL is reported to be stiffer in later stages than in the early stage.[34,36] The CHL has been reported to be one of the factors limiting ER.[8] In addition, ROM limitation occurs because of joint capsule fibrosis with disease progression.[1] In this study, the longer the disease duration, the smaller the change in ROM in the ER before and after anesthesia. This indicates that the ROM after anesthesia is less likely to change because the CHL and joint capsule become structurally stiffer with longer disease duration.

The treatment goals, such as physiotherapy for patients with FS, include pain relief and ROM improvement.[23,32] However, Binder et al reported that aggressive ROM exercise in patients with FS during painful periods exacerbated the pain.[3] Thus, reliable and accurate assessment of shoulder movement with pain is a clinical challenge.[20] In this study, since the participants were patients with FS who performed before shoulder manipulation, before and after ROM could be evaluated without pain and muscle contraction using transmission anesthesia; however, this is difficult in clinical practice, such as in outpatient clinics. Therefore, it is necessary to evaluate ROM immediately before and after the injection of steroids into the joint,[4,31] which has been reported to be highly effective in relieving pain. After overcoming pain-induced ROM limitation, residual ROM restriction should be treated as a true contracture.

Table II
Range of motion results before and after anesthesia.

Variables(n = 54)	Before anesthesia	After anesthesia	ΔROM	*P* values
ROM (°)				
Forward flexion	96.7 ± 19.7	117.7 ± 23.7	21.8 ± 21.8	<.001
Abduction	74.1 ± 23.5	103.8 ± 32.5	29.7 ± 28.4	<.001
External rotation	13.4 ± 15.6	25.6 ± 21.1	12.1 ± 12.5	<.001

ΔROM, difference between ranges of motion before and after anesthesia; *ROM*, range of motion.
Data are presented as means ± standard deviations.

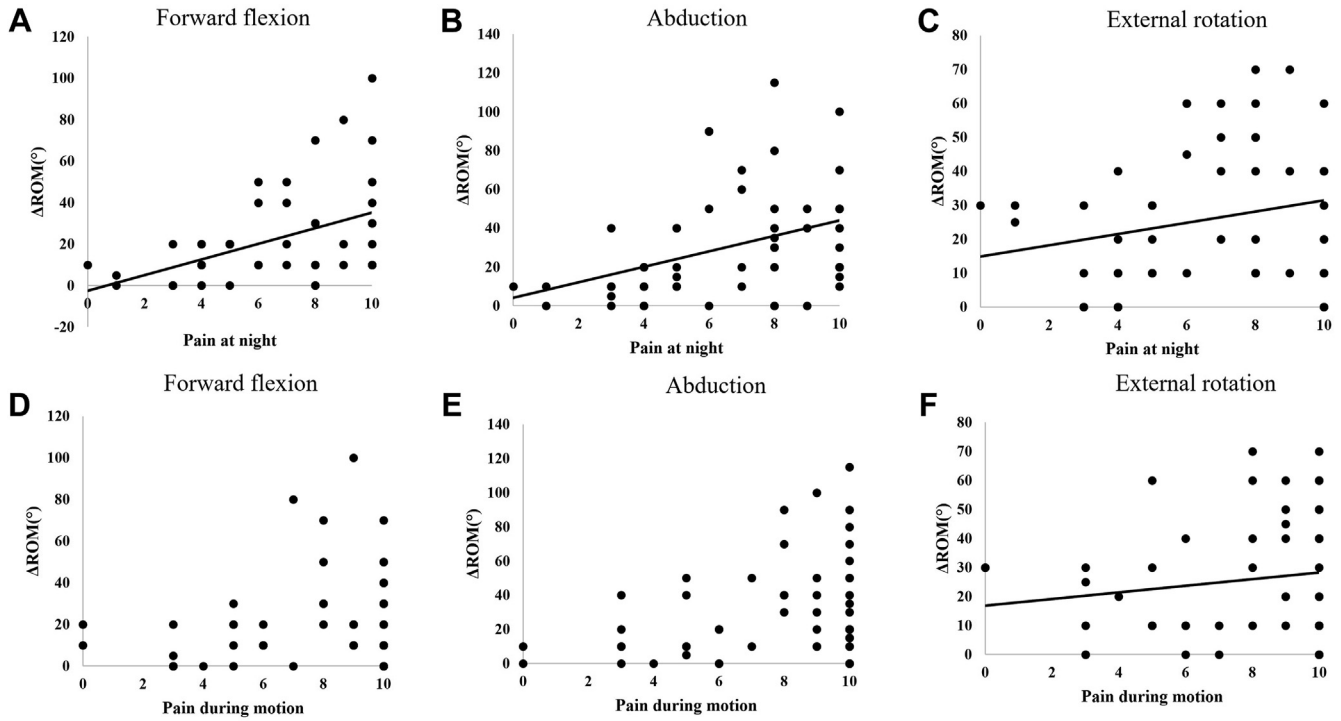

Figure 2 Correlation between pain intensity and ΔROM. A correlation between pain intensity at night and during motion and the difference in the range of motion before and after anesthesia is shown. (A, D) Forward flexion, (B, E) abduction, and (C, F) external rotation. *ΔROM*, difference between ranges of motion before and after anesthesia.

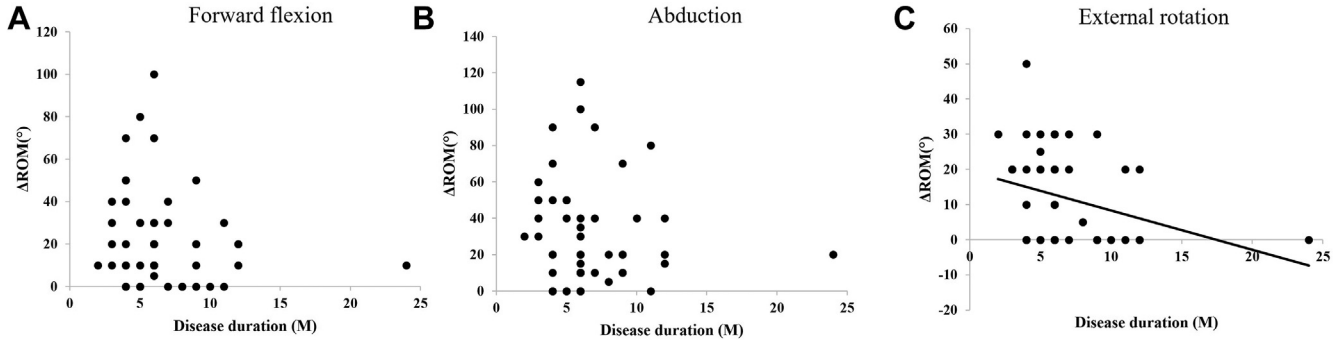

Figure 3 Correlation between duration of disease and ΔROM. A correlation between the duration of the disease and the difference in the range of motion before and after anesthesia is observed. (A) Forward flexion, (B) abduction, and (C) external rotation. *ΔROM*, difference between ranges of motion before and after anesthesia.

This study had some limitations. First, it was limited to patients who desired shoulder joint manipulation using cervical nerve root blocks. We utilized the diagnostic criteria for FS reported by Rangan et al[24]; however, we encountered difficulty distinguishing between cases in the inflammatory and frozen phases. In this study by Rangan et al, of the 54 participants, 31 defined by International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) were supposedly in the frozen phase and 23 assumed to be in the inflammatory phase. Second, although we did not use highly accurate and specialized instruments, we assessed the intra- and inter-rater measurement reliabilities by 2 experienced physical therapists using a small sample size. ROM measurements in the supine position have been shown to be highly reproducible, even in the presence of shoulder pain.[21] Third, the

Table III
Correlation between range of motion and pain intensity.

Variables (n = 54)		Pain at night		Pain during motion	
ROM		*P* values	r	*P* values	r
Forward flexion	Before anesthesia	.051	−.267	.067	−.251
	After anesthesia	.135	.205	.782	.039
Abduction	Before anesthesia	.189	−.187	.059	−.26
	After anesthesia	.193	.18	.973	.005
External rotation	Before anesthesia	.953	−.008	.486	−.097
	After anesthesia	.14	.203	.541	.085

ROM, range of motion; *r*, correlation coefficient.

effects of anesthesia were not evaluated. However, we confirmed the disappearance of spontaneous contraction of the representative muscles from C5 to C6 using needle electromyography after anesthesia and confirmed that the depth of anesthesia was high. Fourth, factors other than pain and muscle contraction those affect the ROM before and after anesthesia were not examined. Future studies investigating the relationships among ROM, magnetic resonance imaging findings, and histological findings of the shoulder joint will help clarify the pathology of FS.

Conclusion

The ROM in patients with FS is susceptible to pain and muscle contraction. Interventions, such as physical therapy, may be recommended after pain relief.

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