

Ultrasound Assessment of the Coracohumeral Ligament and Rotator Interval and Its Association With Physical Function in Patients With Adhesive Capsulitis of the Shoulder: A Scoping Review

Review began 09/27/2026

Review ended 10/12/2026

Published 10/24/2026

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DOI: 10.7759/cureus.118528

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Abstract

In adhesive capsulitis (AC), ultrasound (US) assessment of the coracohumeral ligament (CHL) and rotator interval (RI) is widely performed, but the relationship between these imaging findings and clinical symptoms has not been adequately synthesized. This scoping review aimed to map the evidence on associations between US findings of the CHL and RI and clinical assessments (range of motion (ROM), pain, and patient-reported outcomes) in AC, and to identify implications for clinical practice and future research. Following the Joanna Briggs Institute (JBI) methodology and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (protocol registered on the Open Science Framework), four bibliographic databases (PubMed, Scopus, Ichushi-Web, and PEDro) and two trial registries (International Clinical Trials Registry Platform (ICTRP) and ClinicalTrials.gov) were searched through January 2026 for English- or Japanese-language records. Studies were eligible if they investigated patients with AC and examined associations between US findings of the CHL or RI and physical function. Two reviewers independently screened studies and charted data on study characteristics, US assessments, physical function, and key findings, with disagreements resolved by consensus, and data were synthesized descriptively. Of 2,488 records identified, 17 met the eligibility criteria (16 studies and one trial registration). CHL thickness, the most frequently assessed parameter, was associated with limited external rotation ROM in most studies, whereas the association between RI vascularity and pain was inconsistent; substantial heterogeneity was observed in staging, US measurement, and outcome assessment methods, and an author-developed, hypothesis-generating clinical reasoning matrix was proposed. CHL thickness appears to be a promising US indicator of external rotation limitation in AC, whereas evidence for the clinical significance of RI vascularity remains insufficient, and standardized staging and US protocols are needed to clarify the utility of US-based assessment for treatment decision-making.

Categories: Radiology, Physical Medicine & Rehabilitation, Orthopedics

Keywords: adhesive capsulitis, coracohumeral ligament, frozen shoulder, pain, physical function, rotator interval, scoping review, shoulder range of motion, ultrasonography, ultrasound

Introduction And Background

Adhesive capsulitis (AC) is a condition characterized by marked pain and restricted range of motion (ROM) in the glenohumeral joint [1]. Although the cause of primary (idiopathic) AC remains unclear, it has been associated with diabetes mellitus and thyroid disease, and secondary forms develop after known causes of stiffness and immobility, such as shoulder trauma or surgery [1]. Its pathology is thought to involve synovitis and fibrosis of the joint capsule [2], progressing through pre-adhesive, inflammatory, frozen, and recovery stages, each with distinct pain and stiffness characteristics [3]. Stage-specific treatment is recommended, although these stages cannot be clearly delineated and have been shown to represent a continuum [4].

In patients with AC, thickening of the coracohumeral ligament (CHL) [5] and inflammatory changes accompanied by neovascularization in the rotator interval (RI) [6] have been reported, suggesting that objectively evaluating these features may be useful for staging. The CHL spans from the coracoid process to the humeral tuberosities and forms part of the RI capsule; it has been shown to restrain external rotation and extension with the arm at the side [7]. Neovascularization, the proliferation of abnormal small vessels in inflamed synovium, can be visualized as a Doppler flow signal and has been observed during the early, typically painful, stage of AC [8], whereas the later stages are characterized by less synovitis and more mature adhesions [5]. Objective assessment of RI inflammatory findings and CHL thickness may therefore help in staging AC and inferring physical function, although whether it can guide treatment selection remains unclear.

With the recent spread of ultrasound (US) imaging, non-invasive, real-time assessment of the CHL and RI has become increasingly common in physical therapy practice. Among the findings assessed, CHL thickening [5,9] has been the most widely examined as a diagnostic marker, whereas increased CHL stiffness [10], enlarged cross-sectional area [11], and RI neovascularization [5] remain investigational; none has been validated as a staging or prognostic marker. How these US findings relate to physical function, including pain and direction- and severity-specific ROM limitation, has not been systematically synthesized, and differences in measurement position and staging definitions across studies leave it unclear whether a consistent relationship exists. If a consistent association were established, US indicators might eventually support prognostic prediction and treatment decision-making.

Therefore, the aim of this scoping review (ScR) was to comprehensively map the evidence examining the association between US indicators of the CHL and RI and physical function in AC. A further aim was to clarify methodological heterogeneity and to outline, as a hypothesis-generating exercise, how the mapped findings might be organized into a clinical reasoning framework; this framework represents the authors' interpretation and is not a validated clinical tool.

Review

Methodology

Scoping Review Methodology

The protocol for this ScR was developed using the Joanna Briggs Institute (JBI) methodology [12] and was designed to comply with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guideline [13]. The review protocol was prospectively registered on the Open Science Framework (<https://osf.io/ym8zs/overview>).

Eligibility Criteria

Studies involving patients with AC, frozen shoulder, or idiopathic contracture were included if they performed US assessment of the CHL or RI and reported a statistical association (correlation analysis, between-group comparison, or pre-post comparison) between US findings and physical function (ROM, pain scales, or patient-reported outcomes). No restrictions were placed on disease stage, care setting, region, or diabetes status, and reports, theses, and clinical trial registrations were eligible. Only studies published in English or Japanese were included.

Excluded were studies without US assessment of the CHL or RI, without physical function assessment, or

How to cite this article

Itou T, Funayose H, Isaji Y (October 24, 2026) Ultrasound Assessment of the Coracohumeral Ligament and Rotator Interval and Its Association With Physical Function in Patients With Adhesive Capsulitis of the Shoulder: A Scoping Review. Cureus 18(10): e118528. DOI 10.7759/cureus.118528

without a statistical association between the two; studies involving other conditions (rotator cuff tear, fracture, dislocation, secondary post-surgical contracture, calcific tendinitis, glenohumeral osteoarthritis, rheumatoid arthritis, or stroke); animal, cadaveric, surgical-technique, review, letter, conference-abstract, and case-report publications; and publications in languages other than English or Japanese.

Data Searches

A preliminary PubMed and Ichushi-Web search informed a comprehensive strategy for four bibliographic databases (PubMed, Scopus, Ichushi-Web, and PEDro), combining title/abstract words and index terms. To capture unpublished and ongoing studies, two trial registries (International Clinical Trials Registry Platform (ICTRP) and ClinicalTrials.gov) were also searched. Combinations of Medical Subject Headings (MeSH) and keywords were adapted as needed for each database (Appendix A). Searches were limited to studies published in English or Japanese, with no restriction on publication year. The final search was conducted on January 24, 2026. After the search, all identified citations were collated and uploaded to Rayyan (Rayyan Systems Inc., Cambridge, MA, USA), and duplicate records were removed.

Study Selection

Titles and abstracts were independently screened against the eligibility criteria by two authors (T.I., H.F.); the full texts of retained citations were then independently assessed by the same two authors. Reasons for excluding studies that did not meet the eligibility criteria were recorded in a flow chart. Disagreements between authors at each stage of study selection were resolved through discussion or, when necessary, consultation with a third author (Y.I.). The search results and study inclusion process are presented in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) flow chart (Figure 1) [14].

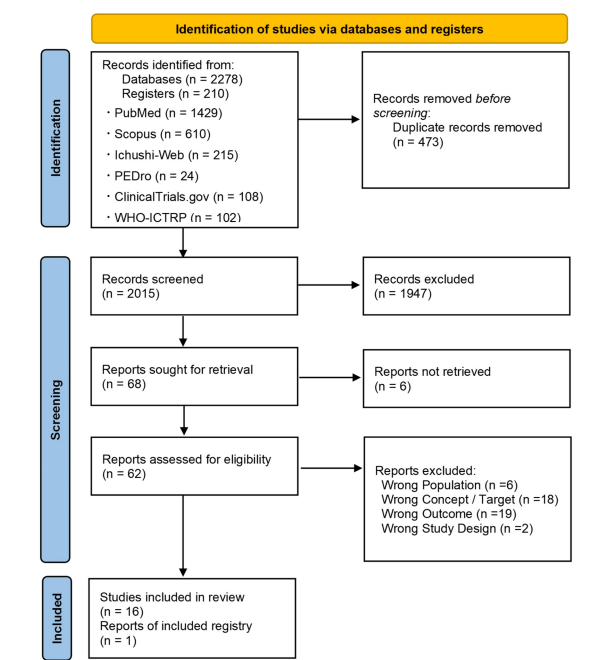


FIGURE 1: PRISMA-ScR flow diagram of study identification, screening, and inclusion
Diagram format adapted from the PRISMA-ScR guideline [13].
PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews; ICTRP: International Clinical Trials Registry Platform

Critical Appraisal

In general, the purpose of a scoping review is to map the available evidence. Because the intent is not to provide a synthesized, clinically meaningful answer to a question or to estimate the strength of evidence, critical appraisal is not recommended [12]. Accordingly, quality appraisal was not performed in this ScR.

Data Extraction

Two independent authors (T.I., H.F.) extracted data from the studies included in the ScR, comprising study authors, year of publication, country, study design, sample size, disease stage, US assessment, and physical function assessment (Appendices B-D). Data extraction was performed using Excel (Microsoft Corp., Redmond, WA, USA), and disagreements between authors were resolved through discussion or consultation with a third author (Y.I.). For missing data, corresponding authors of the studies were contacted to request additional information.

Data Synthesis and Evidence Gap Map

Extracted data were synthesized descriptively, and an evidence gap map (Figure 2) was constructed summarizing, for each combination of US parameter (vertical axis) and clinical outcome (horizontal axis), the number of studies reporting that combination and the direction of the reported findings.

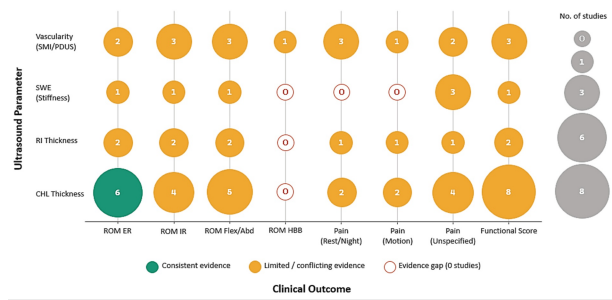


FIGURE 2: Evidence gap map of ultrasound parameters and clinical outcomes in adhesive capsulitis
Bubble size = number of studies reporting each combination. Green = consistent evidence (≥2 independent studies with |r| > 0.3, p < 0.05, or equivalent, in the same direction); orange = limited or conflicting evidence (single study, inconsistent or non-significant findings, or no direct statistical test of association); red border = evidence gap (0 studies). This is a pragmatic, review-specific classification, not a validated level of evidence or an appraisal of study quality.
ROM: range of motion; SMI: superb microvascular imaging; PDUS: Power Doppler Ultrasound; SWE: shear wave elastography; RI: rotator interval; CHL: coracohumeral ligament; ER: external rotation; IR: internal rotation; HBB: hand-behind-back

Because no existing classification scheme was available, the evidence level of each cell was classified a priori into three levels. Consistent evidence (green) required two or more independent studies reporting statistically significant findings in the same direction, meeting at least one of: (1) |r| > 0.3 with p < 0.05; (2) a significant association between the magnitude of change in the US parameter and in the clinical outcome (e.g., multivariate regression); or (3) a significant between-group difference (p < 0.05) in the US parameter when stratified by clinical severity. Limited or conflicting evidence (orange) was assigned when: (1) results were inconsistent across or within studies; (2) a significant association had |r| < 0.3; (3) the US parameter and clinical outcome each improved significantly after treatment without a direct statistical test of their association; (4) findings were reported descriptively without correlation coefficients or p-values; or (5) the combination was supported by only one study, or all available studies reported only non-significant associations. An evidence gap (red) was assigned when no eligible study reported that combination.

These criteria are pragmatic, review-specific rules developed for this mapping exercise. They are not an established evidence-grading system, and the resulting categories should not be interpreted as validated levels of evidence or as an appraisal of study quality. The threshold of |r| > 0.3 was adopted as a conventional benchmark for at least a moderate correlation, and p < 0.05 as the conventional level of statistical significance; at least two independent studies were required so that no combination was classified as consistent on the basis of a single report. Statistical significance, magnitude of association (r, β, or odds ratio), and consistency across studies were considered separately; a combination was classified as consistent only when at least two independent studies reported statistically significant findings in the same direction and, for correlational data, |r| exceeded 0.3.

Results

Study Selection

The study selection flow chart for this ScR is shown in Figure 1. After removing duplicates, a total of 2,015 records were screened by title and abstract, and 68 reports were sought for retrieval as full texts. Six reports could not be retrieved, leaving 62 reports assessed for eligibility in detail. Of these 62, 16 articles and one registry entry (17 records in total) met the eligibility criteria and were included in this ScR for data extraction. Reasons for exclusion at the eligibility stage were: mismatched target condition (n = 6), absent or non-matching US assessment (n = 18), no reported statistical association with physical function (n = 19), and differing study design (n = 2).

Study Characteristics

The characteristics of the included studies are shown in Table 1.

First author	Year	Country	Study design	Sample size	Disease stage
Do [5]	2021	Korea	Retrospective study	61 patients (all AC)	Stage 1 (prefreezing); Stage 2 (freezing); Stage 3 (frozen) ([4]: 0-15 months)
Walmsley [8]	2013	Australia	Consecutive case series	41 patients (all AC)	Early stage (1-3 months)
McKean [10]	2020	UK	Case series	12 patients/24 shoulders; Asymptomatic side (n = 12); Symptomatic side (n = 12)	NR
Wu [15]	2021	Taiwan	Prospective cross-sectional	65 patients (all AC)	NR
Zeng [16]	2025	China	Retrospective study	200 patients (all AC)	NR
Sharma [17]	2024	India	Quasi-experimental	14 patients (all AC)	NR
Park [18]	2017	Korea	Cross-sectional	75 patients (all AC)	Freezing stage: Frozen stage (no definition provided)
Yang [19]	2020	Taiwan	Cohort	53 patients/54 shoulders	NR
Xu [20]	2022	China	Prospective randomized controlled study	63 patients (all AC)	NR
Guan [21]	2022	China	Retrospective Study	40 patients (all AC)	Frozen stage (no definition provided)
Kim [22]	2019	Korea	Retrospective case-control	64 patients (AC: 39, Healthy: 35)	Stage 1, 2 ([4]: 1-9 months)
Xu [23]	2024	China	Prospective study	156 patients (AC: 79, Healthy: 77)	Early-stage (0-3 months)
Sanders [24]	2017	United States	Clinical trial registration (ClinicalTrials.gov; no results posted)	NR (results not publicly available)	NR
Fujiwara [25]	2024	Japan	Observational cross-sectional	15 patients/24 shoulders; Operative side (n=9); Contralateral side (n=15)	NR
Lee [26]	2022	Korea	A single-arm, prospective, observational study	56 patients (all AC)	NR
Wada [27]	2020	Japan	Cross-sectional observational study	32 patients (all AC)	Freezing stage (VAS: 6-10); Frozen stage (VAS: 0-5)
Zhang [28]	2022	China	Prospective cross-sectional	64 patients (all AC)	Stage I, II, III

TABLE 1: Characteristics of the included studies

This trial registration [24] had no publicly available results and was therefore excluded from data synthesis, though it is included in the totals reported in the text (e.g., country distribution, n = 17).

AC: adhesive capsulitis; NR: not reported

The included studies were conducted across eight countries, predominantly in East Asia, most commonly China (n = 5) and South Korea (n = 4) (Table 1). Designs were mainly cross-sectional/observational (n = 7) or retrospective/case series (n = 6), with one prospective cohort study, one quasi-experimental study, one randomized controlled trial (RCT), and one trial registration. Sample sizes ranged from 12 to 200 participants; two studies compared findings with the contralateral shoulder and two included a control group. Disease stage was reported in eight of 16 studies, most often based on symptom duration (n = 4); of the remaining reporting studies, one classified stage based on pain and three gave no clear staging definition (Table 1).

Characteristics of US Assessments

Among the reported US assessments, 13 studies measured CHL thickness, five studies assessed vascularity using Power Doppler Ultrasound (PDUS) or superb microvascular imaging (SMI), three studies assessed CHL tissue stiffness using shear wave elastography (SWE), and two further studies assessed RI thickness (Table 2).

First author, year	US variable	Analysis	Functional outcomes
Do 2021 [5]	CHL thickness	Correlation	PROM ER (r=-0.6), VAS (r=0.003), SPADI Pain (r=-0.24), SPADI Disability (r=-0.16), SPADI Total (r=-0.18)
	RI thickness	Correlation	PROM ER (r=-0.003), VAS (r=-0.01), SPADI Pain (r=-0.27), SPADI Disability (r=-0.17), SPADI Total (r=-0.23)
	PDUS(binary)	Correlation	PROM ER (r=-0.041), VAS (r=0.004), SPADI Pain (r=0.095), SPADI Disability (r=0.195), SPADI Total (r=0.161)
Walmsley 2013 [6]	RI PDUS(binary)	group comparison	SPADI, Resting pain, Night pain, UROM ER: Positive PDUS < Negative PDUS (All NS)
McKean 2020 [10]	CHL thickness	group comparison	CHL thickness: Asymptomatic < Symptomatic, Pre-injection < Post-injection (p<0.05)
	CHL Elastic modulus	group comparison	CHL Elastic modulus(kPa): Pre-injection > Post-injection (p<0.05) OSS: Pre-injection < Post-injection (p<0.05), VAS: Pre-injection > Post-injection (p<0.05)
Wu 2021 [15]	CHL thickness	Correlation	PROM ER (r=-0.335), SPADI total score (r=0.176)
Zeng 2025 [16]	CHL thickness	group comparison	CHL thickness: Pre-treatment > one-year follow-up (p<0.05); CMS score, UROM ER: Pre-treatment one-year follow-up (all p<0.01)
Sharma 2024 [17]	CHL thickness	group comparison	CHL thickness: Baseline > Final (p<0.05) NPRS score: Baseline < Final (p<0.05), UROM: Baseline < Final (p<0.01), SPADI: Baseline > Final (p<0.05)
Park 2017 [18]	CHL thickness	Correlation	PROM ER (r=-0.305), VAS rest (r=-0.071), VAS Motion (r=0.119), VAS Night (r=-0.164), CMS score (r=-0.069)
Yang 2020 [19]	CHL thickness	Linear regression Logistic regression	Change in SPADI (β =13.11, p<0.01) SPADI improvement (OR=0.27, p=0.055)
Xu 2022 [20]	CHL thickness	group comparison	CHL thickness (Baseline): Treatment > Control (NS), CHL thickness (Post treatment): Treatment < Control (p<0.05) Hypoechoic (% Baseline): Treatment > Control (NS), Hypoechoic (% Post treatment): Treatment < Control (p<0.05) VAS (Baseline): Treatment < Control, CMS score(Baseline): Treatment > Control (All NS) VAS (Post treatment): Treatment < Control (NS), CMS score(Post treatment): Treatment > Control (p<0.05)
	RI echo texture	group comparison	
Guan 2022 [21]	CHL thickness	group comparison	CHL thickness: Before treatment > After treatment (p<0.01) CMS ER score: Before treatment > After treatment (NS)
Kim 2019 [22]	CHL thickness	Correlation	UROM ER (r=-0.22), Resting pain (r=0.16), Night pain (r=0.15), Motion pain (r=0.15)
	Subcoracoid triangle PDUS(quantitative)	Correlation	UROM ER (r=-0.24), Resting pain (r=-0.01), Night pain (r=0.09), Motion pain (r=0.17)
	Subcoracoid triangle SMI(quantitative)	Correlation	UROM ER (r=-0.35), Resting pain (r=0.04), Night pain (r=0.26), Motion pain (r=0.73)
Xu 2024 [23]	CHL thickness	group comparison	
	RI PDUS(semiquantitative)	group comparison	CHL thickness: Healthy < Patients (NS) PDUS: Healthy < Patients (p<0.01) SMI: Healthy < Patients (p<0.05) Pain score: Healthy < Patients (p<0.01) ROM <30°: Healthy < Patients (p<0.01) *Mean degrees NR.
	SMI(semiquantitative)	group comparison	
Sanders 2017 [24]	Color Doppler (RI/CHL unspecified)	Correlation (registered)	Result not publicly available
Fujiwara 2024 [25]	CHL thickness	Correlation	UROM ER (r=-0.54)
Lee 2022 [26]	RI thickness	Correlation	Resting pain (r=0.241), Motion pain (r=0.359), SPADI total (r=0.346), PROM ER (r=-0.34)
Wada 2020 [27]	CHL thickness	group comparison	CHL thickness (Freezing phase): Unaffected side > Affected side (NS); CHL thickness (Frozen phase): Unaffected side < Affected side (p<0.01); CHL stiffness values (kPa, Freezing phase): Unaffected side < Affected side (NS); CHL stiffness values (kPa, Frozen phase): Unaffected side < Affected side (p<0.05); UROM ER: Freezing phase > Frozen phase (NS); VAS: Freezing phase > Frozen phase (p<0.01)
	CHL stiffness (kPa)	group comparison	
Zhang 2022 [28]	SWE of CHL (Stage I)	Correlation	VAS Score (r=-0.485), UROM ER (r=0.107)
	SWE of CHL (Stage II)	Correlation	VAS Score (r=0.439), UROM ER (r=-0.448)
	SWE of CHL (Stage III)	Correlation	VAS Score (r=-0.462), UROM ER (r=-0.484)

TABLE 2: Main findings by US parameter and study

CHL: coracohumeral ligament; CMS: Constant-Murley Score; ER: external rotation; kPa: kilopascal; NRS: numeric rating scale; NS: not significant; OR: odds ratio; OSS: Oxford Shoulder Score; PDUS: power Doppler ultrasound; PROM: passive range of motion; RI: rotator interval; SMI: superb microvascular imaging; SPADI: Shoulder Pain and Disability Index; SWE: shear wave elastography; UROM: unspecified range of motion; US: ultrasound; VAS: visual analog scale

CHL thickness was the most frequently assessed US parameter. Measurement position varied across studies: neutral rotation (n = 2), external rotation (n = 4), maximal external rotation (n = 2), and unspecified rotation position (n = 5). The CHL was mainly visualized in the oblique sagittal plane, and the most common measurement site was lateral to the coracoid process (n = 8).

PDUS or SMI was used for vascularity assessment. The primary assessment sites were the RI and the subcoracoid triangle. Assessment methods included qualitative evaluation based on the presence or absence of a flow signal (n = 3), semi-quantitative grading (n = 1), and quantitative measurement of flow signal area (n = 1). SWE was used to assess the CHL in three studies. A circular region of interest (ROI) was typically used, with the mean of multiple measurements commonly calculated.

Characteristics of Clinical Outcome Assessments

Clinical outcomes assessed included ROM, pain, and shoulder-specific functional scales. ROM was the most frequently assessed outcome, evaluated in 14 studies. External rotation and flexion were each reported in 13 studies, followed by internal rotation (n = 8) and abduction (n = 9). No studies assessed adduction or extension. Hand-behind-back (HBB) motion was assessed in four studies.

ROM assessment methods varied across studies. Some studies clearly distinguished between active and passive motion, whereas others did not specify the measurement method. In addition, some studies did not adequately describe the measurement position or conditions.

For pain assessment, the Visual Analogue Scale (VAS; n = 10) and the Numeric Rating Scale (NRS; n = 3) were used. Only five studies distinguished between night pain and movement-related pain, and the type of pain was not clearly defined in most studies.

The method of assessing HBB motion also varied. Studies used the vertebral level reached by the thumb (n = 2), the distance (cm) between the radial styloid process and the T1 spinous process (n = 1), or did not specify the assessment method (n = 1); no consistent assessment method was identified.

Shoulder-specific functional scales were used for functional assessment: the Shoulder Pain and Disability Index (SPADI; n = 6), the Constant-Murley Score (CMS; n = 5), and the Oxford Shoulder Score (OSS; n = 1).

CHL Thickness and Clinical Outcome

The association between CHL thickness and physical function was among the most frequently examined themes. External rotation ROM was the most frequently examined outcome, with five studies reporting a correlation; of these, four found increased CHL thickness significantly associated with reduced external rotation ROM (Table 2). One reported a significant negative correlation on simple regression ($r = -0.335$), remaining significant after adjusting for age and symptom duration ($r = -0.293$) [15]. Another reported CHL thickness decreased and external rotation ROM improved significantly in parallel at one-year follow-up, though the association between changes was not directly tested [16]. Associations with other ROM directions were less consistent, and no study directly examined CHL thickness and HBB.

CHL thickness and pain were correlated in three studies, none significant; one additional study reported significant reductions in both pain and CHL thickness after intervention without directly testing their correlation [17].

CHL thickness and shoulder function were examined in four studies [5,15,18,19], of which only Yang et al. [19] reported a significant association: CHL thickness ≥ 5 mm was significantly associated with less improvement in the SPADI score on multivariable linear regression, though it was not significantly associated with reaching the minimal detectable change on multivariable logistic regression (Table 2; see also the Proposal of a Hypothesis-Generating Clinical Reasoning Matrix subsection below). The remaining three studies found no significant correlation between CHL thickness and shoulder function scores [5,15,18]. Four further studies reported concurrent, significant pre-post or between-group changes in CHL thickness and a functional score without directly testing the association: CMS [20], OSS [10], and SPADI [17], while one found CHL thickness decreased significantly after treatment even though the corresponding change in the CMS external rotation component did not reach significance [21].

Vascularity and RI Changes

This section describes the association between physical function and US findings of vascularity and morphological change in the RI.

Studies using SMI reported relatively consistent findings. One study reported that increased SMI-based vascularity in the subcoracoid fat triangle was significantly associated with external rotation ROM limitation, though a concurrently assessed PDUS measure in the same cohort did not reach significance [22]. Another study reported significantly greater PDUS and SMI vascularity signals, together with greater pain and ROM restriction, in patients with AC compared with healthy controls [23].

In contrast, findings on the association between vascularity assessed with SMI or PDUS and pain were inconsistent. Among the five studies that assessed vascularity, four attempted a statistical analysis of its association with pain: three [5,8,22] reported results, of which only one found a significant positive correlation, while the fourth [24] registered such an analysis but its results were not publicly available (see the Limitations subsection below). The remaining study [23] compared vascularity and pain scores separately between AC and healthy groups but did not directly test their association.

Evidence Gap Map

The evidence gap map for this ScR is shown in Figure 2, based on the classification criteria described above. Consistent findings across multiple studies were obtained for the association between CHL thickness and external rotation limitation. Of the five studies that tested this association by correlation, four reported significant negative correlations ($r = -0.305$ to -0.60 ; Table 2), and two of these had $|r| \geq 0.5$ [5,25]; the classification would therefore not change under a stricter cut-off. However, associations between vascularity or stiffness and HBB motion, or between these parameters and resting or night pain, were supported by few studies or showed conflicting results.

Discussion

Main Findings

This ScR mapped the association between US assessment of the CHL and RI and physical function in AC to examine whether these findings could inform treatment decision-making. Synthesis of the 17 identified records showed a consistent negative correlation between CHL thickness and external rotation ROM with the arm at the side (four of five correlational studies; $r = -0.305$ to -0.60), whereas associations with other ROM directions were less consistent. In contrast, evidence gaps and conflicting results were common for the association between vascularity (SMI/PDUS) or stiffness (SWE) and pain intensity, and for associations with multidirectional ROM limitations such as HBB motion, indicating that sufficient evidence is not yet available in these areas (Figure 2).

CHL Thickness and ROM Limitation

The most consistently supported finding was an association between greater CHL thickness and more limited external rotation with the arm at the side [5,15,18,25]. This is compatible with the cadaveric finding that the CHL restrains external rotation [7], but because most included studies were cross-sectional or retrospective, a causal contribution cannot be inferred. In addition, correlation coefficients ranged widely across studies ($r = -0.22$ to -0.60), and one found no significant association [22], possibly reflecting differences in measurement position. CHL measurement position varied from maximal external rotation [15,19] to unspecified rotation angle [5,22,25] or unreported position [18]; ROM assessment likewise varied across 90° abduction [15], 0° abduction [22,25], unspecified abduction [5], and unreported position [18,19]. Because a cadaveric study showed CHL tension increases particularly during external rotation at low elevation angles or in extension [7], measurement position may have influenced both CHL thickness and ROM findings.

Because CHL thickness on US may be influenced by tension and measurement position, quantitative tissue stiffness assessment using SWE has attracted attention as a complementary parameter. This ScR identified significantly increased CHL stiffness (kPa) in AC [27] and a real-time decrease in stiffness following

treatment [10]. One study found the correlation between CHL stiffness and pain or external rotation ROM varied in direction across disease stages [28]. Another did not directly test the CHL stiffness-ROM association: external rotation ROM did not differ significantly between freezing and frozen phases, whereas CHL stiffness, compared between affected and unaffected shoulders within each phase, reached significance only in the frozen phase [27]. Because stiffness and ROM were not tested against each other on a common axis, evidence for an SWE-ROM association remains limited to a single study with an internally inconsistent direction (Figure 2) [28]. As mechanical changes may precede CHL thickness changes, SWE could be useful for evaluating treatment effects, though values are equipment-dependent and lack established cut-offs, warranting further validation.

Vascularity and Pain

Increased RI vascularity (neovascularization) is presumed to reflect synovitis and to be a major source of pain; however, a consistent correlation with pain indices was not confirmed. This may reflect challenges in both US and pain assessment.

Three factors may explain the US-assessment challenge. First, inflammation at sites other than the RI may influence pain: fibrosis in AC occurs throughout the joint capsule, including the axillary recess (AR), where MRI studies associate both RI scarring and AR synovial/capsular thickening with disease stage [29,30]; because this review focused specifically on RI vascularity, findings may not represent the overall inflammatory distribution, which could explain the lack of association with symptoms. Second, SMI and PDUS visualize microvascular flow and neovascularization within the synovium, whereas more recent studies have assessed hemodynamics of major nutrient vessels - such as peak systolic velocity of the anterior humeral circumflex artery - using pulsed Doppler [31]; these techniques may reflect different aspects of inflammatory activity, and further work is needed to identify which vascular index best reflects symptoms. Third, a physiological gap may exist between US vascularity indices and the actual pain mechanism: neovascularization in AC synovitis is histologically associated with proliferation of nerve endings, a source of pain [32], yet Doppler and SMI capture only the area or presence of small vessels, not cytokine concentrations or nerve excitability itself.

Unclear pain-assessment methods further obscure the correlation with US indices. Most studies assessed pain using a single VAS score or a composite functional score (e.g., SPADI), without distinguishing resting, night, and movement-related pain, which may have prevented an accurate reflection of the association between US inflammatory findings and pain.

Heterogeneity in Staging Definitions

A key factor complicating interpretation of the extracted associations is the heterogeneity in staging definitions. Disease stage was reported in only eight of 16 studies, using differing definitions, most often symptom duration (see Study Characteristics) [4]. Because inflammatory activity and capsular fibrosis are thought to differ across the pre-adhesive, inflammatory, frozen, and recovery stages [3], and stage-related differences in RI vascularity [8] and CHL thickness [5] have been reported, pooling data across studies with inconsistent or unreported staging may obscure genuine stage-dependent associations. Symptom duration alone may also misrepresent the underlying pathological stage, since some patients retain residual synovitis long after onset while others progress to the frozen stage early. Future research should therefore move beyond symptom duration and work toward standardized staging based on objective indicators of underlying pathology, such as inflammatory activity and capsular contracture.

Proposal of a Hypothesis-Generating Clinical Reasoning Matrix

Despite these evidentiary limitations, we outline a hypothesis-generating "US-Based Clinical Reasoning Matrix" (Figure 5). The matrix is the authors' interpretive framework, not a finding extracted from the included studies and not a validated clinical tool. Its elements derive from different sources: (i) the structural axis (CHL thickness) draws on studies reporting associations with external rotation limitation [5,7,15], and the inflammatory axis (RI vascularity) on studies of vascularity [22,23]; (ii) the 5.0 mm CHL threshold was examined in only one included study [19], which adopted it from earlier diagnostic literature, and is not standardized; (iii) the phase labels follow the staging literature [3,8]; and (iv) the quadrant-level predictions and management considerations are the authors' hypotheses and clinical reasoning, which no included study has directly tested.

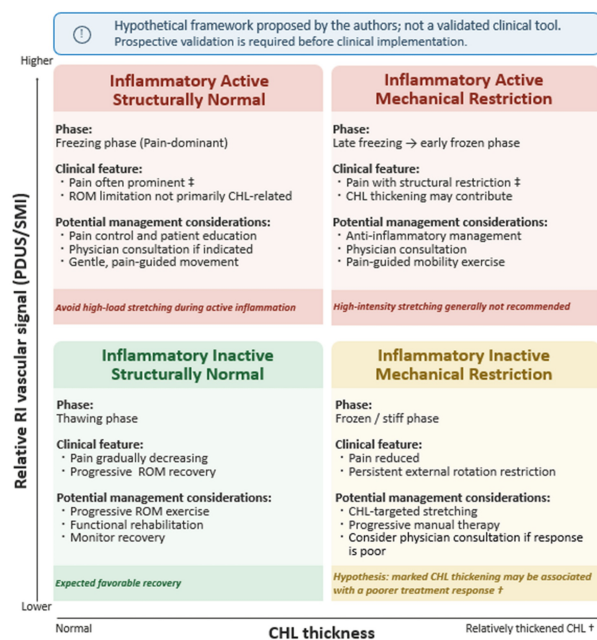


FIGURE 3: US-based clinical reasoning matrix combining CHL thickness and rotator interval vascularity

Hypothetical framework proposed by the authors; not a validated clinical tool. The two axes and the CHL threshold (†) derive from the included studies, whereas the phase labels and the management considerations are the authors' interpretation and were not evaluated in any included study.

† The 3 mm threshold was examined in a single cohort [19], which adopted it from earlier diagnostic literature; it is not a standardized cut-off.

‡ Association between RI vascularity and pain reflects the broader staging literature (e.g., Walmsley et al. [8]); this review found inconsistent correlation between quantitative vascularity indices and pain scores (see the Vascularity and Pain subsection).

CHL: coracohumeral ligament; ROM: range of motion

The figure was created by the authors using Microsoft PowerPoint (Microsoft Corp., Redmond, WA, USA).

The model organizes US findings along two axes: presence or absence of inflammation (RI vascularity) and structural abnormality (CHL thickness). For example, it is hypothesized that absent vascularity with marked CHL thickening (e.g., > 3.0 mm) may be associated with a poorer response to treatment and a more protracted course. The only observation in the included studies that bears on this hypothesis comes from a single cohort treated with US-guided hydrodilatation and corticosteroid, in which CHL thickness > 3.0 mm was associated with less improvement in the SPADI score at two months on multivariable linear regression ($\beta = 13.11$, $p < 0.01$) but showed only a non-significant trend toward a lower likelihood of reaching the minimal detectable change on multivariable logistic regression ($OR = 0.27$, $p = 0.055$) [19]. Because the two analyses differed in statistical significance, the cohort was small (54 shoulders), and the association was observed after one specific treatment, it does not establish a prognostic threshold; it indicates only that marked CHL thickening may warrant further investigation as a prognostic factor.

If validated, this model might help physical therapists anticipate the limits of their own intervention. In that case, therapists could share objective US data with the referring physician to support shared decision-making among the multidisciplinary team and the patient regarding options such as capsular hydrodilatation or surgery.

This matrix must nonetheless be interpreted with caution. The concepts and cut-off values presented were extracted from studies heterogeneous in US assessment methods and staging classifications, and because US assessment is inherently prone to error from equipment performance and examiner technique, the matrix should not be used to guide individual patient care until it has been validated. Validating this matrix through prospective cohort studies using objective staging and standardized US assessment - to develop it into a more robust clinical reasoning tool - remains an important task for future research.

Limitations

This ScR has several limitations. First, consistent with scoping review methodology, no quality appraisal of individual studies was performed, so the quality of the extracted evidence is not guaranteed [12,13]. Second, most extracted literature comprised cross-sectional or retrospective studies, making causal relationships between US findings and physical function difficult to establish; confounding factors affecting AC pathology (e.g., diabetes) were also not adequately adjusted for in many studies. Third, restricting the search to English- and Japanese-language literature introduces a language bias. Fourth, one identified clinical trial registration (grey literature) [24] had no publicly available results and could not be incorporated into data synthesis, raising the possibility of publication bias. Fifth, the classification criteria of the evidence gap map and the clinical reasoning matrix are author-developed and have not been validated; they should be regarded as tools for organizing the evidence, not as graded recommendations.

Conclusions

US assessment of the CHL and RI may help characterize AC pathology, but its value for stratifying treatment remains to be established. CHL thickness showed a consistent association with external rotation limitation with the arm at the side, whereas evidence for RI vascularity as an indicator of pain and for explaining multidirectional ROM limitation remains fragmented, and inconsistent measurement protocols and staging hinder clinical application. Establishing US-based clinical reasoning will require standardized, high-quality prospective studies that validate the proposed hypothesis-generating matrix and clarify whether specific US assessments can inform prognosis and treatment selection.

Appendices

Appendix A

Search strategy

Pubmed	#1 ("Frozen shoulder" OR "Adhesive Capsulitis" OR "Stiff shoulder" OR "Shoulder joint" OR "Shoulder") #2 ("Range of motion" OR "ROM" OR "Stiffness" OR "Restriction" OR "Contracture") AND ("Ultrasonography" OR "Ultrasound" OR "Sonography") #1 AND #2
Scopus	#1 ("Frozen shoulder" OR "Adhesive capsulitis" OR "Stiff shoulder" OR "Shoulder contracture" OR "Scapulohumeral periarthritis") #2 ("Ultrasound" OR "Ultrasonography" OR "Sonography" OR "Sonoelastography" OR "Elastography" OR "Doppler" OR "Shear wave" OR "SWE") #1 AND #2
Ichushi-Web	#1 (肩関節周囲炎/TH or "肩関節周囲炎"/AL or "凍結肩"/AL or "癒着性関節包炎"/AL or "拘縮肩"/AL or "五十肩"/AL or "特発性凍結肩"/AL) #2 (超音波診断/TH or 弾性映像法/TH or "超音波"/AL or "エコー"/AL or "ドップラー"/AL or "エラストグラフィ"/AL or "シェアウェーブ"/AL or "せん断波"/AL or "硬度"/AL or "硬さ"/AL or "厚 さ"/AL or "肥厚"/AL or "弾度"/AL or "血流"/AL or "血管"/AL or "断面積"/AL or "CSA"/AL) #1 AND #2
PEDro	Adhesive capsulitis ultrasound
WHO-ICTRP	Adhesive capsulitis ultrasound
ClinicalTrials.gov	Condition or disease: "Frozen shoulder" OR "Adhesive capsulitis" OR "Stiff shoulder" OR "Shoulder contracture" Other terms: "Ultrasound" OR "Sonography"

TABLE 3: Full search strategy for each database and trial registry
AL: all fields; CSA: cross-sectional area; ROM: range of motion; SWE: shear wave elastography; TH: thesaurus term (controlled vocabulary/subject heading)

Appendix B

Study ID	Study design	Country	Setting	Sample size	Age (mean ± SD)	Sex	Dominant side affected (%)	BMI (mean ± SD)	Diabetes (%)	Inclusion criteria	Symptom duration	Control group	Disease stage	Intervention type	Multivariate adjusted	Conflict
Do 2021 [9]	retrospective study	Korea	Hospital	61 patients (all AC)	56.2 ± 8.9	Female (49.2%)	NR	NR	24.60%	• shoulder pain for at least one month • shoulder stiffness • limitation of passive or active ROM in a capsular pattern	19.6 ± 14.5 weeks	Contralateral side	Stage 1(prefreezing) Stage2(freezing) Stage3(frozen) (4) 0-15 months	NR	No	None
Walsley 2013 [8]	Consecutive case series	Australia	Clinic	41 patients (all AC)	56.0 ± 7.2	Female (46.3%)	46.30%	NR	7.30%	• patients diagnosed with early-stage idiopathic adhesive capsulitis • shoulder pain < 9 months	5.4 ± 1.8 months	NR	Early stage(1-3 months)	NR	No	None
McKean 2020 [10]	Case series	UK	Hospital	12 patients/24 shoulders Asymptomatic side (n = 12) Symptomatic side (n = 12)	54.2 (28-72) if mean (range)	Female (50.0%)	NR	NR	NR	• clinical diagnosis of AC • limitation in the glenohumeral joint (particularly ER limitation) • failure to respond to physiotherapy, oral analgesia, or steroid injection	12.0months (range:3-36)	Contralateral side	NR	Injection + Manipulation	No	None
Wu 2021 [15]	Prospective cross-sectional	Taiwan	Hospital	65 patients (all AC)	54.38 ± 7.2	Female (68.5%)	NR	NR	23.10%	• shoulder pain at least 1 month • limitation > 30° in the glenohumeral joint (meaning flexion < 150°, abduction < 150° and ER < 60° at least two movements) • VAS: 3/10	7.43 ± 6.2 months	NR	NR	NR	Yes	None
Zeng 2025 [16]	Retrospective study	China	Hospital	200 patients (all AC)	56.2 ± 20.4	Female (54.0%)	NR	20.4 ± 9.8	22.50%	• shoulder chronic dull pain • limitation of active and/or passive ROM in 2 directions • ultrasound examination showed □ 2mm glenohumeral joint capsule	9.3 ± 4.8 months	NR	NR	Hydrodilatation + Injection	No	None

[illegible]

[26]	observational study	(all AC)				(87.5%)					active and/or passive ROM in 2 directions		side		injection		
Wada 2020 [27]	cross-sectional observational study	Japan	Hospital	32 patients (all AC)	54.9±9.8 (Freezing phase) 63.4±8.1 (Frozen phase)	19 Female (59.4%)	NR	NR	NR	NR	• shoulder pain • limitation of active and/or passive ROM (forward flexion<100°, ER<10°, IR	NR	Contralateral side	Freezing stage (VAS: 6-10) Frozen stage (VAS: 0-5)	NR	No	None
Zhang 2022 [28]	Prospective cross-sectional	China	Hospital	64 patients (all AC)	51.80 ± 5.05 (Stage I) 53.70±3.54 (StageII) 54.02±3.62 (StageIII)	27 Female (42.2%)	NR StageII:37.0% Right StageIII:30.0% Right	24.80 ± 1.90 StageII: 24.70±1.71 StageIII: 25.54±1.52	NR	NR	• shoulder pain • limited ROM of the shoulder joint • CHL thickness 4mm	NR	Contralateral side	StageI: II: III	NR	No	None

TABLE 4: Basic information and demographics of the included studies

AC: adhesive capsulitis; CHL: coracohumeral ligament; ER: external rotation; NR: not reported; RI: rotator interval; ROM: range of motion; VAS: visual analog scale

Appendix C

Study ID	Limb position	Machine name	Probe orientation	Probe frequency (MHz)	Anatomical landmark	Target structure	Thickness value	Thickness unit	Length value	Length unit	CSA value	CSA unit	Echo-texture	Vascularity type	Vascularity value	Elastography type	Elastography value	Elastography unit
Do 2021 [5]	CHL • sitting • shoulder ER • sitting • the arm by side	R580A with Prestige (Samsung)	CHL: oblique Axial plane, Longitudinal RI: oblique axial plane	3-12MHz	Coracoid process	CHL,RI	CHL: 2.7 ± 0.6 RI 2.2 ± 0.8	mm	NR	NR	NR	NR	NR	POUS(Binary)	Affected shoulder hypervascularity n/N : 11/61 (18.03%)	NR	NR	NR
Walmsley 2013 [8]	• sitting • elbow flexed 90° • forearm supinated	Model M5 (Mindray)	oblique plane, Transverse	6.6MHz	SSP, SSC, Coracoid base, LHB	RI	NR	NR	NR	NR	NR	NR	NR	POUS(Binary)	hypervascularity n/N: 12/41 (29.26%)	NR	NR	NR
McKean 2020 [10]	CHL thickness • sitting or semi-supine • elbow at 90° flexion • the arm at the side. • SWE • sitting or semi-supine • elbow at 90° flexion • the arm at the side. • Shoulder at 30° ER or Max ER	Aplo i700 (Canon)	Axial oblique plane, Longitudinal	15MHz(B mode)	Coracoid process (2mm distance)	CHL	3.3 (range: 1.1–2.9)	mm	NR	NR	NR	NR	NR	NR	NR	Shear Wave	Neutral position: 178 (ICR: 116.4–228.1) 30°ER rotation: 194 (ICR: 138–246.5)	kPa
Wu 2021 [15]	• sitting position • arm by side • elbow at 90°flexion • shoulder maximal ER	ACUSON S2000(Siemens)	axial oblique plane longitudinal	7-14MHz	Lateral Coracoid process (Identified via Dynamic RI/ER & Anisotropy)	CHL	3.12 ± 0.7	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Zeng 2025 [16]	• Sitting	SIEMENS ACUSON(Sequia)	NR	High-frequency	NR	CHL	Pre-treatment: 4.2±1.7; one year after treatment: 2.1±1.1	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Sharma 2024 [17]	• Sitting • arm in neutral	NR	axial oblique plane, longitudinal	NR	Lateral Coracoid process	CHL	1.82 ± 0.55	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Park 2017 [18]	NR	EPiQ 5(Philips)	Transverse	5-18MHz	rotator cuff interval	CHL	1.3 ± 0.3	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Yang 2020 [19]	• Sitting • elbow at 90° flexion • shoulder	ACUSON S2000 (Siemens)	axial oblique plane,	6-18MHz	Coracoid process	CHL	3.04 ± 0.67	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

		longitudinal														maximal		ER	
Study	Position	Probe	Plane	Frequency	Process	Measurement	Unit	RI	NR	NR	NR	NR	n/N	QOR	PDUS	AC group	PDUS	RI	NR
Xu 2022 [20]	NR	Mylab90 (Esaote)	Transverse and Longitudinal	12-18MHz	NR	CHL:RI	3.5 ± 1.9 (CHL)	mm	NR	NR	NR	NR	n/N: 23/63 (36.51%)	NR	NR	NR	NR	NR	NR
Guan 2022 [21]	- Sitting	Arista 850(Hbachi)	NR	6-15MHz	NR	CHL	Before treatment:4.5 (IQR: 4.2-4.8) After treatment: 2.5 (IQR: 2.3-3.4)	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Kim 2019 [22]	- sitting position - elbow flexion - shoulder slightly ER	Aplio500(Canon)	oblique sagittal plane Transverse	14MHz (B 7MHz: SMI)	Coracoid process	CHL / subcoracoid triangle	3.2 (IQR range 1.90)	mm	NR	NR	NR	NR	n/N:26/39(66.67%)	SMI(Quantitative area)(PDUS(Quantitative area)	AC group SMI: 2.95- (IQR: 3.34) PDUS: 0.60- (IQR: 1.89)	NR	NR	NR	NR
Xu 2024 [23]	RI + Sitting + shoulder in a neutral position CHL + ER	Aplio 400 (Toshiba)	Oblique plane	CHL:14MHz and SMI:7MHz(B mode)	SMI: between the supraspinatus and subscapularis; CHL: lateral aspect of the acromion	CHL:RI	Healthy control:2.03±0.97 Patients:2.60±1.01	mm	NR	NR	NR	NR	n/N: 64/79 (81.01%)	SMI(Semiquantitative grade)(PDUS(Semiquantitative grade)	SMI (n/N) 0: 0/79 (0.0%) 1: 14/79 (17.7%) 2: 45/79 (57.0%) 3: 20/79 (25.3%) PDUS (n/N) 0: 0/79 (8.9%) 1: 40/79 (50.6%) 2: 29/79 (36.7%) 3: 3/79 (3.8%)	NR	NR	NR	NR
Fujiwara 2024 [25]	- Sitting - elbow flexion - shoulder External rotation from 45° IR position	Aplio 800 (Canon)	Longitudinal	18MHz	coracoid process	CHL	Operative side:1.00 ± 0.31 contralateral side:0.68 ± 0.29	mm	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Lee 2022 [26]	- sitting - elbow flexion + forearm supination + shoulder extension	HM7DA(Samsung)Voluson E6(GE)	Longitudinal (ARY)(Short axis (RI)	5-13 MHz(B mode)	RI thickness: shortest distance between the LHBT and peribursal fat. Hypervascularity: High signal in RI	RI	Affected 2.0 ± 0.6 Unaffected:1.7 ± 0.5	mm	NR	NR	NR	NR	NR	PDUS(Binary)	Hypervascularity n/N: 1/56 (1.8%)	NR	NR	NR	NR
Wada 2020 [27]	- sitting - shoulder at 0° abduction and neutral rotation.	Anplexor (SuperSonic Imagine)	Longitudinal	NR	coracoid process	CHL	Freezing phase Affected Side:3.7 ± 1.0 Unaffected Side:3.4 ± 0.7 Frozen phase Affected Side:4.4 ± 1.4 Unaffected Side: 3.3 ± 1.1	mm	NR	NR	NR	NR	NR	NR	NR	NR	Shear Wave	Freezing phase: 270.3 ± 142.5 Frozen phase: 287.2±135.3	kPa
Zhang 2022 [28]	- supine - elbow flexion + shoulder at 10°ER	LOGIQ S8(GE)	Long axis	NR	Coracoid process.	CHL	NR	mm	NR	NR	NR	NR	NR	NR	NR	NR	Shear Wave	Stage1: 110.0 (IQR: 90.3-130.5) Stage2: 158.8 (IQR: 120-220) Stage3: 151.6 (IQR: 110.6-210.7)	kPa

TABLE 5: Ultrasound assessment methods and findings of the included studies

CHL: coracohumeral ligament; CSA: cross-sectional area; ER: external rotation; ICC: intraclass correlation coefficient; IR: internal rotation; kPa: kilopascal; NR: not reported; PDUS: power Doppler ultrasound; RI: rotator interval; SMI: superb microvascular imaging; SWE: shear wave elastography; LHB: long head of biceps tendon; SSC: subscapularis; SSP: supraspinatus

Appendix D

[illegible]

		elbow 90° flexion	with the hand placed behind the back is measured					5: 13-17 • below sacrum: 18	± 21.3° 35.5 ± 16.9°	14.8 ± 12.8 ± 3.2°	117.5 ± 135.5 ± 26.9°	StageII: 82.2 ± 135.5 ± 109.0 ± 39.0°							(Level)
									Adduction Total:43.3 ± 16.4 °										
									• Positive measuring the distance between the radial styloid process and the spinous process of T1.	PDU:41.1 ± 16.6° Negative 14.1° PDU:48.6 ± 15.0° Abduction 53.0 ± 14.6° Total:38.5 ± 17.5° Positive PDU:36.3 ± 15.0° Negative PDU:43.8 ± 22.3°	Abduction Total: 103.9 ± 18.6° Positive 18.3° PDU: 101.2 ± 18.0° Negative PDU: 110.4 ± 16.8° Total: 69.8 ± 18.2° Positive 16.3° Negative 17.1°								Total: 43.5 ± 8.3 cm Positive PDU: 45.0 ± 9.1 cm Negative PDU:3 9.9 ± 4.4 cm
Walsley 2013 [8]	Passive	• shoulder 90° adduction and neutral	• shoulder 90° abduction	NR	NR	NR	NR												
McKean 2020 [10]	NR	• ROM measure the arm by side • forearm supination	• ROM measure the hand is placed between their shoulder blades	• ROM measure the arm above their head	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Wu 2021 [15]	Passive/Active	• Supine • shoulder 90° abduction • elbow flexion • forearm pronation	• Supine • shoulder 90° abduction • elbow flexion • forearm pronation	• elbow full extension	NR	• elbow full extension	NR	NR	24.21 ± 24.5°	28.95 ± 26.8°	124.98 ± 24.0°	NR	86.98 ± 19.1°	NR	NR	NR	NR	NR	NR
Zeng 2025 [16]	NR	NR	NR	NR	NR	NR	NR	NR	Pre-treatment: 10° (IQR: 5-15); 1 year after treatment: 50° (IQR: 40-60)	Pre-treatment: 35° (IQR: 20-40); 1 year after treatment: 155° (IQR: 45-60)	Pre-treatment: 89° (IQR: 80-105); 1 year after treatment: 155° (IQR: 150-165)	NR	Pre treatment: 125°(IQR: 110-135) 1 year after treatment : 170°(IQR: 155-180)	NR	NR	NR	NR	NR	NR
Sharma 2024 [17]	Active	• sitting • shoulder adduction • elbow 90° flexion • forearm neutral supination-pronation	• sitting • shoulder adduction • elbow 90° flexion • forearm neutral supination-pronation	• Scaption	NR	NR	NR	NR	NR	NR	NR	NR	NR	Baseline:24.28 ± 14.67° Post Exercise:72.85 ± 9.94°	NR	Baseline:37.14 ± 20.58° Post Exercise:166.42 ± 13.75°	NR	NR	NR
Park 2017 [18]	Passive	NR	NR	NR	NR	NR	NR	NR	30.0 ± 11.5°	18.9 ± 10.9°	114.3 ± 15.1°	NR	100.1 ± 19.3°	NR	NR	NR	NR	NR	NR
Yang 2020 [19]	NR	NR	NR	NR	NR	NR	NR	NR	<30° *16/32 (60.4%)	NR	flexion <120° *1/22 (4.5%)	NR	abduction <90° *1/30 (66.6%)	NR	NR	NR	NR	NR	NR

Xu 2022 [24]	Active	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
Guan 2022 [21]	Active	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	CMS score before treatment: 4 (IQR: 2-6) After treatment: 8 (IQR: 6-8)	CMS score before treatment: 2 (IQR: 2-4) After treatment: 4 (IQR: 4-6)	Before treatment: CMS score: 6 (IQR: 4-8) After treatment: CMS score:10 (8-10)	NR	Before: 90 (60-90) CMS score: 4 (2-4) After: 138 (100-153) 8 (6-8)	NR	NR	
Kim 2019 [22]	NR	* shoulder 0° abduction * elbow 90 ° flexion	* shoulder 90° abduction * elbow 90 ° flexion	* upper limb was elevated forward above the head	NR	* the upper limb was raised from the side	NR	NR	40°(IQR: 30)	20°(IQR: 30)	130°(IQR: 25)	NR	125°(IQR: 30)	NR	NR	NR	NR	NR	NR	NR	NR	
Xu 2024 [23]	NR	NR	NR	NR	NR	NR	NR	NR	Grade 0/1/2/3(N=17) External rotation <30° : 0 (0.0%) 7 (10.6%) 41 (62.1%) 18 (27.3%)	Grade 0/1/2/3 (N=18) Internal rotation <30° : 0 (0.0%) 3 (10.6%) 22 (84.4%) 7 (21.9%)	Grade 0/1 /2 /3(N=18) Flexion <30° : 0 (0.0%) 16 (88.9%) 35 (17.2%) 13 (22.4%)	NR	Grade 0/1/2/3 (N=18) Abduction <30° : 0 (0.0%) 5 (8.2%) 40 (66.6%) 16 (26.2%)	NR	NR	NR	NR	NR	NR	NR		
Fujisawa 2024 [25]	NR	* Supine - the arm by side * elbow 90° flexion	NR	* Supine * elbow extension	NR	NR	NR	NR	Operative side:17.2 ± 9.4° Contralateral side:49.0 ± 14.3°	NR	Operative side:105 ± 24.6° Contralateral side:157 ± 23.2°	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
Lee 2022 [26]	Passive	* Supine * shoulder 90°abduction	* Supine * shoulder 90°abduction	Supine	NR	Supine	NR	NR	33.0 ± 14.1°	34.0 ± 16.4°	124.5 ± 18.1°	NR	87.2 ± 16.7°	NR	NR	NR	NR	NR	NR	NR	NR	
Wads 2020 [27]	NR	NR	NR	NR	NR	NR	NR	NR	Freezing phase 4.0±5.6° Frozen phase 2.6±5.6°	NR	Freezing phase 30.3±9.2° Frozen phase 91.2±7.6°	NR	NR	NR	NR	NR	NR	NR	NR	NR	Buttock level : Freezing , Frozen phase :	
Zhang 2022 [28]	NR	* standing * shoulder 0° flexion * elbow 90° flexion * forearm supination	* the hand is placed behind the back, and the level reached by the thumb is scored	* standing * elbow extension * forearm pronation	NR	NR	NR	C thigh f: hip 2: Stagef: 27.0° sacroiliac (IQR: 20.0-42.0) joint 3: L5 4: L4 5: Stageff: 13.0 L3 6: L2 *IQR: 6.80-33.30 7: L1 8: 33.30 T12 9: T9: Stagefff: 45.0° (IQR: 30.0- 89.0) shoulder blade	Stagef: 113.0°(IQR: 88.0-140.0) Stageff: 70.0°(IQR: 65.0-96.0) Stagefff: 132.0°(IQR: 108.0-157.0)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	Stagef: 4.0 (IQR: 2.0-7.0) Stageff: 1.0 (IQR: 1.0, 2.0) Stagefff: 3.0 (IQR: 2.0, 5.0)	

TABLE 6: Physical function outcomes (range of motion and pain) of the included studies

CMS: Constant-Murley Score; ER: external rotation; HBB: hand-behind-back; IQR: interquartile range; IR: internal rotation; NPRS: numeric pain rating scale; NRS: numeric rating scale; OSS: Oxford Shoulder Score; PDUS: power Doppler ultrasound; ROM: range of motion; SPADI: Shoulder Pain and Disability Index; VAS: visual analog scale

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Acquisition, analysis, or interpretation of data: Takato Itou, Hikaru Funayose, Yuichi Isaji

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Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

An AI chatbot (Claude; Anthropic, San Francisco, California, USA) was used to assist with reorganizing the manuscript structure for journal-specific formatting requirements, converting the reference style, and editorial formatting of text, tables, and figures. The AI tool was not used to generate, analyze, or interpret scientific data or findings. All scientific content, data, and interpretations are the sole responsibility of the authors, who reviewed and verified all AI-assisted edits.

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