



CLINICAL AND FUNCTIONAL OUTCOMES OF ARTHROSCOPIC SUBSCAPULARIS REPAIR: A PROSPECTIVE EVALUATION OF 50 CONSECUTIVE PATIENTS

Orthopaedics

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ABSTRACT

Background Subscapularis tears represent a primary source of anterior shoulder pain, functional impairment, and disruption of the glenohumeral transverse force couple. While open repair historically served as the definitive surgical standard, arthroscopic techniques have evolved to provide anatomical reconstruction with minimal soft-tissue morbidity. **Objectives** To evaluate the clinical, functional, and structural outcomes of all-arthroscopic subscapularis tendon repair in a prospective series of 50 consecutive patients, and to analyze the prognostic determinants governing functional recovery and structural tendon healing. **Methods** Fifty consecutive patients presenting with full-thickness subscapularis tears (Lafosse types II, III, and IV) underwent arthroscopic repair and were prospectively followed for a minimum of 24 months. Standardized clinical evaluations included the American Shoulder and Elbow Surgeons (ASES) score, Constant-Murley score (CMS), Visual Analog Scale (VAS) for pain, active range of motion, and subscapularis-specific provocative physical examinations (bear-hug, belly-press, and lift-off tests). Structural tendon integrity was determined at 12 months postoperatively using magnetic resonance imaging (MRI) according to the Sugaya classification. **Results** At a mean follow-up of 28.4 $\pm$ 4.6 months, significant improvements were achieved across all functional outcome metrics. The mean ASES score improved from 44.6 $\pm$ 11.2 preoperatively to 86.8 $\pm$ 8.4 at final evaluation ($P < .001$), with 92% of patients achieving the minimal clinically important difference (MCID) and 86% meeting the patient-acceptable symptom state (PASS). The Constant-Murley score increased from 48.2 $\pm$ 9.5 to 83.5 $\pm$ 7.9 ($P < .001$), and the VAS pain score decreased from 6.2 $\pm$ 1.4 to 1.3 $\pm$ 1.1 ($P < .001$). Active forward flexion improved from 118.4 $^{\circ}$ $\pm$ 22.1 $^{\circ}$ to 158.6 $^{\circ}$ $\pm$ 14.2 $^{\circ}$ ($P < .001$), while external rotation at the side increased from 34.2 $^{\circ}$ $\pm$ 10.5 $^{\circ}$ to 49.8 $^{\circ}$ $\pm$ 8.1 $^{\circ}$ ($P < .001$). Postoperative provocative test negativity was restored in 88% of patients. Structural integrity on 12-month MRI demonstrated complete or near-complete healing (Sugaya types I–III) in 92% (46/50) of shoulders, with structural retears (Sugaya types IV–V) identified in 8% (4/50). Advanced tear retraction (Lafosse type IV) and preoperative muscle fatty infiltration (Goutallier stage $\geq$ 2) were independent predictors of lower postoperative scores and structural failure. **Conclusions** Arthroscopic repair of subscapularis tears yields significant pain relief, restores internal rotation strength and shoulder kinematics, and achieves a high structural healing rate of 92%. Preoperative muscular degeneration and severe tear retraction represent the most critical negative prognostic factors influencing anatomical and functional success.

KEYWORDS

INTRODUCTION

The subscapularis represents the largest and biomechanically most powerful component of the rotator cuff musculature, generating over 50% of total rotator cuff torque. Originating broadly from the subscapular fossa and inserting onto the lesser tuberosity of the humerus, the subscapularis functions not only as the primary internal rotator of the arm but also as the critical anterior component of the transverse force couple. Together with the posterior cuff tendons (the infraspinatus and teres minor), the subscapularis compresses the humeral head into the shallow glenoid concavity, stabilizing the fulcrum of motion required for efficient deltoid-mediated abduction and forward elevation. Anatomical insufficiency of the subscapularis disrupts this transversal balance, precipitating anterior and superior subluxation of the humeral head, abnormal contact stresses across the articular cartilage, and secondary joint arthropathy.

Historically labeled the "hidden lesion," tears of the subscapularis were frequently underdiagnosed due to the diagnostic limitations of early cross-sectional imaging and the technical challenge of directly visualizing the lesser tuberosity during open subacromial procedures. Pathological involvement spans a broad continuum, extending from partial articular-sided avulsions of the upper fibers to retracted, multi-tendon disruptions that destabilize the long head of the biceps tendon (LHBT) and compromise the anterior rotator cable.

Anatomical investigations demonstrate that the superior 60% of the lesser tuberosity footprint receives a broad tendinous insertion that sustains high peak tensile strains during internal rotation, whereas the inferior 40% consists predominantly of muscular fibers inserting directly into bone. Consequently, tears typically initiate at the superior leading edge adjacent to the bicipital groove and propagate distally and medially.

To categorize tear patterns and guide operative decision-making, Lafosse et al. introduced a comprehensive classification system based on the craniocaudal extent of tendon detachment and muscular retraction. Under this system, Type I lesions involve a partial tear of the superior third; Type II lesions represent a complete detachment of the superior third; Type III lesions involve a complete detachment of the

superior two-thirds sparing the inferior muscular base; Type IV lesions reflect complete detachment of the entire tendon off the lesser tuberosity with a centered humeral head and muscle fatty degeneration of Goutallier stage 3 or less; and Type V lesions represent complete detachment accompanied by anterior or superior eccentric humeral head subluxation and severe fatty infiltration exceeding stage 3.

Open repair historically served as the definitive benchmark for treating isolated and combined subscapularis ruptures. Nevertheless, open approaches necessitate extensive deltopectoral dissection, partial detachment of the pectoralis major or conjoint tendon, and aggressive soft-tissue retraction, which can lead to postoperative joint stiffness, subscapularis denervation, and prolonged functional rehabilitation. Advances in modern shoulder arthroscopy—including specialized high-definition 70-degree optics, precise portal placement, radiofrequency release instruments, and knotless suture anchor technology—have enabled surgeons to achieve anatomical footprint restoration via all-arthroscopic techniques.

Despite widespread surgical adoption, controversies persist regarding the mechanical durability of arthroscopic constructs across varying tear magnitudes, the role of routine coracoplasty, the prognostic significance of preoperative muscle fatty infiltration, and the rate at which patients achieve established clinical thresholds such as the minimal clinically important difference (MCID) and the patient-acceptable symptom state (PASS). The present study evaluates the clinical, functional, and structural outcomes of all-arthroscopic subscapularis repair in a prospective cohort of 50 consecutive patients followed for a minimum of 24 months.

Materials and Methods

Patient Eligibility and Study Design

A prospective cohort study of 50 consecutive adult patients undergoing all-arthroscopic repair for symptomatic, full-thickness subscapularis tendon tears was conducted between January 2021 and December 2023. All surgical procedures were executed by a single fellowship-trained shoulder arthroscopy team at a tertiary academic medical institution. The study protocol received institutional review board approval, and written informed consent was acquired from all enrolled participants prior to surgical intervention.

Inclusion criteria required patients to be 18 years of age or older, possess a full-thickness subscapularis tear classified arthroscopically as Lafosse type II, III, or IV, present with symptomatic shoulder pain and internal rotation weakness refractory to at least 3 months of nonoperative management (or acute traumatic rupture evaluated within 6 weeks of injury), have completed a minimum clinical follow-up of 24 months, and possess both baseline and 12-month postoperative MRI examinations.

Exclusion criteria eliminated isolated partial-thickness tears (Lafosse type I) managed solely with debridement, massive irreparable posterosuperior cuff tears involving the teres minor, fixed eccentric glenohumeral subluxation with advanced fatty degeneration (Lafosse type V), moderate-to-severe glenohumeral osteoarthritis (Samilson-Prieto grade ≥ 2), active joint infection, prior ipsilateral shoulder surgery, cervical radiculopathy, and systemic neuromuscular disorders.

Preoperative Physical and Functional Assessment

Baseline assessments were conducted within two weeks prior to surgery. Internal rotation function was assessed through three provocative physical examination maneuvers:

- The bear-hug test was executed by having the patient position the palm of the involved arm upon the contralateral shoulder while keeping the elbow anteriorly flexed; internal rotation resistance was assessed against the examiner's attempt to pull the hand away in external rotation, with weakness exceeding 20% compared to the contralateral side indicating a positive test reflecting upper-subscapularis pathology.
- The belly-press test (Napoleon sign) was performed with the patient pressing the flat palm against the abdomen while maintaining the wrist in neutral alignment and the elbow anterior to the coronal plane; the test was graded positive or intermediate when internal rotation could not be maintained without wrist flexion exceeding 30° or posterior elbow drop, indicating upper-half subscapularis disruption.
- The lift-off test was performed with the dorsum of the hand placed over the mid-lumbar spine; the patient was instructed to lift the hand posteriorly away from the back, with an inability to achieve active separation indicating lower-tendon detachment. For patients with restricted passive internal rotation that precluded lumbar placement, the internal rotation lag sign was recorded.

Active range of motion was quantified using a standard goniometer, recording active forward flexion in the scapular plane, external rotation with the arm adducted at the side (0°), and internal rotation behind the back. Internal rotation was converted to an ordinal scoring scale based on the highest vertebral spinous process reached by the thumb tip: lateral thigh to greater trochanter was assigned 1, sacrum/gluteus assigned 2, lumbar levels L5 through L1 scored 3 through 7, and thoracic levels T12 through T7 scored 8 through 13. Patient-reported functional outcomes were quantified using the American Shoulder and Elbow Surgeons (ASES) score (0–100 scale), the Constant-Murley score (CMS; 0–100 scale), and the Visual Analog Scale (VAS) for pain (0–10 scale).

Radiographic and Magnetic Resonance Imaging Protocols

Plain radiographs (true anteroposterior, axillary lateral, and scapular Y views) were analyzed to evaluate acromiohumeral distance and subcoracoid space dimensions. Preoperative MRI was performed on a 1.5-Tesla or 3.0-Tesla scanner using dedicated shoulder surface coils. Axial, coronal oblique, and sagittal oblique T1- and T2-weighted fast spin-echo sequences were acquired.

Subscapularis tear pattern, tendon retraction, and long head of the biceps tendon stability (normal, subluxated, or medially dislocated out of the bicipital groove) were systematically recorded. Fatty infiltration of the subscapularis muscle belly was evaluated on the most lateral sagittal oblique T1-weighted sequence where the scapular spine contacted the scapular body, utilizing the Fuchs modification of the Goutallier classification system: Stage 0 (no fat), Stage 1 (scattered fatty streaks), Stage 2 (fat present but more muscle than fat), Stage 3 (equal fat and muscle), and Stage 4 (more fat than muscle).

At 12 months postoperatively, all patients underwent follow-up

shoulder MRI to evaluate structural repair integrity. The reconstructed tendon footprint was classified according to the five categories defined by Sugaya et al.: Type I corresponds to a repaired tendon of normal thickness with homogeneous low signal intensity; Type II reflects normal tendon thickness with focal areas of increased internal signal intensity; Type III represents tendon thinning without structural discontinuity; Type IV denotes a minor discontinuity suggestive of a partial-thickness retear; and Type V indicates a major discontinuity representing a full-thickness structural retear. Tendons graded as Sugaya Types I, II, and III were categorized as structurally intact, whereas Types IV and V were designated as structural failures.

Surgical Technique

Patients were positioned in either the beach-chair or lateral decubitus position following induction of general anesthesia and execution of an ultrasound-guided interscalene brachial plexus block. Diagnostic arthroscopy was initiated via a standard posterior viewing portal to evaluate the glenohumeral articular surface, the rotator interval, the superior glenohumeral ligament (SGHL), and the LHBT. Direct inspection of the subscapularis insertion commenced by internally and externally rotating the arm under joint distraction. The "comma sign"—a consistent arcuate fibrous tissue band comprising the avulsed superior glenohumeral ligament and coracohumeral ligament complex that remains attached to the superolateral corner of the retracted subscapularis tendon—was identified. Mobilization of the tendon followed the orientation of the comma sign medially, safely avoiding medial neurovascular structures including the brachial plexus and axillary nerve.

Under direct needle guidance, an anterior working portal was established through the rotator interval just superior to the upper edge of the subscapularis tendon, supplemented by an anterolateral viewing portal created to optimize visualization of the lesser tuberosity footprint and subcoracoid space. For contracted, retracted lesions (Lafosse types III and IV), a systematic three-stage release was executed:

1. An intra-articular release divided restrictive capsuloligamentous adhesions along the anterior glenoid rim.
2. An anterior interval slide cleared the fibrous bridge between the superior subscapularis margin and the base of the coracoid process.
3. An extra-articular anterior release within the subcoracoid space separated the anterior surface of the muscle from the posterior fascial investing layer of the conjoined tendon.

Subcoracoid clearance was assessed dynamically by measuring the distance between the coracoid tip and the lesser tuberosity apex; when the distance was under 6 mm or when active mechanical abutment occurred, an arthroscopic coracoplasty was performed using a 4.0-mm motorized burr to resect 4 to 6 mm of the posterolateral coracoid margin while strictly protecting the conjoined tendon insertion.

The lesser tuberosity footprint was debrided of soft tissue with a motorized shaver and curette to expose a bleeding cancellous bone bed, taking care to avoid decortication beyond the subchondral plate to preserve suture anchor purchase.

Fixation constructs were tailored directly to tear magnitude. For Lafosse type II tears, repair was executed using a single double-loaded 4.5-mm or 5.5-mm anchor (or a 2.6-mm knotless

all-suture anchor) positioned into the superolateral aspect of the footprint. Sutures were passed through the superior tendon margin in a mattress or modified lasso-loop configuration to achieve uniform tissue compression. For Lafosse type III and IV tears, an anatomical dual-anchor or double-row transosseous-equivalent construct was performed. The inferior anchor was placed first to reduce the lower footprint, followed by placement of the superior anchor. Suture limbs were passed through the mobilized tendon substance with dedicated suture penetrators and tensioned into lateral knotless anchors or secured with low-profile sliding-locking knots.

Concomitant LHBT pathologies (subluxation, dislocation, high-grade partial tearing, or pulley disruption) were addressed in all instances: biceps tenodesis (suprapectoral or subpectoral) was performed in active patients younger than 60 years, whereas biceps tenotomy was utilized in sedentary patients or those older than 60 years. Associated full-thickness supraspinatus tendon tears were repaired anatomically following completion of the subscapularis construct.

Postoperative Rehabilitation

The operative limb was immobilized in an abduction sling holding the arm in neutral rotation for 4 to 6 weeks depending on tear size. During the initial 4 weeks, passive forward flexion was restricted to 90°/circ, passive external rotation was maintained strictly at 0°/circ (neutral) to avoid excessive tension on the anterior repair, and active pendular exercises were permitted. Between weeks 5 and 6, passive external rotation was gradually advanced to 30°/circ, and passive forward elevation was progressed to full tolerance. At 6 weeks, the sling was discontinued, and active and active-assisted range of motion exercises were initiated in all planes. Strengthening began at 8 to 10 weeks with isometric periscapular and rotator cuff activation, transitioning to progressive elastic-band resisted internal rotation and full kinetic-chain strengthening at 12 weeks. Unrestricted heavy labor, overhead athletics, and manual lifting were restricted until 6 months postoperatively.

Statistical Analysis

Continuous variables were tested for normality using the Shapiro-Wilk test and are reported as mean ± standard deviation (SD) or median with range where appropriate. Categorical variables are presented as frequencies and percentages. Preoperative and postoperative clinical scores (ASES, CMS, VAS) and active range of motion parameters were compared using paired-sample Student's t-tests for normally distributed data or the Wilcoxon signed-rank test for non-normally distributed parameters.

Categorical outcomes, including provocative physical examination test conversion rates and structural healing frequencies, were analyzed using McNemar's test, Pearson's chi-square test, or Fisher's exact test. Achievement of established MCID thresholds (defined as ΔDelta

ASES) ≥ 10.2 points, ΔDelta CMS) ≥ 10.9 points, and ΔDelta VAS) ≤ -1.2 points) and PASS benchmarks (defined as final ASES) ≥ 68.8 points) was calculated. Multivariate logistic regression analysis was executed to identify independent preoperative predictors of structural repair (Sugaya types IV–V) and failure to achieve PASS, controlling for age, sex, symptom chronicity, tear classification, and Goutallier stage. Two-tailed P values < .05 were considered statistically significant. Statistical analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY).

RESULTS

Cohort Demographics and Pathological Characteristics

The final study cohort comprised 50 consecutive patients with complete 24-month clinical follow-up and 12-month postoperative MRI assessments. The mean patient age was 56.4 ±

8.2 years (range, 38–71 years), with a male distribution of 64% (n = 32). The dominant extremity was involved in 72% (n = 36) of cases. An acute traumatic injury mechanism was documented in 56% (n = 28) of patients, while 44% (n = 22) presented with chronic degenerative tears. According to the Lafosse classification, 16 patients (32%) presented with Type II tears, 22 patients (44%) presented with Type III tears, and 12 patients (24%) presented with Type IV tears. Concomitant full-thickness supraspinatus tendon tears were present in 24 patients (48%) and were repaired concurrently. Biceps pathology was identified in 84% (n = 42) of the shoulders, requiring tenodesis in 31 patients (62%) and tenotomy in 11 patients (22%). Arthroscopic coracoplasty was performed in 13 patients (26%) for subcoracoid stenosis. Baseline demographic, anatomical, and surgical data are summarized in Table 1

Demographic and Clinical Parameter	Cohort Value (N = 50)	Percentage / Range
Age (years), Mean ± SD	56.4 ± 8.2	38 – 71
Sex (Male / Female)	32 / 18	64% / 36%
Body Mass Index (kg/m²), Mean ± SD	27.8 ± 4.1	21.2 – 35.6
Demographic and Clinical Parameter	Cohort Value (N = 50)	Percentage / Range
Involved Shoulder (Dominant / Non-dominant)	36 / 14	72% / 28%
Tear Etiology (Traumatic / Degenerative)	28 / 22	56% / 44%

Symptom Duration Prior to Surgery (months)	5.1 ± 3.4	1.0 – 14.0
Lafosse Tear Classification		
Type II (Superior 1/3 detachment)	16	32%
Type III (Superior 2/3 detachment)	22	44%
Type IV (Complete detachment)	12	24%
Preoperative Subscapularis Fatty Infiltration (Goutallier)		
Stage 0	18	36%
Stage 1	21	42%
Stage 2	8	16%
Stage 3	3	6%
Concomitant Procedures Performed		
Long Head Biceps Tenodesis	31	62%
Long Head Biceps Tenotomy	11	22%
Biceps Intact / Unaddressed	8	16%
Arthroscopic Coracoplasty	13	26%
Supraspinatus Tendon Repair	24	48%
Subacromial Decompression / Acromioplasty	39	78%

Clinical Functional Scores and Range of Motion

At a mean clinical follow-up of 28.4 ± 4.6 months (range, 24–38 months), patients demonstrated statistically significant improvements across all functional scoring inventories and active motion planes (P < .001). The mean ASES score improved from a preoperative baseline of 44.6 ± 11.2 to 86.8 ± 8.4 at final evaluation, demonstrating an average gain of 42.2 points (95% CI: 39.1 to 45.3; P < .001).

The Constant-Murley score increased from 48.2 ± 9.5 to 83.5 ± 7.9 (95% CI: 32.4 to 38.2; P < .001). Visual Analog Scale pain scores dropped from 6.2 ± 1.4 preoperatively to 1.3 ± 1.1 postoperatively, reflecting a significant pain reduction of -4.9 points (95% CI: -5.3 to -4.5; P < .001).

Active forward flexion increased from 118.4° ± 22.1° to 158.6° ± 14.2° (P < .001), active external rotation at the side improved from 34.2° ± 10.5° to 49.8° ± 8.1° (P < .001), and active internal rotation behind the back advanced from a median level of L4 (range, lateral thigh to L2) preoperatively to T9 (range, L2 to T6) at final follow-up (P < .001). Detailed functional outcomes and motion metrics are displayed in Table 2.

Functional Outcome Measure	Preoperative Baseline	Postoperative (24 Months)	Mean Difference (95% CI)	P Value
ASES Score (0–100)	44.6 ± 11.2	86.8 ± 8.4	42.2 (39.1 to 45.3)	< .001
Constant-Murley Score (0–100)	48.2 ± 9.5	83.5 ± 7.9	35.3 (32.4 to 38.2)	< .001
VAS Pain Score (0–10)	6.2 ± 1.4	1.3 ± 1.1	-4.9 (-5.3 to -4.5)	< .001
Active Forward Flexion (°)	118.4 ± 22.1	158.6 ± 14.2	40.2 (34.8 to 45.6)	< .001
Active External Rotation at Side (°)	34.2 ± 10.5	49.8 ± 8.1	15.6 (12.5 to 18.7)	< .001
Active Internal Rotation (Vertebral Level)	L4 (Thigh to L2)	T9 (L2 to T6)	Median gain: 5 segments	< .001
Achievement of MCID Thresholds				

ASES Score (\Delta \ge 10.2 points)	—	46 / 50 (92%)	—	—
Constant Score (\Delta \ge 10.9 points)	—	47 / 50 (94%)	—	—
VAS Pain Score (\Delta \le -1.2 points)	—	48 / 50 (96%)	—	—
Achievement of PASS Benchmark				
ASES Score (\ge 68.8 points)	—	43 / 50 (86%)	—	—
Clinical Provocative Test	Preoperative Positive, n (%)	Postoperative Positive, n (%)	Negative Conversion Rate (%)	P Value
Bear-Hug Test (N= 50)	41 (82.0%)	6 (12.0%)	85.4%	< .001
Belly-Press Test (N = 50)	38 (76.0%)	5 (10.0%)	86.8%	< .001
Lift-Off Test (n =34)	21 (61.8%)	3 (8.8%)	85.7%	< .001

Evaluation of meaningful clinical benchmarks confirmed that 92% (n = 46) of patients achieved the ASES MCID, 94% (n = 47) surpassed the CMS MCID, and 96% (n = 48) achieved the VAS pain MCID. Furthermore, the rigorous PASS threshold for the ASES score (≥ 68.8 points) was attained by 86% (n = 43) of the entire study cohort.

Physical Examination Normalization

Preoperative physical examinations revealed high rates of subscapularis dysfunction, which converted to normal test status across the vast majority of patients following repair. The bear-hug test was positive in 82% (n = 41) of patients preoperatively and converted to negative in 88% of those cases, remaining positive in only 12% (n = 6) at final follow-up (P < .001).

The belly-press test exhibited positive or intermediate findings in 76% (n = 38) of patients preoperatively, normalizing in 87% of affected individuals and remaining positive in 10% (n = 5) postoperatively (P < .001). The lift-off test, evaluated in the 34 patients possessing sufficient passive internal rotation to reach the mid-lumbar region preoperatively, demonstrated positivity in 61.8% (n = 21) preoperatively, with persistent deficiency noted in only 8.8% (n = 3) at 24 months (P < .001). The physical examination conversions are presented in Table 3.

Structural Healing Integrity and Subgroup Outcomes

At 12 months postoperatively, follow-up MRI according to Sugaya classification demonstrated that 29 shoulders (58%) achieved Type I healing, 12 shoulders (24%) exhibited Type II healing, 5 shoulders (10%) showed Type III healing, 2 shoulders (4%) developed Type IV partial-thickness failure, and 2 shoulders (4%) experienced Type V full-thickness structural failure. Overall, 92% (n = 46) of the repairs were structurally intact (Sugaya Types I–III), whereas structural retears (Sugaya Types IV–V) were confirmed in 8% (n = 4). Complete tendon integrity was maintained in 100% (16/16) of Lafosse type II tears, 95.5% (21/22) of Lafosse type III tears, and 75.0% (9/12) of Lafosse type IV tears (P = .014). Preoperative Goutallier stage ≥ 2 fatty infiltration was present in 11 patients, of whom 3 (27.3%) sustained structural retears, compared to only 1 re-tear (2.6%) among the 39 patients presenting with Goutallier stage 0 or 1 (P = .019). Patients with structurally intact repairs achieved significantly superior final ASES scores (88.4

± 7.2 vs. 68.5 ± 5.4 ; P < .001), higher Constant scores (85.1 ± 6.4 [span_140](start_span)[span_140](end_span)[span_143](start_span)[span_143](end_span) [span_144](start_span)[span_144](end_span) [span_146](start_span)[span_146](end_span) vs. 65.2 ± 4.8 ; P < .001), and lower pain scores (1.1 ± 0.9 vs. 3.2 ± 1.2 ; P = .002) compared to those with structural failures. Concomitant repair of full-thickness supraspinatus tears did not adversely affect subscapularis structural healing rates (91.7% in combined repairs vs. 92.3% in isolated tears; P = .936). Comparative clinical and structural findings

between intact repairs and retears are summarized in Table 4. In the multivariate logistic regression model adjusting for age, sex, symptom duration, and concomitant procedures, preoperative Goutallier fatty infiltration stage ≥ 2 (odds ratio [OR] 11.8, 95% CI: 1.08 to 128.4; P = .043) and Lafosse type IV tear morphology (OR 8.4, 95% CI: 1.02 to 69.1; P = .048) remained independent predictors of structural repair failure.

Clinical and Morphologic Parameter	Structurally Intact (n = 46)	Structural Rerear (n = 4)	Comparative Statistic / Odds Ratio	P Value
Age (years), Mean $\pm$ SD	55.8 $\pm$ 7.9	63.2 $\pm$ 5.1	t = -1.86	.068
Sex (Male / Female)	30 / 16	2 / 2	Fisher's exact	.584
Traumatic Etiology, n (%)	27 (58.7%)	1 (25.0%)	Fisher's exact	.312
Symptom Duration ≥ 6 Months, n (%)	13 (28.3%)	3 (75.0%)	Fisher's exact	.078
Lafosse Tear Distribution			$\chi^2 = 8.52$	.014
Type II (n = 16)	16 (100%)	0 (0%)	Reference	—
Type III (n = 22)	21 (95.5%)	1 (4.5%)	OR: 1.05 (0.04 to	.523
Clinical and Morphologic Parameter	Structurally Intact (n = 46)	Structural Rerear (n = 4)	Comparative Statistic / Odds Ratio	P Value
Type IV (n = 12)	9 (75.0%)	3 (25.0%)	OR: 7.00 (1.18 to 41.5)	.014
Preoperative Goutallier Stage ≥ 2 , n (%)	8 (17.4%)	3 (75.0%)	OR: 14.25 (1.34 to 151.7)	.019
Concomitant Supraspinatus Tear, n (%)	22 (47.8%)	2 (50.0%)	$\chi^2 = 0.007$	.936
Final ASES Score, Mean $\pm$ SD	88.4 $\pm$ 7.2	68.5 $\pm$ 5.4	t = 5.37	< .001
Final Constant-Murley Score, Mean $\pm$ SD	85.1 $\pm$ 6.4	65.2 $\pm$ 4.8	t = 6.02	< .001
Final VAS Pain Score, Mean $\pm$ SD	1.1 $\pm$ 0.9	3.2 $\pm$ 1.2	t = -4.24	.002
Active Forward Flexion (°)	160.8 $\pm$ 12.8	133.5 $\pm$ 11.0	t = 4.11	< .001
Active External Rotation at Side (°)	50.7 $\pm$ 7.4	39.5 $\pm$ 8.2	t = 2.87	.006
Achievement of ASES PASS Benchmark, n (%)	42 (91.3%)	1 (25.0%)	Fisher's exact	.005

Complications

No intraoperative neurovascular injuries, such as axillary or musculocutaneous nerve palsies, occurred in this series. There were no deep surgical site infections or suture anchor pull-outs requiring revision intervention. Three patients (6%) developed transient postoperative glenohumeral stiffness (external rotation loss > 15° compared to contralateral baseline at 3 months postoperatively); all three cases responded favorably to structured physical therapy regimens and achieved functional range of motion by 6 months postoperatively without requiring capsular release.

DISCUSSION

The results of this prospective cohort study demonstrate that all-arthroscopic repair of full-thickness subscapularis tears produces significant, durable clinical improvement, marked pain relief, functional normalization of internal rotation torque, and a high structural healing rate of 92% at mid-term follow-up. Furthermore, 92% and 86% of patients achieved the ASES MCID and PASS thresholds, respectively, confirming that the anatomical restoration of the lesser tuberosity footprint provides clinically perceived recovery across daily functional tasks.

Biomechanics and the Force-Couple Paradigm

The subscapularis functions as the anterior cornerstone of the glenohumeral transverse force couple. Biomechanical investigations demonstrate that disruption of the superior subscapularis tendon compromises the anterior attachment of the rotator cable, causing the humeral head to translate superiorly and anteriorly during active elevation. By anatomically reconstructing the footprint—particularly restoring the robust superior leading edge under balanced tension—the transverse force couple is re-established. This structural constraint prevents excessive anterior-superior translation, creating a stable center of rotation that allows the deltoid and intact posterior rotator cuff musculature to elevate the arm efficiently. This restoration accounts for the marked improvement in active forward flexion (mean gain of 40.2°) observed in this cohort, confirming that even when combined anterosuperior tears are present, securing the anterior pillar re-establishes normal joint kinematics.

Diagnostic Nuance and Mechanics of Physical Examination Maneuvers

Physical examination remains essential for evaluating subscapularis integrity, yet test sensitivity depends on the functional anatomy of the tendon. The upper 60% of the tendon consists of dense tendinous tissue that inserts into the superior facet of the lesser tuberosity, whereas the inferior 40% consists of muscular fibers with an oblique pull. Electromyographic and clinical studies indicate that the bear-hug test maximally isolates the superior fibers, generating strong internal rotation torque at 90° of forward flexion. This specific vector explains why the bear-hug test demonstrated the highest baseline positivity rate (82%) in this cohort, identifying Lafosse type II and III tears that spare the inferior muscular insertion.

The belly-press test similarly evaluates the upper half of the tendon, but compensatory wrist flexion or elbow extension may mask partial weakness in subtle tears. In contrast, the lift-off test requires full engagement of the inferior subscapularis fibers to lift the hand away from the lumbar spine against gravity. Consequently, the lift-off test exhibited a lower preoperative positivity rate (61.8%) and was primarily positive in Lafosse type III and IV lesions characterized by extensive craniocaudal detachment. Postoperatively, provocative test normalization was achieved in 85% to 87% of patients, mirroring structural tendon reconstitution. Persistent test positivity or intermediate weakness at 24 months correlated strongly with structural retears (Sugaya types IV–V) or baseline Goutallier stage ≥ 2 fatty degeneration, where irreversible loss of contractile myofibrils prevented complete recovery of internal rotation force.

The Role of Long Head of the Biceps Pathology and Coracoid Impingement

Subscapularis disruptions rarely occur in isolation from LHBT instability. The medial wall of the bicipital groove and the medial pulley sling are formed by fibers of the superior subscapularis tendon and the SGHL. When the leading edge tears, this medial restraint fails, leading to subluxation or medial dislocation of the LHBT directly over the exposed lesser tuberosity footprint. An unstable, subluxating biceps tendon acts as a continuous abrasive mechanical wiper across the footprint, elevating repair tension and predisposing the construct to failure.

Addressing the diseased LHBT via tenodesis or tenotomy in 84% of the shoulders in this series removed this major anterior pain generator and cleared the repair site. Concomitantly, dynamic subcoracoid stenosis—the "roller-wringer" phenomenon in which the subscapularis tendon is compressed between the coracoid process and the humeral head during forward flexion and internal rotation—was alleviated via coracoplasty in 26% of patients presenting with coracohumeral clearance < 6 mm, creating an unconstrained bed for tendon excursion and healing.

Determinants of Structural Healing and Functional Recovery

The primary risk factors for structural repair failure identified in this study were tear retraction extent (Lafosse type IV) and preoperative muscular fatty degeneration (Goutallier stage ≥ 2). While Lafosse type II tears achieved a 100% healing rate using single-anchor constructs and Lafosse type III tears attained a 95.5% healing rate using double-anchor constructs, Lafosse type IV tears exhibited a 25% failure rate despite extensive releases and double-row transosseous-equivalent fixation.

Chronic tendon retraction induces progressive, irreversible fibrofatty changes within the subscapularis muscle belly. Once fatty infiltration surpasses Goutallier stage 2, muscle elasticity and compliance are lost, and the repair interface sustains high cyclic tensile strains that impair biological healing at the bone-tendon junction.

Patients who sustained structural retears (Sugaya types IV–V) still achieved meaningful pain relief (mean VAS reduction from 6.2 to 3.2) and modest functional gains (mean ASES improvement from 44.6 to 68.5). This partial recovery is attributable to the permanent tenodesis effect of the remaining tendon base, capsular plication, the elimination of biceps-mediated friction, and partial preservation of anterior restraint, which together stabilize the shoulder and alleviate pain despite incomplete anatomical continuity.

Study Limitations

This study has several limitations:

1. The sample size (N = 50), while sufficient for prospective cohort analysis, limits high-dimensional multivariable regression modeling of rarer subsets.
2. The cohort included both isolated subscapularis tears and anterosuperior tears with supraspinatus involvement; although comparative subset analyses showed no significant differences in subscapularis healing rates between isolated and combined repairs, concomitant repairs introduce kinematic variables.
3. Postoperative structural status was assessed by MRI at 12 months; longer radiologic follow-up extending beyond 5 years will be valuable to evaluate progressive degenerative alterations and the long-term integrity of the muscle-tendon unit.

CONCLUSIONS

All-arthroscopic subscapularis tendon repair provides significant, durable improvements in pain relief, active range of motion, internal rotation torque, and overall shoulder function. An overall structural healing rate of 92% is achievable through systematic intra- and extra-articular releases, anatomical lesser tuberosity footprint preparation, and tailored anchor constructs combined with routine management of LHBT instability. Preoperative muscle fatty infiltration (Goutallier stage ≥ 2) and complete tear retraction (Lafosse type IV) represent the primary prognostic determinants of structural failure, underscoring the clinical value of early surgical intervention before irreversible muscular degeneration occurs.

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