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Glenohumeral synovitis score predicts early shoulder stiffness following arthroscopic rotator cuff repair

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ABSTRACT

Background: This study was conducted to determine if there is an association between an intraoperative glenohumeral synovitis score (GHSS) and postoperative shoulder stiffness in patients undergoing arthroscopic rotator cuff repair (ARCR).

Methods: Intraoperative GHSS was collected retrospectively from standardized arthroscopic images on consecutive patients undergoing primary ARCR. Range of motion was collected preoperatively and postoperatively at 3 and 6 months.

Results: 290 consecutive patients underwent primary ARCR. At three-months follow-up, 32 (11.0%) patients had glenohumeral stiffness. Patients with stiffness had significantly higher mean GHSS.

Conclusion: Higher intraoperative GHSS was associated with early postoperative shoulder stiffness at three-months after ARCR.

1. Introduction

Shoulder stiffness is a common complication after arthroscopic rotator cuff repair (ARCR). The rate of postoperative shoulder stiffness following ARCR is variable due to the heterogeneity of diagnostic criteria and is reported in the literature from 2.3 to 28.5%.[1–7] Preoperative risk factors for developing postoperative shoulder stiffness following ARCR have been reported as preoperative shoulder stiffness, age less than 50 years old, workers compensation, diabetes, hypothyroidism, and coexisting diagnosis of calcific tendonitis or adhesive capsulitis.[2,7,8] Intraoperative risk factors reported include single-tendon tears, partial articular-sided tears, and concomitant labral repair.[2]

One potential intraoperative variable that has not been explored is the degree of glenohumeral synovitis at the time of ARCR. Glenohumeral synovitis is frequently encountered during ARCR, yet our understanding of its etiology and impact on clinical outcomes is poorly understood. Studies have shown glenohumeral joint and subacromial space synovial tissue taken at time of rotator cuff repair is associated with increased inflammation, angiogenesis and production of inflammatory mediators.[9–11] However, there has been no investigation of glenohumeral synovitis on clinical outcomes after ARCR.

Recently, Davis et al.[12] reported a validated intraoperative scoring system to classify the degree of glenohumeral synovitis—the glenohumeral synovitis score (GHSS)—based on capsule characteristics during arthroscopy. The GHSS was created to provide surgeons a quick and reproducible tool to grade the degree of synovitis during shoulder arthroscopy.

The purpose of this study was to determine if the degree of intraoperative capsular synovitis is associated with development of postoperative shoulder stiffness following ARCR.

2. Materials and methods

2.1. Study group

Following approval by the local institutional review board, this retrospective review of arthroscopic rotator cuff repairs was undertaken. Between January 2015 and February 2017, 290 consecutive primary ARCR were performed by one of two fellowship trained shoulder and elbow surgeons. Inclusion criteria for this study was

Abbreviations: glenohumeral synovitis score, (GHSS); arthroscopic rotator cuff repair, (ARCR); passive external rotation, (PER); passive forward elevation, (PFE)

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patients undergoing primary ARCR for symptomatic partial or full-thickness rotator cuff tear. Exclusion criteria included revision ARCR, open rotator cuff repair, irreparable rotator cuff tear, concurrent glenohumeral joint stabilization procedure, and inadequate intraoperative photos to generate GHSS.

2.2. Demographics and preoperative evaluation

From retrospective chart review, demographics and clinical data were recorded. Shoulder range of motion was obtained by clinical exam from the treating surgeon as part of the standard care provided. The following planes of motion were recorded: passive forward elevation (PFE) in the scapular plane, passive external rotation with arm at the side (PER). Goniometer to measure shoulder range of motion was not routinely used during the study period.

2.3. Surgical technique/intraoperative protocol

Patient were positioned in the beach-chair position. A posterior portal was created as a viewing portal. Arthroscopic images were obtained during glenohumeral joint diagnostic arthroscopy in a standardized fashion. The following intraarticular structures were photographed in all cases: rotator interval, superior labrum, anterior capsule, glenoid, humeral head, axillary recess, posterosuperior rotator cuff insertion, subscapularis insertion, long head of biceps tendon, posterior capsule. The characteristics of the rotator cuff pathology (size, number of tendons, full versus partial thickness) were obtained from intra-operative assessment. Concomitant procedures were performed as indicated at the time of rotator cuff repair and were recorded. Single-row versus double-row repair of the rotator cuff was performed based on treating surgeon preference and was not standardized.

2.4. Obtaining glenohumeral synovitis score

Retrospectively, the treating surgeons assigned glenohumeral synovitis grades based on standardized arthroscopic images on consecutive patients. The degree of glenohumeral synovitis was recorded, as previously described,[12] based on the following characteristics: color of capsule (pale, pink, or red); villous projections (none, few, or extensive); capillaries in capsule (scattered or hypertrophied); and axillary recess (normal or contracted). Scores were assigned from 0 to 6 (Table 1). A higher GHSS, indicates a greater degree of synovitis.

2.5. Postoperative rehabilitation

All patients underwent the same postoperative rehabilitation protocol. Patients were immobilized in an abduction sling for a total of 6 weeks. Patients initiated a home-based physical therapy program at 2 weeks that includes passive cane-assisted external rotation, passive supine forward elevation, and pendulum exercises. Formal physical therapy was initiated at 6 weeks and included passive motion in other planes, active-assisted, and active motion. Strengthening was started at a minimum of 10 weeks after surgery.

Table 1
Glenohumeral synovitis score calculation.

Characteristic	Question	Response (Score)
Color	How would you describe the color of the capsule?	Pale (0) Pink (1) Red (2)
Villi	How would you describe the villous projections?	None (0) Few (1) Extensive (2)
Capillaries	How would you describe the capillaries of this capsule?	Scattered (0) Hypertrophied (1)
Axillary recess	How would you describe the axillary recess of this capsule?	Normal (0) Contracted (1)
When totaled, scores range from 0 to 6.		

2.6. Postoperative evaluation

At 6 weeks, 3 and 6 months and final follow-up patients were seen for evaluation and range of motion was recorded by the treating surgeon. PFE and PER were recorded from the clinic notes. Every patient in the stiffness cohort was followed at 6 months with clinical evaluation and range of motion recorded. In the non-stiff cohort, 10.1% (26/258) did not have any follow-up beyond their 3-month visit.

2.7. Definition of shoulder stiffness

At the preoperative and 3-month follow-up, patients were classified as having post-operative stiffness if their PFE was $< 100^{\circ}$ or their PER was $< 30^{\circ}$.[13] This defined our stiffness and non-stiff groups. Patients with symptomatic loss of shoulder motion at 3-months were initially treated with physical therapy, oral non-steroidal anti-inflammatories, oral steroids, or glenohumeral steroid injection. The stiffness patients were examined at 6-months and were recorded as either “resolved stiffness” or “persistent stiffness”. Resolved stiffness was assigned if PFE was greater than 100° and PER greater than 30° at 6-month follow up. Patients with persistent stiffness and who had plateaued in terms of improvement with physical therapy were offered continued observation versus arthroscopic capsular release.

2.8. Statistical analysis

Initially, to assess predictors of post-arthroscopic rotator cuff repair stiffness, specifically GHSS, univariate analysis of the differences in the tested variables was made between those patients with and without defined post-operative stiffness. First, data normality for continuous variables was confirmed with a skewness and kurtosis less than two and 12, respectively. For continuous variables, the comparison was performed with a Student's t-test. For dichotomous variables, the comparison was made with a Chi-squared test. Following this, to confirm independence of associations found in univariate analysis, reverse stepwise multivariate logistic regression was undertaken. To evaluate GHSS as a diagnostic predictor of post-operative stiffness a receiver operating characteristic (ROC) analysis was performed. Data analysis was performed in RStudio (Version 1.0.136; RStudio, Inc.; Boston, MA).

3. Results

A total of 290 consecutive patients underwent primary ARCR. At 3-months follow-up, 32 (11.0%) patients had defined shoulder stiffness. Of the 32 patients that developed stiffness at 3-months: 25 (78.6%) had resolution of stiffness by 9–12 months (mean GHSS 3.2), 4 (12.5%) patients had persistent stiffness (mean GHSS 3.7) and did not undergo further surgical intervention, and 3 (9.4%) patient underwent capsular release (mean GHSS 3.3) at mean 40.3 weeks (range: 29–53 weeks) from the date of surgery.

Patients with stiffness at three-months had significantly higher GHSS (mean: 3.3) than patients that did not develop stiffness (2.5; $p < 0.001$; Table 2). Specifically, grading of hypertrophied capillaries (34.3% versus 15.5%; $p = 0.02$) and red capsule color (18.8% vs 6.2%; $p = 0.002$) subcategories was statistically associated with post-operative stiffness. Multivariate analysis provided decreased number of tendons (odds ratio [OR] = 0.48), decreased passive pre-operative external rotation (OR = 0.96), and GHSS grade (OR = 2.26) as the statistically significant independent predictors of post-operative stiffness following ARCR (Table 3). ROC curve analysis provided an area under the curve (AUC) of 0.65 for GHSS predicting postoperative stiffness. ROC provided an optimal threshold of 3.0 with a sensitivity and specificity of 81.25% (26/32) and 47.3% (122/258), respectively.

Table 2
Demographics, synovitis grade, rotator cuff tear characteristics, comorbidities and concomitant procedures between the stiffness and non-stiff cohorts.

Variable	Post-operative Stiffness (n = 32)	No Stiffness (n = 258)	p-value
Age	55.9 (28–78)	57.9 (33–88)	0.30
Gender			
Male	21 (65.6%)	158 (61.2%)	0.77
Female	11 (34.3%)	100 (38.6%)	
Synovitis Grade	3.28 (1.0–6.0)	2.47 (0–6.0)	< 0.001
Axillary Recess			
Normal	7 (21.9%)	95 (36.8%)	0.15
Contracted	25 (78.1%)	163 (63.2%)	
Capillary Grade			
Scattered	21 (65.6%)	218 (84.5%)	0.02
Hypertrophied	11 (34.3%)	40 (15.5%)	
Villous Projection Grade			
None	3 (9.4%)	55 (21.1%)	0.24
Few	25 (78.1%)	182 (70.5%)	
Extensive	4 (12.5%)	21 (8.1%)	
Color			
Pale	1 (3.1%)	63 (24.4%)	0.002
Pink	25 (9.7%)	179 (69.4%)	
Red	6 (18.8%)	16 (6.2%)	
Number of Tendons	1.9 (1–3)	1.6 (1–4)	0.06
Tear Thickness			
Full thickness	28 (87.5%)	223 (86.4%)	1.0
Partial Thickness	4 (12.5%)	35 (13.4%)	
Passive Pre-operative Forward Elevation	135.6 (40–175)	143.2 (40–175)	0.20
Passive Pre-operative External Rotation	38.3 (0–70)	51.3 (0–90)	< 0.001
Comorbidities			
Diabetes	5 (15.6%)	29 (11.2%)	0.66
Hypothyroid	2 (6.3%)	15 (5.8%)	0.98
Hyperlipidemia	12 (37.5%)	97 (37.6%)	1.0
Adhesive Capsulitis	1 (3.1%)	0 (0%)	0.21
Concomitant Procedures			
Sub-acromial Decompression	24 (75%)	126 (48.8%)	0.009
Distal Clavicle Excision	3 (9.4%)	11 (4.2%)	0.40
Biceps Tenodesis	7 (21.9%)	106 (41.0%)	0.06
Labral Debridement	0 (0%)	7 (2.7%)	0.74
Capsular Release	9 (28.1%)	34 (13.2%)	0.06

Table 3
Multivariate analysis.

Variable	OR	95% CI	p-value
Synovitis Grade	2.26	1.56–3.40	< 0.001
Number of Tendons	0.48	0.25–0.86	0.02
Passive Preoperative Forward Elevation	1.01	0.99–1.03	0.10
Passive Preoperative External Rotation	0.96	0.93–0.98	0.001
Sub-acromial Decompression	2.54	0.99–7.09	0.06

OR = odds ratio, CI = confidence interval.

Preoperative PFE, preoperative stiffness, partial-thickness versus full-thickness tears, size of rotator cuff tear (including massive), concomitant procedures, and demographic factors were not associated with stiffness.

Eighty-four patients had shoulder stiffness preoperatively (mean GHSS of 2.7). Of these patients, 43 patients underwent capsular release at the time of ARCR (mean preoperative PER of 36°, mean GHSS of 2.8). Of the patients who underwent capsular release at time of ARCR, 20.9% (9/43) had defined shoulder stiffness at 3-months postoperative compared to 12.2% (5/41) of patients that had preoperative stiffness (mean GHSS of 2.6) and did not undergo a capsular release (p = 0.282).

4. Discussion

Postoperative shoulder stiffness is a common complication after ARCR. Although several risk factors for patients with persistent postoperative shoulder stiffness have been reported, the cause of tissue fibrosis and predictors are likely multifactorial. Variable degrees of glenohumeral synovitis are commonly observed during ARCR; however, the influence of synovitis on the development of stiffness has not been defined.

We found that patients who had shoulder stiffness at three months after ARCR had increased glenohumeral synovitis as evidenced by a higher GHSS. Jo et al.[14] evaluated 54 full-thickness rotator cuff tears undergoing ARCR and assessed the severity and location of intraoperative synovitis in the subacromial space and glenohumeral joint using macroscopic and microscopic methods. They found the macroscopic severity of synovitis to be greater in the glenohumeral joint compared to the subacromial space. Microscopic assessment also showed greater severity of synovitis in the glenohumeral joint compared to subacromial space. Their results support that the glenohumeral joint may be the predominant location of synovitis in rotator cuff disease, however, they did not correlate their findings with clinical outcomes.

In this study, red color of the glenohumeral capsule and hypertrophic capillaries, both a component of the GHSS, were independently associated with postoperative shoulder stiffness at 3 months. Tauro[7] evaluated 72 patients with rotator cuff tears and concomitant preoperative shoulder stiffness who underwent ARCR. That analysis grouped patients preoperatively based on severity of range of motion deficits and classified the capsule intraoperatively as normal, erythematous, synovitic, or thick and contracted. He found the 6 patients in the group with the greatest preoperative range of motion deficit had the most substantial changes to the capsule intraoperatively. Three of these patients, with coexisting diagnosis of adhesive capsulitis, were the only ones to have the capsule classified as “thick and contracted” and were the only patients that required capsular release postoperatively for symptomatic shoulder stiffness. Although Tauro's classification of capsule characteristics was not validated and subjective, it was consistent with our finding that patients with a greater degree of glenohumeral synovitis were at increased risk to develop postoperative shoulder stiffness.

We evaluated a subset of our patients with rotator cuff tear and concomitant preoperative shoulder stiffness and did not find capsular release to be protective of persistent stiffness at three-months following surgery. Studies evaluating outcomes between patients with rotator cuff tear and shoulder stiffness managed with MUA with or without capsular release compared to non-stiff shoulders with rotator cuff repair only, found no difference in final outcomes or range of motion between the two groups.[15–18] Studies comparing MUA alone versus MUA and capsular release at time of rotator cuff repair with a stiff shoulder found MUA and capsular release resulted in quicker recovery of shoulder range of motion,[19] improved final forward elevation and external rotation,[19] and improved functional outcomes in patients with diabetes[20] compared to MUA alone. We did not find capsular release protective of postoperative stiffness at three-months, as 20.9% (9/43) of capsular release patients were stiff compared to 12.2% (5/41) that did not undergo release.

Based on previous reports,[1,5,6] we defined postoperative shoulder stiffness at three-months in patients with PFE less than 100° and/or PER less than 30°. There is no consensus definition of postoperative shoulder stiffness following ARCR.[13] We found an 11.0% (32/290) rate of postoperative shoulder stiffness at three-months following ARCR and resolution of stiffness in 79% by one year. Brislin et al.[1] reported complications after 263 ARCR and found postoperative stiffness was the most common (8.7%; 23/263) at three months. Of these, 91.3% (21/23) resolved with extended therapy, one patient underwent capsular release, and one patient declined further surgery. Parsons et al.[5] reported on 43 ARCR and found nearly one-quarter of patients (23.3%) had postoperative stiffness at the two-month follow-up. At one year follow-up, these patients had no difference in range of motion or functional scores compared to patients who did not have early stiffness.

Peters et al.[6] evaluated stiffness in 105 ARCRs and reported a stiffness rate of 21% and 19% at 3 months and 15% and 14% at 6 months for partial-thickness and full-thickness tears, respectively.

Our study did not evaluate synovial tissue biopsies. However, previous investigations, using microscopic techniques to evaluate synovial tissue collected during rotator cuff repair, have shown increased inflammatory changes. Abrams et al.[9] sampled synovial tissue in patients with rotator cuff tears and without rotator cuff tear. They found increased levels of synovial inflammation, angiogenesis and inflammatory mediators compared to controls. Similarly, Shindle et al.[11] found increased synovial inflammation and increased expression of inflammatory mediator in patients with full-thickness rotator cuff tears compared to partial-thickness tears. Gotoh et al.[10] found increased inflammatory mediators in synovial tissue from the subacromial space of patient with full-thickness and partial thickness rotator cuff tears and found increased expression in those with full-thickness tears. They also showed increased inflammatory mediator production correlated with preoperative pain versus controls. We did not evaluate the influence of synovitis on preoperative or postoperative pain scores or compliance with physical therapy; however, we expect these factors to be interrelated.

Our results suggest high GHSS is an intraoperative risk factor for shoulder stiffness following ARCR. Other risk factors that were associated with stiffness included decreased preoperative PER and decreased number of torn tendons. Huberty et al.[2] evaluated a series of 489 ARCRs and reported risk factors for postoperative shoulder stiffness including age less than 50 years, workers' compensation status, coexisting diagnosis of calcific tendonitis or adhesive capsulitis, single-tendon cuff repairs, PASTA repairs and concomitant labral repairs. Other studies reporting risk factors for postoperative shoulder stiffness have been a series of mixed arthroscopic, mini-open and open rotator cuff repairs.[21,22] These studies reported risk factors of preoperative stiffness, worker's compensation, longer duration of symptoms, diabetes, larger tears, open repair, and an older age. These reports are difficult to interpret as there is a large difference in the degree of tissue trauma and manipulation associated with open procedures. In a follow-up to Huberty et al.'s study, Koo et al.[3] used a subset of their risk factors to identify 79 patients with at least 1 risk factor for postoperative stiffness and implemented a customized rehabilitation regimen that emphasized closed-chain passive forward elevation, and they reported no postoperative stiffness at a mean of 8 months follow up compared to a historical control rate of 7.8%. Their results show that they used previously reported risk factors for postoperative stiffness to identify high risk patients and made postoperative management changes to prevent the complication. Future studies, could identify patients with these risk factors and threshold GHSS of greater than 3.0 and consider modifying intraoperative or postoperative management to mitigate the risk of postoperative shoulder stiffness.

The findings of this study must be viewed in the light of its limitations. First, this was a retrospective review with all the limitations inherent of that study design—including grading of GHSS based upon saved arthroscopic images rather than live video; however, we believe that the standardized and comprehensive photographs taken at the time of arthroscopy minimize the impact of this limitation. We used a scoring system to evaluate synovitis that did not differentiate between the location of synovitis within the joint. We used the synovitis scoring system described by Davis et al.[12] because of familiarity and validity of the system based on 19 surgeons with different experience and training. Range of motion was obtained by surgeons without standardization and can be prone to error and bias. Finally, we did not formally evaluate compliance with physical therapy or quantify the influence of pain on the development of stiffness.

5. Conclusion

Patients with greater degrees of glenohumeral synovitis at time of ARCR were more likely to develop postoperative shoulder stiffness than patients with lower grades of synovitis. This intraoperative risk factor for postoperative shoulder stiffness may allow surgeons to adjust intraoperative and/or postoperative management to prevent post-operative stiffness.

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Level of evidence

Level III, Case-control Study. Treatment Study.

CRediT authorship contribution statement

Zhen Tan: Data curation, Project administration. **Benjamins A. Hendy:** Data curation, Formal analysis, Writing - original draft. **Benjamin Zmistowski:** Data curation, Software, Formal analysis, Writing - original draft. **Robin S. Camp:** Data curation, Resources, Project administration. **Charles L. Getz:** Methodology, Investigation, Writing - review & editing, Supervision. **Joseph A. Abboud:** Methodology, Investigation, Writing - review & editing, Supervision. **Surena Namdari:** Methodology, Investigation, Writing - review & editing, Supervision.

Declaration of competing interest

Zheng Tan, MD - Declarations of interest: none
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