Factors Related to Pain in Patients With Retorn Rotator Cuffs

Early Postoperative Pain Predicts Pain at 12 Months Postoperatively

Yang-Soo Kim,* MD, PhD, Ki-Ho Kang,* MD, and Hyo-Jin Lee,*† MD, PhD

Investigation performed at the Department of Orthopedic Surgery, Seoul St Mary's Hospital, School of Medicine, The Catholic University of Korea, Seoul, Republic of Korea

Background: Retearing of a repaired rotator cuff leads to diverse symptoms, including pain, regardless of the degree of the tear, but the relationship between pain and retears is poorly understood.

Purpose: To determine which factors are correlated with shoulder pain in retears of a repaired rotator cuff.

Study Design: Case-control study; Level of evidence, 3.

Methods: We retrospectively reviewed a cohort of patients who were diagnosed as having a retear on magnetic resonance imaging after primary rotator cuff repair. The primary outcome variable of interest was the visual analog scale (VAS) for pain score at 12-month and final follow-up (mean, 25.2 months). We evaluated the relationship of pain at 12-month and final follow-up with preoperative patient factors (age, sex, and underlying conditions), preoperative range of motion, and preoperative pain; postoperative pain at 3 and 6 months; and perioperative conditions (tear extent, tear size, accompanying lesions, and procedures other than rotator cuff repair).

Results: A total of 48 patients were reviewed. The VAS score at 3 months postoperatively showed a positive correlation with the VAS score at 12 months postoperatively ($\rho = 0.537$; $P < .001$) and at final follow-up ($\rho = 0.537$; $P < .001$). Univariate and multivariate regression analyses revealed that the VAS score at 3 months postoperatively ($P = .0001$ and $P = .0017$, respectively), hypertension ($P = .0108$ and $P = .0073$, respectively), and late detection of the retear ($P = .0091$ and $P = .0208$, respectively) were significant predictors of pain at 12 months postoperatively.

Conclusion: The presence of pain in the early postoperative period, underlying hypertension, and late detection of the retear were related to pain severity in patients 12 months after rotator cuff surgery.

Keywords: rotator cuff; retear; pain

A rotator cuff tear is a common disease that often affects daily life. In recent years, because of the remarkable development in diagnosis and treatment, the condition is rather easily approached and managed, especially considering the available surgical treatment methods. However, despite the advances in every modality, a retear after rotator cuff repair has been a concern for a long time.[2,15,29,32] Notably, the incidence of retears has been reported to be up to 35% for small tears[11,14,19,22,33] and higher in the case of larger or multiple tendon involvement.[4,10] Retears of the rotator cuff cannot be completely prevented because of a variety of factors, which include continued tendon degeneration and tension at the repair site.

Despite this relatively high retear rate, not all cases of retorn tendons necessarily end up undergoing additional procedures for the restoration of tendon integrity. It is clear that successful treatment of rotator cuff tears and the

†Address correspondence to Hyo-Jin Lee, MD, PhD, Department of Orthopedic Surgery, Seoul St Mary's Hospital, School of Medicine, The Catholic University of Korea, 505 Banpo-dong, Seocho-gu, Seoul 137-701, Republic of Korea (email: hyojin1229@gmail.com).

*Department of Orthopedic Surgery, Seoul St Mary's Hospital, School of Medicine, The Catholic University of Korea, Seoul, Republic of Korea.

Final revision submitted March 5, 2020; accepted March 17, 2020.

The authors have declared that there are no conflicts of interest in the authorship and publication of this contribution. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from Seoul St Mary's Hospital, School of Medicine, The Catholic University of Korea (No. KC17OESI0118).

The Orthopaedic Journal of Sports Medicine, 8(9), 2325967120947414
DOI: 10.1177/2325967120947414

presence of good tendon integrity are associated with superior functional outcomes. However, a lack of pain does not necessarily depend on integrity of the repaired tendon or constitute a good prognosis of the disease. In fact, the overall clinical outcomes of rotator cuff repair have often been reported to be satisfactory, despite the high retear rate.[1,3,10,14] There are some symptom-free patients in whom a retear of the rotator cuff is found by chance during a regular postoperative evaluation.

Clinically, there is no definitive indication for surgical repair of rotator cuff retears, and surgeons tend to rely on their experience in managing patients with retears. Among many symptoms caused by a retorn rotator cuff, functional disability and pain are primary concerns that induce patients to return for a re-evaluation. Pain caused by mechanical alterations within the joint and inflammation of the retorn rotator cuff usually requires further treatment rather than mere observation.

Pain severity in patients with retears can be an important parameter for decision-making, but there is not much demonstrated in the literature directly related to evaluating pain in the setting of rotator cuff retears after arthroscopic fixation. The objective of this research was to determine if there are modifiable and nonmodifiable factors that are related to pain severity in the setting of rotator cuff retears after fixation. The primary outcome variable of interest was the visual analog scale (VAS) for pain score (0 = no pain and 10 = most severe pain) at 12 months postoperatively and at final follow-up among patients who sustained a retear after primary rotator cuff repair.

METHODS

This study was approved by our hospital's institutional review board. We reviewed 472 patients who were diagnosed with either a partial- or full-thickness tear of the supraspinatus tendon and underwent arthroscopic rotator cuff repair between March 2010 and June 2014. Preoperative rotator cuff lesions were confirmed by magnetic resonance imaging (MRI), performed using a 3-T open-type scanner (Magnetom Verio; Siemens), before surgery and visual inspection at the time of the arthroscopic procedure. Oblique coronal, oblique sagittal, and axial T2-weighted spin echo MRI scans (repetition time and echo time of 0.4000 and 60-70 milliseconds, respectively) were acquired for structural and qualitative assessments of the torn rotator cuff. All the patients were recommended to undergo postoperative MRI at 3 and 12 months after surgery. Among the reviewed patients, 157 patients underwent follow-up MRI at both 3 and 12 months postoperatively.

Among these 157 patients, 48 were identified as having sustained a rotator cuff retear after arthroscopic repair and were enrolled in this study. Repaired rotator cuff integrity was evaluated using the Sugaya classification.[31] Sugaya type IV and V tears were considered to be retears.

TABLE 1
Descriptive Data and Analyzed Factors[a]

Variable	Value
Preoperative patient characteristics	
Mean age (range), y	64.90 (55-73)
Sex, male/female	21/27
Underlying diseases	
Diabetes mellitus	6
Hypertension	14
Thyroid problems	3
Mean ROM	
Forward flexion, deg	139.48
External rotation at abduction, deg	80.21
External rotation at side, deg	83.75
Internal rotation[b]	T9
Mean VAS for pain scores	
Preoperatively	5.16
3 mo postoperatively	3.06
6 mo postoperatively	1.71
12 mo postoperatively	1.48
Final follow-up	0.85
Perioperative characteristics	
Full-/partial-thickness tear	48/0
Mean initial tear size, retraction/anteroposterior, cm	2.73/1.53
Repair technique	
Single row	19
Suture bridge	29
Footprint coverage	
Complete repair	32
Partial repair	16
Accompanying procedures	
Subscapularis repair	17
Capsulectomy	1
Biceps tenotomy/tenodesis	32
Mean retear size, retraction/anteroposterior, mm	30.22/14.47

[a]Data are shown as No. unless otherwise indicated. ROM, range of motion; VAS, visual analog scale.
[b]Internal rotation, measured in the sedentary position, was evaluated by using the tip of the thumb to reach the vertebral level.

Clinical Assessment

Factors that were thought to be related to pain in patients with retears were categorized into 3 groups: preoperative patient characteristics, VAS for pain scores, and perioperative characteristics and findings (Table 1). Preoperative factors included age, sex, and the existence of underlying conditions (hypertension, diabetes mellitus, or thyroid problems) as well as range of motion (ROM). A condition was considered to be underlying if it was being treated or managed after a diagnostic confirmation but not if it was in a controlled state without treatment. Preoperative ROM included forward flexion, external rotation at the side, external rotation at 90° of abduction, and internal rotation. VAS for pain scores were measured both preoperatively and at 3, 6, and 12 months postoperatively, and final follow-up. Regarding perioperative conditions, the extent of the tear (full- vs partial-thickness) and tear size were confirmed using MRI and during the initial arthroscopic procedure.

Surgical Procedure

Per surgeon preference, suture bridge techniques were performed in small- to medium-sized tears, while in the case of tears larger than medium size, single-row repair including Mason-Allen sutures was preferred. Tear size was classified on the basis of greatest dimension as either small (<1 cm) or medium (1-3 cm).[6] Footprint coverage (complete vs partial repair) of the repaired rotator cuff was reviewed. The tear was noted as completely repaired if the torn supraspinatus tendon was restored to its anatomic footprint and was noted as partially repaired if the tendon could not be restored to the footprint because of degeneration or retraction. In case there was a subscapularis lesion exceeding grade III according to the Lafosse classification,[21] repair was performed. Also, symptomatic long head of the biceps tendons with apparent lesions, such as partial ruptures or instability, were either tenotomized or tenodesed depending on patient age. Patients older than 60 years underwent tenotomy, and tenodesis was performed for those younger than 60 years. In patients with shoulder stiffness (ie, forward flexion <100° [maximum is 150°; forward flexion is glenohumeral motion without scapulohumeral rhythm[16]], external rotation <45°, or internal rotation of the back at a level lower than the first lumbar spine), anterior and inferior capsulectomy were simultaneously completed during the process of rotator cuff repair.[18] As postoperative MRI was performed twice, at 3 and 12 months after the initial surgical procedure, the detection time of the retear was also evaluated. Retears were evaluated using the Sugaya classification and were also based on the retear pattern.[5]

Rehabilitation Protocol

Standardized rehabilitation protocols were applied to all the patients who underwent arthroscopic rotator cuff repair. An abduction brace was worn for 4 weeks after surgery. Pulley exercises were prescribed to increase forward flexion after 4 postoperative weeks. When passive shoulder ROM was restored to 90%, isometric exercises in all planes were recommended. TheraBand (TheraBand, Akron, OH) exercises, strengthening exercises for the muscles to stabilize the scapula, and advanced muscle strengthening exercises were taught. All listed procedures were recommended until the final follow-up visit. No limit was imposed on the use of the shoulder within a tolerable range. The rehabilitation protocol was followed by the patients under monthly supervision.

Statistical Analysis

To evaluate the association between the VAS for pain score and listed factors, univariate and multivariate linear regression were performed. The VAS scores at 12 months postoperatively and at final follow-up were established as dependent variables, and independent variables included the other factors mentioned earlier. The level of significance was set at $P < .05$. The Pearson correlation coefficient (ρ) was used to determine the relationship between VAS scores at 12 months postoperatively and at final follow-up and evaluated factors.

RESULTS

Patient Cohort

Patient characteristics are listed in Table 1. The participant age range was from 55 to 73 years, and the male-to-female ratio was 21:27. The mean final follow-up was 25.2 months. The mean tear size before initial surgery was medium. The mean size of the retear was greater than the initial tear size, but there was an overall gradual reduction of pain postoperatively.

Correlation Evaluation

The VAS score at 12 months postoperatively showed a positive correlation with VAS scores at both 3 months ($\rho = 0.537$; $P < .001$) and 6 months ($\rho = 0.392$; $P = .008$) postoperatively. Also, the later the retear was identified on MRI scan (12 months postoperatively), meaning that the retear occurred at least 3 months after surgery, the higher the degree of pain perceived at 12 months after surgery ($\rho = 0.384$; $P = .009$). The VAS score at final follow-up showed a positive correlation with the VAS score at 3 months postoperatively ($\rho = 0.537$; $P < .001$).

Univariate regression analysis revealed that factors that were related to the VAS score at 12 months postoperatively were VAS scores at 3 months ($P < .001$) and 6 months ($P = .0077$) postoperatively as well as hypertension ($P = .0108$). Also, late detection of the retear ($P = .0091$) was a factor related to the VAS score at 12 months postoperatively (Table 2). The VAS score at 3 months postoperatively ($P = .0017$), hypertension ($P = .0073$), and late detection of the retear ($P = .0208$) were the factors related to the VAS score at 12 months postoperatively according to multivariate linear regression analysis (Table 3).

In the case of the VAS score at final follow-up, the VAS score at 3 months postoperatively ($P < .001$) was the sole factor that showed a positive correlation. Univariate regression analysis showed that the VAS score at 3 months postoperatively was the sole significant factor that affected the VAS score at final follow-up (Table 4).

DISCUSSION

The results of our study demonstrated that pain during the early postoperative period, time until the occurrence of a retear, and existence of hypertension was correlated with the severity of pain in patients with a retorn rotator cuff. The more pain that patients perceived during the early postoperative period until 6 months after surgery, the higher the degree of pain at a point at least 1 year after surgery. Also, late detection of the retear, which can be interpreted as the occurrence of a retear at least 3 months after primary repair, was related to pain at 12 months after the initial rotator cuff repair.

TABLE 2
Univariate Analysis of the Relationship Between the VAS for Pain Score at 12 Months Postoperatively and Associated Factors[a]

Variable	Estimate	Standard Error	*t* Value	*P* Value
Sex	–0.0500	0.6222	–0.08	.9363
Underlying disease				
Diabetes mellitus	1.0641	0.8950	1.19	.2410
Hypertension	1.6498	0.6187	2.67	.0108[b]
Thyroid problems	0.0952	1.2394	0.08	.9391
Preoperative ROM				
Flexion	0.0195	0.0210	0.93	.3587
External rotation at 90°	0.0439	0.0221	1.99	.0527
External rotation at abduction	0.0441	0.0255	1.73	.0906
Internal rotation	0.0354	0.0217	0.95	.0858
VAS for pain score				
Preoperatively	–0.0096	0.1423	–0.07	.9463
3 mo postoperatively	0.4969	0.1191	4.17	.0001[b]
6 mo postoperatively	0.4637	0.1659	2.80	.0077[b]
Retear type	–0.6970	0.7223	–0.96	.3401
Retear classification (Sugaya)	0.5926	0.6246	0.95	.3481
Retear size				
Retraction	0.0408	0.0290	1.41	.1669
Anterior-posterior	0.0337	0.0313	1.08	.2882
Retear detection period	0.1683	0.0616	2.73	.0091[b]
Repair technique	–0.7395	0.6277	–1.18	.2452
Footprint coverage	0.4667	0.6520	0.72	.4780
Accompanying procedures				
Capsulectomy	–1.6136	2.0830	–0.77	.4428
Subscapularis repair	0.8676	0.6238	1.39	.1714
Biceps tenotomy	–0.4286	0.8709	–0.49	.6253
Biceps tenodesis	1.3214	0.9034	1.46	.1512

[a]ROM, range of motion; VAS, visual analog scale.
[b]$P < 0.05$ value with statistical significance.

TABLE 3
Multivariate Analysis of the Relationship Between the VAS for Pain Score at 12 Months Postoperatively and Associated Factors[a]

Variable	Estimate	Standard Error	*t* Value	*P*
Retear detection period	0.1167	0.0484	2.41	.0208[b]
VAS for pain score				
3 mo postoperatively	0.3895	0.1152	3.38	.0017[b]
6 mo postoperatively	0.1078	0.1571	0.69	.4967
Hypertension	1.3821	0.4877	2.83	.0073[b]

[a]VAS, visual analog scale.

There are a few reasons why pain was selected as the sole outcome parameter of this study. Pain is an important factor that compels patients to seek treatment for rotator cuff tears, along with functional disability. Also, pain and subjective functional deficits are important factors that influence a surgeon's decision to continue with treatment in cases of retearing.[24] Lastly, as most of the functional outcome measures include a pain-related questionnaire, analyzing pain severity can be a good and brief way to determine patients' overall satisfaction after rotator cuff repair.

For many orthopaedic diseases, pain is closely related to disease severity, and pain is also a good parameter for the determination of treatment effects.[20,25,28] Several studies have previously tried to evaluate the factors related to pain severity in patients with rotator cuff tears. However, when it comes to rotator cuff tears, pain is not always correlated with disease severity or tear size and vice versa. In fact, patients with partial-thickness rotator cuff tears showed more pain than did those with full-thickness tears.[8,9,12,35] Rotator cuff tear size and fatty degeneration are known to be significant factors that affect healing of the tendon, but these did not show a direct proportional association with pain severity.[7,26,34] A cross-sectional study by Harris et al[13] revealed that female sex, high education, and preserved shoulder strength were significantly related to less pain provocation in rotator cuff tears. Also, a separate study[7] identified increased comorbidities, lower education level, and race as significant factors associated with pain in rotator cuff tears.

To the best of our knowledge, there has only been a single study[17] that has evaluated factors affecting patient satisfaction and functional outcomes in recurrent rotator cuff tears. That study concluded that younger age, workers'

TABLE 4
Univariate Analysis of the Relationship Between the VAS for Pain Score at Final Follow-up and Associated Factors[a]

Variable	Estimate	Standard Error	*t* Value	*P* Value
Sex	0.3400	0.4251	0.80	.4283
Underlying disease				
Diabetes mellitus	0.2949	0.6244	0.47	.6392
Hypertension	–0.0783	0.4595	–0.17	.8654
Thyroid problems	–0.2619	0.8522	–0.31	.7601
Preoperative ROM				
Flexion	0.0164	0.0144	1.14	.2623
External rotation at 90°	0.0271	0.0153	1.77	.0844
External rotation at abduction	0.0263	0.0177	1.49	.1435
Internal rotation	0.0244	0.0357	1.28	.0982
VAS for pain score				
Preoperatively	0.1187	0.0969	1.22	.2275
3 mo postoperatively	0.3424	0.0820	4.18	.0001[b]
6 mo postoperatively	0.0757	0.1236	0.61	.5431
Retear type	–0.3030	0.4877	–0.62	.5378
Retear classification (Sugaya)	0.4074	0.4300	0.95	.3487
Retear size				
Retraction	0.0180	0.0202	0.89	.3787
Anterior-posterior	0.0267	0.0215	1.25	.2196
Retear detection period	–0.0037	0.0460	–0.08	.9357
Repair technique	–0.1408	0.4384	–0.32	.7497
Footprint coverage	–0.1333	0.4510	–0.30	.7689
Accompanying procedures				
Capsulectomy	–0.9318	1.4367	–0.65	.5201
Subscapularis repair	0.2374	0.4374	0.54	.5902
Biceps tenotomy	0.2460	0.6173	0.40	.6923
Biceps tenodesis	0.6071	0.6404	0.95	.3487

[a]ROM, range of motion; VAS, visual analog scale.

compensation claim, and lower education level were significantly related to poorer functional outcomes in retears. It is interesting, however, that many of these factors related to pain severity in rotator cuff tears are external factors, such as age, sex, or socioeconomic aspects, which belong to the category of nonanatomic factors and are mostly uncontrollable. There were a few factors of note that are directly related to the condition of the torn tendon itself.

In this study, patients' pain levels at 3 and 6 months after surgery were significant predictors of their pain at 12 months after surgery. Also, pain at 3 months postoperatively had a positive relationship with pain at final follow-up, which was around 2 years after the initial surgical procedure. As pain in the early postoperative period seems to remain beyond the postoperative 1-year point in patients with retears, intensive pain control may be beneficial in patients with symptomatic retears in case additional surgical treatment methods are not available. Still, there is no doubt that superior results are likely without retears, and the ideal management of pain after rotator cuff repair is to prevent retears.

The relationship between pain and hypertension is potentially of great interest but is not clearly understood. Hypertension has been shown to be inversely associated with acute pain by the increase in pain threshold.[30] However, the relationship between hypertension and pain sensitivity is completely reversed in the case of chronic pain, with those affected showing an increased sensitivity to acute pain and a higher intensity of chronic pain.[23,27] In our study, the existence of hypertension had a proportional relationship with pain at 12 months postoperatively in patients with retears. This can be interpreted as a suggestion that pain in patients with retears is not acute but rather chronic and may be connected to pain in the early postoperative period (ie, at 3 months). However, the results of this study cannot explain the benefits of controlling hypertension in alleviating pain in patients with retears.

Regarding the results of this study, setting the nonanatomic, uncontrollable factors aside, active pain control may help to relieve symptoms in patients with retears after 1 year. Also, revision surgery should be considered in patients in pain with the early detection of retears rather than allowing them to continue having persisting pain.

There are some limitations to the present study. First, the VAS for pain, which was used as the sole barometer of this study, is a 1-dimensional (linear) scale that may not have accurately reflected patients' outcomes. It would have been more helpful to use clinical assessments, such as the Constant score, in addition to the VAS for pain or MRI. Second, as the results were derived from patients with retears, pain factors or suggestions made to reduce pain cannot be applied to patients experiencing pain

without a retear. Also, pain from the early postoperative period may persist, regardless of the condition of the repaired tendon. Third, the small sample size of patients with retears may have affected our ability to detect pain factors in these patients. A larger sample size may have decreased the chance of type II errors by increasing the power of the study. Some factors with relatively low *P* values including preoperative ROM, repair of the subscapularis, and biceps tenodesis might have been overlooked because of the small sample size. Fourth, as MRI was performed twice, at 3 and 12 months postoperatively, we were not able to notice the exact time of retear occurrence. Also, the interpretation of MRI scans in the early postoperative period is unreliable. Still, no other diagnostic tool can provide more exact information than MRI. Fifth, the clinical results of rotator cuff repair can be affected by the quality of postoperative management including rehabilitation. In this study, the same standardized home-based rehabilitation protocol was applied to the enrolled patients, but individual compliance with the home-based program was not reflected. Meanwhile, customized rehabilitation depending on disease severity or accompanying lesions can affect not only pain perception, but also final results including the retear rate. Sixth, homogenization of the repair method was not achieved. There were 2 different surgical methods used for rotator cuff repair based on surgeon preference according to the size of the tear. Seventh, this level 4 study only showed correlations and cannot explain a cause-effect relationship between various factors and pain.

In conclusion, the presence of pain in the early postoperative period, hypertension, or late detection of the retear were related to pain severity in patients with retears at least during the first year after surgery.

REFERENCES

1. Anderson K, Boothby M, Aschenbrener D, van Holsbeeck M. Outcome and structural integrity after arthroscopic rotator cuff repair using 2 rows of fixation: minimum 2-year follow-up. *Am J Sports Med*. 2006;34(12):1899-1905.
2. Bailey JR, Kim C, Alentorn-Geli E, et al. Rotator cuff matrix augmentation and interposition: a systematic review and meta-analysis. *Am J Sports Med*. 2019;47(6):1496-1506.
3. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? *J Bone Joint Surg Am*. 2005;87(6):1229-1240.
4. Calvert PT, Packer NP, Stoker DJ, Bayley JI, Kessel L. Arthrography of the shoulder after operative repair of the torn rotator cuff. *J Bone Joint Surg Br*. 1986;68(1):147-150.
5. Cho NS, Yi JW, Lee BG, Rhee YG. Retear patterns after arthroscopic rotator cuff repair: single-row versus suture bridge technique. *Am J Sports Med*. 2010;38(4):664-671.
6. DeOrio JK, Cofield RH. Results of a second attempt at surgical repair of a failed initial rotator-cuff repair. *J Bone Joint Surg Am*. 1984;66(4):563-567.
7. Dunn WR, Kuhn JE, Sanders R, et al. Symptoms of pain do not correlate with rotator cuff tear severity: a cross-sectional study of 393 patients with a symptomatic atraumatic full-thickness rotator cuff tear. *J Bone Joint Surg Am*. 2014;96(10):793-800.
8. Fukuda H. Partial-thickness rotator cuff tears: a modern view on Codman's classic. *J Shoulder Elbow Surg*. 2000;9(2):163-168.
9. Fukuda H. The management of partial-thickness tears of the rotator cuff. *J Bone Joint Surg Br*. 2003;85(1):3-11.
10. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. *J Bone Joint Surg Am*. 2004;86(2):219-224.
11. Gazielly DF, Gleyze P, Montagnon C. Functional and anatomical results after rotator cuff repair. *Clin Orthop Relat Res*. 1994;304:43-53.
12. Gschwend N, Ivosevic-Radovanovic D, Patte D. Rotator cuff tear: relationship between clinical and anatomopathological findings. *Arch Orthop Trauma Surg*. 1988;107(1):7-15.
13. Harris JD, Pedroza A, Jones GL, Group MS. Predictors of pain and function in patients with symptomatic, atraumatic full-thickness rotator cuff tears: a time-zero analysis of a prospective patient cohort enrolled in a structured physical therapy program. *Am J Sports Med*. 2012;40(2):359-366.
14. Harryman DT II, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA III. Repairs of the rotator cuff: correlation of functional results with integrity of the cuff. *J Bone Joint Surg Am*. 1991;73(7):982-989.
15. Hein J, Reilly JM, Chae J, Maerz T, Anderson K. Retear rates after arthroscopic single-row, double-row, and suture bridge rotator cuff repair at a minimum of 1 year of imaging follow-up: a systematic review. *Arthroscopy*. 2015;31(11):2274-2281.
16. Inman V. Observations on the function of the shoulder joint. *J Bone Joint Surg*. 1944;26(1):1.
17. Kim HM, Caldwell JM, Buza JA, et al. Factors affecting satisfaction and shoulder function in patients with a recurrent rotator cuff tear. *J Bone Joint Surg Am*. 2014;96(2):106-112.
18. Kim YS, Lee HJ, Park IJ. Clinical outcomes do not support arthroscopic posterior capsular release in addition to anterior release for shoulder stiffness: a randomized controlled study. *Am J Sports Med*. 2014;42(5):1143-1149.
19. Knudsen HB, Gelineck J, Sojbjerg JO, Olsen BS, Johannsen HV, Sneppen O. Functional and magnetic resonance imaging evaluation after single-tendon rotator cuff reconstruction. *J Shoulder Elbow Surg*. 1999;8(3):242-246.
20. Kuroyanagi Y, Nagura T, Matsumoto H, Otani T, Toyama Y, Suda Y. Weight-bearing flexion angle correlates significantly with severity of knee osteoarthritis. *Knee*. 2009;16(5):371-374.
21. Lafosse L, Jost B, Reiland Y, Audebert S, Toussaint B, Gobezie R. Structural integrity and clinical outcomes after arthroscopic repair of isolated subscapularis tears. *J Bone Joint Surg Am*. 2007;89(6):1184-1193.
22. Liu SH. Arthroscopically-assisted rotator-cuff repair. *J Bone Joint Surg Br*. 1994;76(4):592-595.
23. Maixner W, Fillingim R, Kincaid S, Sigurdsson A, Harris MB. Relationship between pain sensitivity and resting arterial blood pressure in patients with painful temporomandibular disorders. *Psychosom Med*. 1997;59(5):503-511.
24. Montgomery SR, Petrigliano FA, Gamradt SC. Failed rotator cuff surgery, evaluation and decision making. *Clin Sports Med*. 2012;31(4):693-712.
25. Neogi T, Felson D, Niu J, et al. Association between radiographic features of knee osteoarthritis and pain: results from two cohort studies. *BMJ*. 2009;339:b2844.
26. Park JS, Park HJ, Kim SH, Oh JH. Prognostic factors affecting rotator cuff healing after arthroscopic repair in small to medium-sized tears. *Am J Sports Med*. 2015;43(10):2386-2392.
27. Sacco M, Meschi M, Regolisti G, et al. The relationship between blood pressure and pain. *J Clin Hypertens (Greenwich)*. 2013;15(8):600-605.
28. Sadosky AB, Bushmakin AG, Cappelleri JC, Lionberger DR. Relationship between patient-reported disease severity in osteoarthritis and self-reported pain, function and work productivity. *Arthritis Res Ther*. 2010;12(4):R162.

29. Shen C, Tang ZH, Hu JZ, Zou GY, Xiao RC. Incidence of retear with double-row versus single-row rotator cuff repair. *Orthopedics*. 2014; 37(11):e1006-e1013.
30. Sheps DS, Bragdon EE, Gray TF 3rd, Ballenger M, Usedom JE, Maixner W. Relation between systemic hypertension and pain perception. *Am J Cardiol*. 1992;70(16):3F-5F.
31. Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: single-row versus dual-row fixation. *Arthroscopy*. 2005;21(11):1307-1316.
32. Walsh MR, Nelson BJ, Braman JP, et al. Platelet-rich plasma in fibrin matrix to augment rotator cuff repair: a prospective, single-blinded, randomized study with 2-year follow-up. *J Shoulder Elbow Surg*. 2018;27(9):1553-1563.
33. Wulker N, Melzer C, Wirth CJ. Shoulder surgery for rotator cuff tears: ultrasonographic 3-year follow-up of 97 cases. *Acta Orthop Scand*. 1991;62(2):142-147.
34. Wylie JD, Suter T, Potter MQ, Granger EK, Tashjian RZ. Mental health has a stronger association with patient-reported shoulder pain and function than tear size in patients with full-thickness rotator cuff tears. *J Bone Joint Surg Am*. 2016;98(4):251-256.
35. Xu Y, Bonar F, Murrell GA. Neoinnervation in rotator cuff tendinopathy. *Sports Med Arthrosc Rev*. 2011;19(4):354-359.