Observational Study

Medicine®

OPEN

Discrimination between pain and contracture in limited passive motion patients with rotator cuff tear

A STROBE-compliant cross-sectional study

Seung-Hyun Yoon, MD, PhD[a], Doohyung Lee, MD, PhD[b,*], HongRi Li, MD[c], Heonju Kweon, MD[b], Jung Hwan Ahn, MD[d]

Abstract

Either pain or contracture may limit shoulder passive range of motion (PROM) in patients with rotator cuff disease, and an appropriate treatment may be determined according to its cause. If there is no change in PROM under general anesthesia, contracture, rather than pain, may be the underlying condition. Our goal was to devise a physical examination that would help discriminate between pain and contracture in limited PROM patients with rotator cuff tear.

This is a STROBE-compliant cross-sectional study. Patients with rotator cuff tears (N = 28) were scheduled for arthroscopic repair. The main outcome measure was PROM, including flexion, external rotation (ER), and abduction obtained by a blinded examiner before and after the induction of general anesthesia, and the abduction/ER ratio was calculated. In order to perform a subgroup analysis, patients were divided into 2 groups, one where abduction difference after the general anesthesia was 8°≤ (n = 22) and the other 8°> (n = 6).

Patients' average age (62.6 ± 7.2 years), symptom duration (13.0 ± 10.0 months), intensity of shoulder pain on a visual analog scale (4.8 ± 2.1), and Constant-Murley functional score (63.4 ± 8.9); the ratio of gender (male: female = 12:16); and the arthroscopic findings were recorded. According to the correlation analysis, the abduction/ER ratio before general anesthesia was correlated best with the change in PROM after general anesthesia (correlation coefficient –0.74, $P < .001$); the correlations for abduction and flexion were –0.69 and –0.57, respectively ($P < .001$ and .002, respectively). The age, gender, height, weight, duration of symptoms, trauma history, visual analog score for shoulder pain, Constant-Murley functional score, size of rotator cuff tear, and biceps pathology did not differ significantly between the 2 groups in the subgroup analysis ($P > .05$). The only significant difference between the 2 groups was in the synovitis status ($P = .04$).

Patients with greater abduction/ER ratio before anesthesia exhibited fewer PROM changes after anesthesia. The abduction/ER ratio was strongly and inversely correlated with PROM changes, allowing physicians to choose an appropriate treatment for limited PROM in patients with rotator cuff tears.

Abbreviations: ER = external rotation, PROM = passive range of motion.

Keywords: contracture, general anesthesia, range of motion, rotator cuff, shoulder pain

1. Introduction

Limited passive range of motion (PROM) of the shoulder is common in patients with rotator cuff tears; more than 40% of patients with full-thickness tears exhibit mild or moderate limitations.[1] There may be different reasons why a patient may have limited PROM in rotator cuff tears, but the most common ones include

(1) pain originating from secondary inflammation of the bursa and synovium (bursitis and synovitis) due to the rotator cuff tear[2,3] and
(2) contracture of the soft tissues around the glenohumeral joint after rotator cuff tears (secondary frozen shoulder).[4,5]

When inflammatory pain is the main cause, oral non-steroidal anti-inflammatory drugs or local corticosteroid injections are appropriate for treatment, but when contracture is present, physical therapy with stretching and flexibility exercises may be helpful.[6]

However, in real life, it is not easy to discriminate between the 2 symptoms (inflammatory pain and contracture). Although general anesthesia or blockage of the brachial plexus nerve eliminates pain during PROM measurement and allows

Editor: Saeed Ilbeigi.

This work was supported by the new faculty research fund of Ajou University School of Medicine.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

[a] Department of Physical Medicine and Rehabilitation, [b] Department of Orthopedic Surgery, [c] Department of Orthopedic Surgery, [d] Department of Emergency Medicine, Ajou University School of Medicine, Suwon, Republic of Korea.

[*] Correspondence: Doohyung Lee, Department of Orthopedic Surgery, Ajou University School of Medicine, Worldcup-ro 164, Yeongtong-gu, Suwon 16499, Republic of Korea (e-mail: doolunglee@gmail.com).

Copyright © 2020 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: Yoon SH, Lee D, Li H, Kweon H, Ahn JH. Discrimination between pain and contracture in limited passive motion patients with rotator cuff tear: a STROBE-compliant cross-sectional study. Medicine 2020;99:31(e21391).

Received: 1 May 2018 / Received in final form: 12 June 2020 / Accepted: 20 June 2020

http://dx.doi.org/10.1097/MD.0000000000021391

discrimination between pain and contracture during the diagnosis of limited PROM, such approaches may be difficult to perform in an outpatient clinic. If pain and contracture can be discriminated with a simple physical examination, it would help physicians make decisions on treatment guidelines.

The purpose of this study was to devise a simple physical examination to discriminate between inflammatory pain and contracture. For this purpose, we investigated the correlations among the PROM values of flexion, abduction, and external rotation (ER) before and after general anesthesia. The abduction/ER ratio proposed by Cyriax was also included to help discriminate between pain and contracture as underlying causes of limited PROM.[7–9] Our hypothesis was that the greater the abduction/ER ratio is before anesthesia, the less the change will be in PROM after anesthesia.

2. Methods

2.1. Study design and subjects

This was a single-center, cross-sectional study. The study was designed and data collected in a prospective manner. The sample size was determined using the abduction/ER ratio before anesthesia with a type I error of 0.05 and a power of 0.80, and 20 patients were required as a result. In general, only the primary end point is used in the sample size estimation.[10] Given our decision to use abduction/ER ratio as the primary end point, only the abduction/ER ratio, and no other PROM measurements (abduction, flexion, and ER), was used in the sample size. Considering the potential drop-out rate, the final total sample size was 28. From July 2012 to February 2013, we recruited 32 patients who required arthroscopy to treat rotator cuff tears. They were patients at the department of orthopedics of the Ajou University Hospital in Suwon, Republic of Korea.

The following inclusion criteria were applied:

(1) unilateral shoulder pain of more than 3 months' duration despite sufficient conservative treatments, such as subacromial injections or medications, including non-steroidal anti-inflammatory drugs;
(2) confirmation of rotator cuff tear via magnetic resonance imaging, and
(3) the presence of a rotator cuff tear with positive Neer and Hawkins signs.

We excluded 4 patients who

(1) had undergone prior shoulder surgery (n = 2);
(2) exhibited arthritis of the glenohumeral joint (n = 1);
(3) had a systemic inflammatory joint disease, such as rheumatoid arthritis (n = 1); or
(4) exhibited muscle-originated pain, such as muscle tightness and myofascial pain syndrome.

After screening with inclusion and exclusion criteria, 28 patients were finally enrolled in this study in the order of their arrival to the outpatient clinic (Fig. 1).

All procedures were approved by the Institutional Review Board of the hospital. Written informed consent was obtained from all subjects. Data on symptom duration, history of previous trauma, pain (as assessed on a visual analog scale), and physical characteristics were collected and evaluated. When recording histories of previous trauma, we considered injuries caused by slipping, heavy lifting at work, or low-energy impacts to be "minor" and injuries sustained in traffic accidents, falls from heights, or high-energy impacts to be "major." All subjects underwent thorough physical examinations, including an evaluation of Neer and Hawkins impingement tests[11] as well as empty can and muscle strength tests. The Constant-Murley functional score,[12] consisting of four sub-scales, namely, pain (15 points), activities of daily living (20 points), strength (25 points), and range of motion (40 points), was also recorded.

During arthroscopy, the rotator cuff and the surrounding bursa, ligaments, and synovium were evaluated. The size of the rotator cuff tear was classified as partial, small (< 1 cm), medium (1 to 3 cm), and large (> 3 cm).[13] We recorded the arthroscopic status of synovial inflammation (synovitis) to evaluate the severity of soft tissue inflammation around the rotator cuff. We defined synovitis as an opaque villus formation accompanied by proliferation or hypervascularization, and categorized the synovitis depending on its focal or global distribution.[14]

2.2. PROM measurements before and after the induction of general anesthesia

Before arthroscopic surgery, authors blinded to clinical information measured the shoulder PROM at the outpatient clinic using a long-arm goniometer (Sammons Preston, Jackson, MI). PROM in flexion, abduction, and ER were recorded with the patient in a supine position. ER was measured with upper arms at the sides and elbows bent 90 degrees. The next day, in the operation room, general anesthesia was induced and maintained with remifentanil (target blood concentration 3.5–4.5 ng/mL) and propofol (target blood concentration 3.0–4.5 μg/mL) in 50% (v/v) air. All the patients were given rocuronium (0.6 mg/kg) to facilitate tracheal intubation. Blood concentrations of propofol and remifentanil were controlled using the Orchestra system (Fresenius Kabi, Bad Homburg, Germany). After the induction of general anesthesia, PROM measurements were repeated. The abduction/ER ratio before and after general anesthesia were calculated.

2.3. Subgroup analysis

Subgroup analysis was performed by dividing the patients into 2 groups, one where difference in the abduction angle after general anesthesia was 8°≤ (group I, markedly increased PROM after general anesthesia) and the other group where difference was 8°> (group II, minimally increased PROM after general anesthesia).

2.4. Statistical analysis

The Mann-Whitney *U* test was used to compare continuous data, and Fisher exact test was performed to compare categorical data between the groups. To adjust the *P* value for repeated measurements of PROM, Bonferroni method was applied. Spearman rho was employed to evaluate the correlation between PROM values obtained before and after the induction of anesthesia; the change in abduction before and after the induction of anesthesia was selected as a variable that represents the change of PROM before and after the anesthesia. To eliminate the source of bias, we used the correlation analysis with age and gender as confounders. The evaluator who collected the data was blinded. Sensitivity analysis was not conducted because it was not applicable. Significance was accepted for *P* values of $< .05$. All statistical analyses were performed using SPSS statistical software, version 22 (IBM Inc., Armonk, NY).

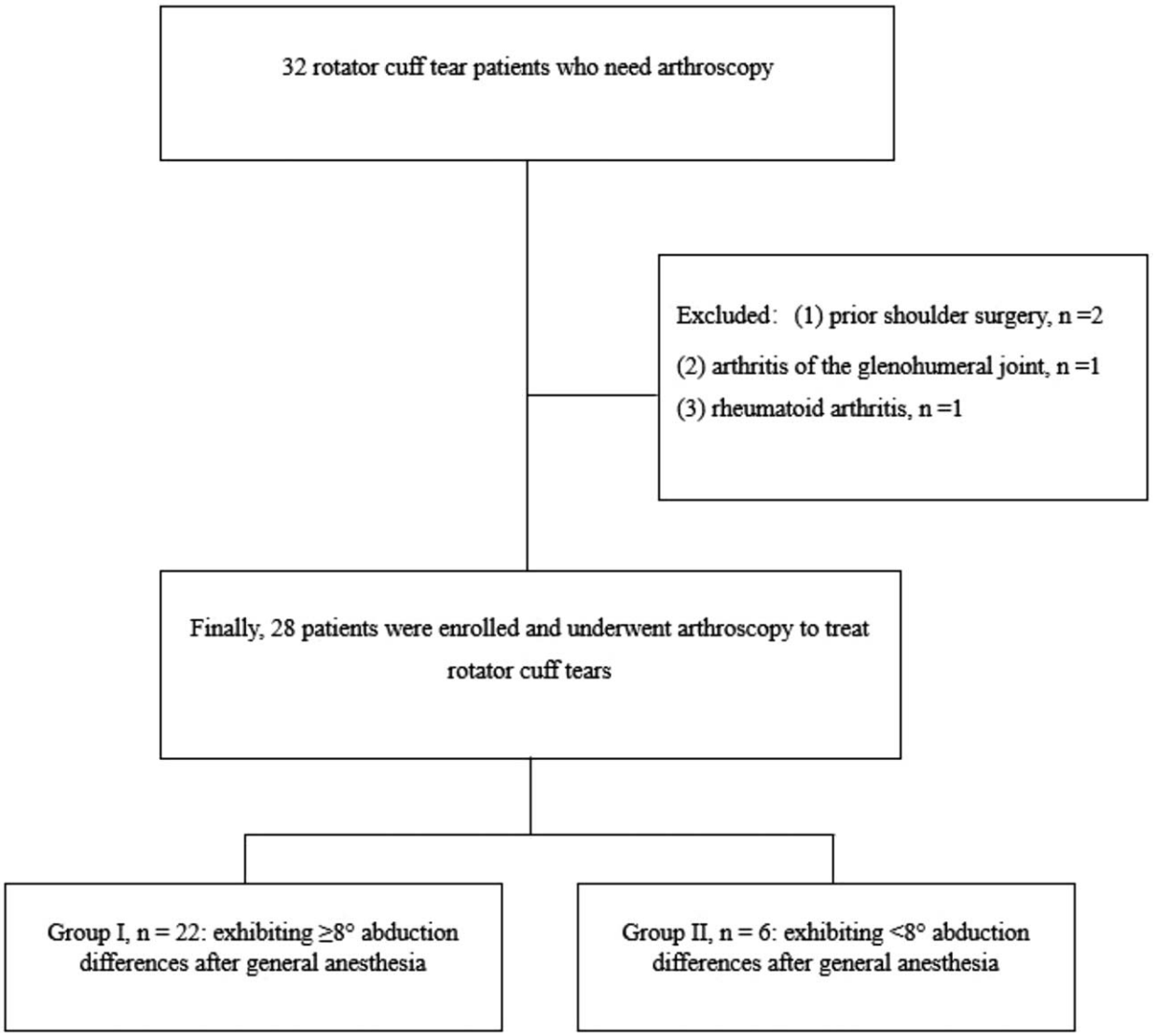

Figure 1. Flow chart of subject inclusion.

3. Results

Demographic characteristics of all 28 patients included in this study are presented in Table 1; the average age was 62.6 ± 7.2 years, the ratio of male to female was 12:16, the duration of symptoms was 13.0 ± 10.0 months, the intensity of shoulder pain assessed with a visual analog scale was 4.8 ± 2.1, and the average Constant-Murley functional score was 63.4 ± 8.9. All of the patients were Korean. We collected all variables in a prospective manner, with no missing data for quantitative variables. The confounder-adjusted correlation coefficients (gender and age as confounders) between the PROM values obtained before and after induction of anesthesia were –0.74 for the abduction/ER ratio ($P < .001$), –0.69 for abduction ($P < .001$), –0.57 for flexion ($P = .002$), and 0.37 for ER ($P = .06$); patients with a higher abduction/ER ratio and more flexion and abduction exhibited fewer PROM changes. This result supports our hypothesis that the greater the abduction/ER ratio before anesthesia, the less the change in PROM is afterwards.

Subgroup analysis data on age, gender, height, weight, trauma history, visual analog scale for shoulder pain and Constant-Murley functional scores, rotator cuff tear sizes, synovitis status, and biceps pathologies between the groups are presented in Table 1. The only significant difference between the 2 groups was in synovitis status ($P = .04$; Table 1 and Fig. 2). Table 2 shows the comparison of the PROM between the groups before anesthesia.

4. Discussion

Either pain or contracture may limit shoulder PROM in patients with rotator cuff tear, and appropriate treatment is determined by the cause. Through this study, we constructed a simple physical examination to facilitate discrimination between pain and contracture in limited PROM patients. Among flexion, abduction, ER, and abduction/ER ratio, the abduction/ER ratio showed the highest correlation in discriminating between the two symptoms, followed by abduction and flexion. Therefore, calculating this ratio in rotator cuff tear patients would help to easily find the proper cause of limited PROM.

We have suggested pain due to inflammation and contracture of the soft tissue around the glenohumeral joint as the two most

Table 1

Demographic data for patients.

	Total (N = 28)	Group I (n = 22)	Group II (n = 6)	*P*
Age (yrs)*	62.6 ± 7.2	62.2 ± 7.4	64.2 ± 6.8	.68†
Gender, *n* (%) male: female	12: 16 (42.9: 57.1)	9: 13 (40.9: 59.1)	3: 3 (50.0: 50.0)	.69‡
Height (cm) *	159.9 ± 9.0	160.3 ± 9.7	158.5 ± 6.3	.64†
Weight (kg) *	63.6 ± 11.9	63.8 ± 12.8	62.9 ± 8.5	1.00†
Duration of symptoms (mo)	13.0 ± 10.0	12.9 ± 10.5	13.2 ± 8.4	.72†
Trauma history, *n* (%) none: minor: major	14: 13: 1 (50.0: 46.4: 3.6)	10: 11: 1 (45.5: 50.0: 4.5)	4: 2: 0 (66.7: 33.3: 0)	.61‡
VAS for shoulder pain*	4.8 ± 2.1	4.8 ± 2.2	4.7 ± 2.4	.94†
Constant score*	63.4 ± 8.9	62.5 ± 9.3	66.8 ± 7.3	.31†
Arthroscopic findings				
Size of rotator cuff tear, *n* (%) partial: small: medium: large	4: 2: 8: 14 (14.3: 7.1: 28.6: 50.0)	4: 2: 7: 9 (18.2: 9.1: 31.8: 40.9)	0: 0: 1: 5 (0: 0: 16.7: 83.3)	.29‡
Synovitis status, *n* (%)	15: 9: 4	9: 9: 4	6: 0: 0	**.04**‡
normal: focal: global	(53.6: 32.1: 14.3)	(40.9: 40.9: 18.2)	(100: 0: 0)	
Biceps pathology, *n* (%) SLAP or substance tear	5 (17.9)	3 (13.6)	2 (33.3)	.30‡

VAS = visual analog scale, Constant score = Constant/Murley functional score, SLAP = superior labrum anterior to posterior.

* Values are expressed as means ± standard deviation.

† Mann–Whitney U–test for between-group comparison ($P < .05$).

‡ Fisher's exact test for between-group comparison ($P < .05$).

common causes of limited PROM; most pathologies related to limited PROM can be categorized into either one of the two causes. Other than that, non-inflammatory muscle pain that can be accompanied by a rotator cuff tear (eg, muscle tightness and myofascial pain syndrome) or degenerative arthritis may also be a cause of limited PROM.[4] However, we conducted physical and radiological examinations during the patient enrollment to exclude those patients whose major cause of limited PROM is muscle pain or degenerative arthritis, and included only those whose pain is due to the inflammation of soft tissue or contracture.

We performed a subgroup analysis by dividing the patients into 2 groups, one (group I, markedly increased PROM after general anesthesia) where the abduction difference after the general anesthesia was 8°≤ (group I, n = 22) and the other where the difference was 8°> (group II, minimally increased PROM after general anesthesia) (group II, n = 6). We selected the abduction measurement among other shoulder PROM because it is

(1) the most common motion that leads to the impingement of supraspinatus[15] and
(2) a motion that is commonly impacted in patients with frozen shoulders.[16]

Patients were divided into 2 groups at the 8-degree point because it is the minimal detectable change measurable using goniometry.[17]

In the subgroup analysis, we hypothesized that there would be severe inflammatory pain of the bursa and synovium in group I, which would lead to significant PROM changes before and after general anesthesia, while the main cause of the symptom in group II was more contracture than inflammation and would show minimal changes. To test our hypothesis, we used arthroscopy to

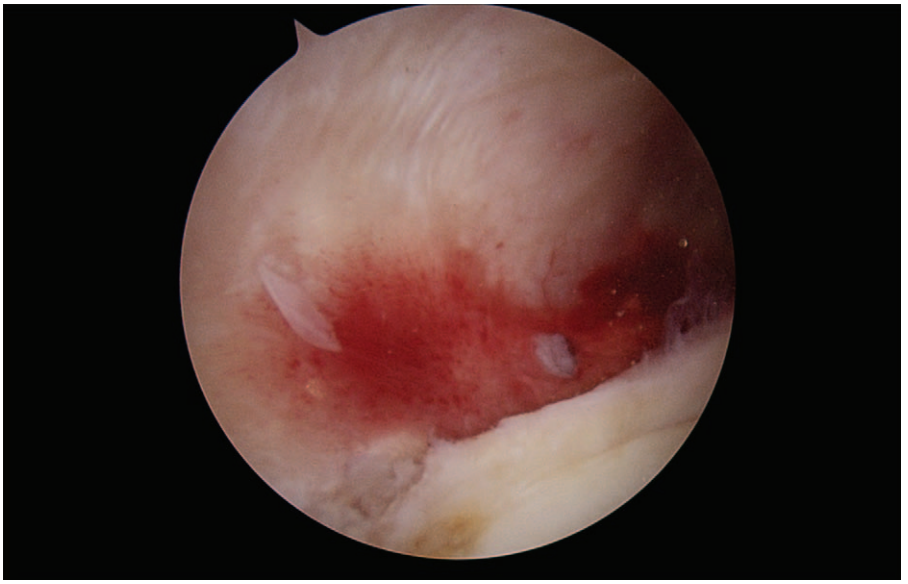

Figure 2. Arthroscopic image of synovitis in the posterosuperior area, viewed from the anterior portal.

Table 2

PROMs before anesthesia comparing group I and II.

	Group I (n = 22)	Group II (n = 6)	P*
Abduction/ER ratio before anesthesia	1.7 ± 0.4	3.2 ± 1.2	<.001
Flexion before anesthesia (°)	140.7 ± 14.9	155.7 ± 19.8	.024
Abduction before anesthesia (°)	105.4 ± 20.0	141.2 ± 29.4	.002
ER before anesthesia (°)	64.4 ± 10.9	49.3 ± 18.3	.048
Change of PROM after anesthesia	46.4 ± 17.3	8.3 ± 6.9	<.001

ER = external rotation, PROM = passive range of motion.
Values are expressed as means ± standard deviation.
* Repeated measurement and Bonferroni's method for between-group comparison.
P value was corrected by Bonferroni's method.

evaluate the severity of synovitis in the two groups. The result showed that while there was no difference between the 2 groups in age, size of rotator cuff tear, visual analog scale for shoulder pain, Constant-Murley functional scores, and biceps pathology, a significant difference was found between the two groups in glenohumeral joint (focal and global) synovitis (59.1% vs 0%), proving that our hypothesis is correct.

We added the abduction/ER ratio as well as flexion, abduction, and ER to the physical examination to discriminate between pain and contracture as the cause of limited PROM. We considered abduction and ER together from the concept of a "capsular" or "non-capsular" pattern in the pathology of the shoulder, as proposed by Cyriax.[7,8] A typical "capsular" pattern is present in the joint when its capsule is affected. This pattern could be the result of the joint reacting with a muscle spasm, which leads to capsular constriction. Each joint, including the shoulder, has a unique pattern of limitation. In the case of impingement syndrome, the abduction motion is restricted to a great extent, but the ER plane shows little limitation. Likewise, if inflammation of the soft tissue is a major reason for limited PROM, then the abduction/ER ratio will decrease.

There are several strengths to our study. First, to our knowledge, this is the first study to quantify the PROM changes of patients with rotator cuff tears before and after general anesthesia. Second, this study was performed in a prospective manner. Although some studies have evaluated the clinical result of limited PROM in rotator cuff tear, studies have yet to investigate the underlying causes. Third, with the result of this study, we were able to propose a simple test to discriminate the cause of limited PROM in patients with rotator cuff tear. This test will in turn help physicians select an effective treatment methodology. Furthermore, this study has minimized any potential bias by performing a correlation analysis with age and gender as confounders. Lastly, the strength of this study lies in the fact that the evaluator who collected the data was blinded.

However, there are also several limitations to our study. First, whereas most shoulder disorders studies that require measurements of PROM include flexion, abduction, internal rotation, and ER measurements, we were not able to include the measurement of internal rotation in our study. Studies on rotator cuff tear usually measure the degree of internal rotation with a hand- behind-the- back motion. This can be done with patients in standing positions at outpatient clinics. However, this measurement was not feasible in patients under general anesthesia who could not straighten their back. Additionally, while some studies measure internal rotation after 90-degree shoulder abduction,[18] many of the patients in our study expressed difficulty with the positioning due to pain. Second, the total number of patients included in our study was relatively small and the patients were not divided into 2 groups in a well-balanced manner. This may have some limitation in generalizing our study result. Third, it may be difficult to generalize the measurements since only one evaluator measured all the PROMs. However, even though inter- and intra-tester reliabilities were not evaluated, the long-arm goniometer has frequently been used to measure shoulder PROM and has shown high intra- (0.87–0.99) and inter-tester (0.84–0.90) reliability.[19] Finally, the result of this study strongly indicates that the abduction/ER ratio is related to pain and contracture; however, the information on the correlation between the two is not yet sufficient enough to be used as a detailed treatment guideline.

In conclusion, upon re-examination under general anesthesia, limited PROM measurements in patients with rotator cuff tears were overestimated by pain. Patients with higher abduction/ER ratio and more flexion and abduction exhibited fewer PROM changes. The abduction/ER ratio was strongly and inversely correlated with PROM changes, allowing physicians to choose an appropriate treatment for limited PROM in patients with rotator cuff tears. In the future, further research will be needed to improve generalizability by increasing the number of participants and to quantitatively suggest the relationship between abduction/ER ratio and severity of pain and contracture.

Acknowledgments

The authors thank Aeree Park, MA, for translation of the article and Hyun Young Lee, PhD, for the statistical support.

Author contributions

Conceptualization: Seung-Hyun Yoon.
Data curation: Doohyung Lee, Heonju Kweon.
Methodology: Seung-Hyun Yoon, HongRi Li, Jung Hwan Ahn.
Supervision: Seung-Hyun Yoon, HongRi Li, Heonju Kweon.
Visualization: Heonju Kweon.
Writing – original draft: Seung-Hyun Yoon, Doohyung Lee.
Writing – review & editing: Seung-Hyun Yoon, HongRi Li, Heonju Kweon.

References

[1] Tauro JC. Stiffness and rotator cuff tears: incidence, arthroscopic findings, and treatment results. Arthroscopy 2006;22:581–6.
[2] Bigliani LU1, Levine WN. Subacromial impingement syndrome. J Bone Joint Surg Am 1997;79:1854–68.
[3] Chillemi C, Petrozza V, Franceschini V, et al. The role of tendon and subacromial bursa in rotator cuff tear pain: a clinical and histopathological study. Knee Surg Sports Traumatol Arthrosc 2016;24:3779–86.

[4] Itoi E, Arce G, Bain GI, et al. Shoulder stiffness: current concepts and concerns. Arthroscopy 2016;32:1402–14.
[5] Kim YY, Chung BM, Kim WT, et al. MRI findings predictive of shoulder stiffness in patients with full-thickness rotator cuff tears. Am J Roentgenol 2020;18:1–6.
[6] Sun Y, Lu S, Zhang P, et al. Steroid injection versus physiotherapy for patients with adhesive capsulitis of the shoulder: a PRIMSA systematic review and meta-analysis of randomized controlled trials. Medicine (Baltimore) 2016;95:e3469.
[7] Walmsley S, Osmotherly PG, Rivett DA. Movement and pain patterns in early stage primary/idiopathic adhesive capsulitis: a factor analysis. Physiotherapy 2014;100:336–43.
[8] Cyriax J.H. Cyriax's illustrated manual of orthopaedic medicine. 2nd ed. London, UK: Butterworth and Heinneman; 1996.
[9] Petersen CM, Hayes KW. Construct validity of Cyriax's selective tension examination: association of end-feels with pain at the knee and shoulder. J Orthop Sports Phys Ther 2000;30:512–21.
[10] Sakpal TV. Sample size estimation in clinical trial. Perspect Clin Res 2010;1:67–9.
[11] Hughes P. The Neer sign and Hawkins-Kennedy test for shoulder impingement. J Physiother 2011;57:260.
[12] Levy O, Haddo O, Massoud S, et al. A patient-derived Constant-Murley score is comparable to a clinician-derived score. Clin Orthop Relat Res 2014;472:294–303.
[13] Burkhart SS, Danaceau SM, Pearce CEJr. Arthroscopic rotator cuff repair: analysis of results by tear size and by repair technique-margin convergence versus direct tendon-to-bone repair. Arthroscopy 2001; 17:905–12.
[14] Loeuille D, Chary-Valckenaere I, Champigneulle J, et al. Macroscopic and microscopic features of synovial membrane inflammation in the osteoarthritic knee: correlating magnetic resonance imaging findings with disease severity. Arthritis Rheum 2005;52:3492–501.
[15] Cone RO3rd, Resnick D, Danzig L. Shoulder impingement syndrome: radiographic evaluation. Radiology 1984;150:29–33.
[16] Sun Y, Zhang P, Liu S, et al. Intra-articular steroid injection for frozen shoulder: a systematic review and meta-analysis of randomized controlled trials with trial sequential analysis. Am J Sports Med 2017; 45:2171–9.
[17] Kolber MJ, Fuller C, Marshall J, et al. The reliability and concurrent validity of scapular plane shoulder elevation measurements using a digital inclinometer and goniometer. Physiother Theory Pract 2012; 28:161–8.
[18] Yoon SH, Lee HY, Lee HJ, et al. Optimal dose of intra-articular corticosteroids for adhesive capsulitis: a randomized, triple-blind, placebo-controlled trial. Am J Sports Med 2013;41:1133–9.
[19] MacDermid JC, Chesworth BM, Patterson S, et al. Intratester and intertester reliability of goniometric measurement of passive lateral shoulder rotation. J Hand Ther 1999;12:187–92.