

2024 Kappa Delta Ann Doner Vaughan Award: Nonsurgical Treatment of Symptomatic, Atraumatic Full-Thickness Rotator Cuff Tears—a Prospective Multicenter Cohort Study With 10-Year Follow-Up

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ABSTRACT

The Multicenter Orthopaedic Outcomes Network Shoulder Group conducted a prospective cohort study of 452 patients with symptomatic atraumatic rotator cuff tears treated with a physical therapy program to determine the predictors of failure of nonsurgical treatment, to provide insight into indications for surgery. After 10 years, we found the following: (1) Physical therapy was effective for over 70% of patients. (2) PROMs showed statistical and clinical improvement after 12 weeks of therapy and did not decline over 10 years. (3) Cuff tear severity did not correlate with pain, duration of symptoms, or activity level. (4) Of those who had surgery, 56.7% had surgery in the first 6 months while 43.3% had surgery between 6 months and 10 years. (5) Early surgery was primarily driven by low patient expectations regarding the effectiveness of therapy. (6) Later surgery predictors included workers' compensation status, activity level, and patient expectations. (7) Only 1 patient had a reverse arthroplasty (0.2% of the cohort). These data suggest that physical therapy is an effective and durable treatment of atraumatic symptomatic rotator cuff tears and most patients successfully treated with physical therapy do not exhibit a decline in patient-reported outcomes over time. Reverse arthroplasty after nonsurgical treatment is exceptionally rare.

Shoulder pain accounted for 12.6 million ambulatory care visits to physician offices in 2015 in the United States.¹ The direct annual healthcare expense attributable to shoulder disorders was estimated to be \$7 billion in the United States in 2000.² Rotator cuff disorders are considered the most common underlying cause, with estimates varying between 65% and 85% of people presenting with shoulder pain, depending on the setting and age of the study population.³⁻⁵

The approach to treating rotator cuff tears is not clear. Historically, the presence of the condition served as the indication for rotator cuff repair surgery for many surgeons.⁶ Dunn et al surveyed the members of the American Academy of Orthopaedic Surgeons to gain insight into clinical decision making by presenting hypothetical cases and found very little agreement among surgeons,⁷ and furthermore, the surgeons had different perceptions regarding the effectiveness of the surgical procedures performed for rotator cuff tears. This may explain the tremendous geographic variation noted for rotator cuff surgery in the United States,^{8,9} with North Dakota performing 85.52 rotator cuff repairs while Mississippi performed 9.41 rotator cuff repairs/100,000 Medicare patients.⁸ This represents nearly 10-fold difference in surgery rates. These data suggest that there is no clear agreement on the indications for surgery for patients with rotator cuff tears.

To understand rotator cuff disease more thoroughly and help define the indications for rotator cuff repair surgery, our Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Group engineered a multicenter prospective cohort study of patients with symptomatic, atraumatic full-thickness rotator cuff tears treated nonsurgically. We suspected that some patients would do well with nonsurgical treatment while others would not. By identifying characteristics that differ between the 2 groups, we could help establish indications for rotator cuff tear repair.

Creation of the MOON Shoulder Group

The first meeting of the MOON Shoulder Group was on May 17, 2004, with an intent to develop a multicenter outcomes network to prospectively collect data on patients with rotator cuff disease to answer clinically important questions and better understand the natural history and treatment of rotator cuff disease. Before collecting patient data, we built the foundation to conduct this mission, including (1) establishing the research

questions, (2) identifying where the highest agreement would be found when classifying rotator cuff disease, (3) reducing variation in our practices using the best evidence, and (4) determining the outcome measures of interest to answer our research question.

Building the Foundation-Agreement Studies, Systematic Reviews, and Consensus

To study rotator cuff disease with patients from multiple centers, we knew we had to identify the rotator cuff disease classification system that had the best interobserver and intraobserver agreement. Kuhn et al¹⁰ identified 6 different methods of classifying rotator cuff tears described in the literature. The components of these systems included partial-thickness rotator cuff tears and classification by size, shape, configuration, number of tendons involved, topography, and nature of the long head of the biceps. Arthroscopic videos were delivered to members of the MOON Shoulder Group to review and classify the rotator cuff tear using the 6 classification systems described in the literature. We found that the interobserver agreement was high (95%) when distinguishing between full-thickness and partial-thickness tears ($\kappa = 0.85$). The investigators agreed on the side (articular vs bursal) of involvement for partial-thickness tears (observed agreement 92%, $\kappa = 0.85$) but could not agree when classifying the depth of the partial-thickness tear (observed agreement 49%, $\kappa = 0.19$). The best agreement for full-thickness tears was seen when the tear was classified by topography as described by Patte using the degree of retraction in the frontal plane¹¹ (observed agreement 70%, $\kappa = 0.54$).

Similarly, Spencer et al¹² had members of the MOON Shoulder Group review 27 MRI scans of various patients with rotator cuff disease, assessing both interobserver and intraobserver agreement. The best kappa statistics were found for detecting the difference between a full-thickness and partial-thickness rotator cuff tear ($\kappa = 0.77$) and for the number of tendons involved for

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full-thickness tears ($k = 0.55$). Our group was less successful agreeing on the interpretation of partial-thickness rotator cuff tears. When designing our data collection forms, the findings of both studies allowed us to collect data that had the highest level of agreement, improving the validity of our multicenter data.

The MOON Shoulder Group also conducted agreement studies on the following areas: measuring acromial enthesophytes,¹³ clavicle fractures,^{14,15} MRI for shoulder instability,¹⁶ arthroscopic pathology for shoulder instability,¹⁷ 3D CT glenoid bone loss in instability,¹⁸ subscapularis tears,¹⁹ supraspinatus central tendon pathology,²⁰ biceps tendon pathology,²¹ and SLAP lesions.²² By identifying the optimal methods to describe shoulder pathology, we had confidence that our multicenter group would be collecting data as accurately and precisely as possible.

To reduce variations in our practice patterns, we developed consensus among the group and reached agreement on radiographic imaging views and MRI sequencing to be used at each site. Interestingly, the indication for surgery for full-thickness rotator cuff tears was an area where we did not find agreement among members in the group. We did identify 2 systematic reviews in the literature studying indications for surgery for full-thickness rotator cuff tears. Oh et al²³ studied how the following variables influenced the outcomes after surgical repair of a rotator cuff tear: demographic features, acuity of the tear, physical examination findings, and imaging findings. This review concluded that chronological age should not affect the decision for surgery, the effect of the patient's sex was unclear, an active worker's compensation claim may portend worse results after surgery, and surgery is preferred if the patient presents with weakness or functional disability.²³ Marx et al²⁴ reviewed the described indications for surgery by authors who reported on outcomes after rotator cuff repair. Of 86 reviewed articles, the indications for surgery were mentioned in only 44%. Of those articles, the indications for surgery included limitations in activities of daily living (31%), failure of nonsurgical treatment (52%), duration of nonsurgical treatment (26%), and nocturnal pain (16%). The data for each of these criteria had notable variation, making it difficult to draw recommendations from this review.²⁴ Finally, Wolf et al²⁵ authored a narrative review that produced 2 algorithms for treatment of patients with rotator cuff tears, 1 for patients younger than 50 years and one for patients older than 50 years or "physiologically younger patients".

The absence of high-level literature to help define the indications for surgery is likely why there is great geo-

graphic variation in rotator cuff repair rates in the United States^{8,9} and may explain why our group and other orthopaedic surgeons could not agree on who should have surgery and who should not.⁷

With this in mind, the MOON Shoulder Group set out to conduct a prospective cohort study to identify the features that would predict failure of nonsurgical treatment of symptomatic atraumatic full-thickness rotator cuff tears, providing insight into the indications for surgery.

Prospective Cohort Study Design to Assess Predictors of Failure of Nonsurgical Treatment

All patients aged 18 to 100 years with shoulder symptoms and MRI-documented, symptomatic, atraumatic, full-thickness rotator cuff tears were invited to participate. We defined a traumatic tear as any history of trauma that precipitated the patient's symptoms. Patients were excluded if they had a history of injury, pain related to the cervical spine, scapular pain, previous shoulder surgery, glenohumeral arthritis, inflammatory arthritis, adhesive capsulitis, previous proximal humeral fracture, bilateral rotator cuff tears, or dementia.

At the initial visit, patients completed a questionnaire that detailed demographic data and included validated patient-reported outcome measures (PROMs) (Short Form 12 [SF-12] score, American Shoulder and Elbow Surgeons [ASES] score, Western Ontario Rotator Cuff [WORC] index score, Single Assessment Numeric Evaluation [SANE] score, Self-Administered Comorbidity Questionnaire, and Shoulder Activity Scale score). We used the Minimal Clinically Important Difference (MCID) for our outcome measures to determine clinical significance: WORC score 11.7%,²⁶ ASES score 12 to 17 points,²⁷ SANE score 15%,²⁸ and VAS pain score 1.4 points.²⁹ Outcome scores were collected at patient entry into the study (Time 0) and at each follow-up point (6 weeks; 12 weeks; 1 year; and 2, 5, 7, and 10 years). Physical examination data were also collected at the initial and 6-week and 12-week visits.

The details regarding nonsurgical treatment in the literature are highly varied, so we developed a physical therapy protocol based on a systematic review of randomized controlled trials demonstrating effectiveness of physical therapy in treating rotator cuff disease.³⁰ We distilled the elements of the physical therapy protocols from these articles into a "benchmark" protocol,³⁰ which was used for this prospective cohort study.

Patients were given 2 instructive rehabilitation books (available at www.moonshoulder.com), one for physical therapists and another for home-based physical therapy written at the eighth-grade level with an accompanying DVD that demonstrated the appropriate technique for the rehabilitation exercises. The specific exercises included daily range of motion (postural exercises, active-assisted motion, active training of scapular muscles, active range of motion); daily flexibility (anterior and posterior shoulder stretching); and strengthening three times per week (rotator cuff and scapula exercises). Therapists were instructed to provide manual mobilization exercises as needed, because there is evidence to support their use in impingement, and to progress the patient to a home therapy program when ready. Based on the systematic review, heat and cold were recommended as modalities but other modalities were not.³⁰

Patients returned after performing the therapy program for 6 weeks. At that point, patients were given 3 options: (1) If they considered themselves “cured,” no additional treatment or formal follow-up was prescribed. (2) If they were “improved,” patients continued the physical therapy program for another 6 weeks. (3) If they were “no better,” they could elect to have surgery. Patients could choose to have surgery at any time. Patients were contacted at 6 weeks; 12 weeks; 1 year; and 2, 5, 7, and 10 years to determine whether they had surgery and what surgery was performed and to collect PROMs.

Cohort Population Demographics

The MOON group physicians saw 2,233 patients with rotator cuff tear during the enrollment period (January 17, 2007, to September 23, 2010). Of these patients, 1,280 were excluded for the following reasons: acute traumatic tears (38%), previous surgery (11%), bilateral disease (8%), neck disorders (6%), frozen shoulder (2%), dislocation (3%), rheumatoid disease (1%), and fracture (1%). Of the remaining 953 patients eligible to enroll in the study, 452 (47%) elected to do so. Of this group, 30 patients withdrew from the study during the 10-year follow-up.

The mean age of the study population was 62.6 years (range, 31-90 years), with 51% men and 49% women. The dominant arm was affected in 68%. The right arm was affected in 70%. Most (89.5%) were nonsmokers. The cohort population was predominantly White (86%), Black (8%), or Asian (3%). Many patients had

comorbidities, with hypertension, back pain, and osteoarthritis most common. Before enrolling in the study, 23% of patients had already tried some physical therapy, 40% had received injections, and 80% had tried nonsteroidal anti-inflammatory drugs.^{23,31}

MRI demographics included superior humeral head migration in 15% of patients. Rotator cuff tears involving only the supraspinatus were seen in 70% of patients. Tear size was minimal in 48% of patients and was retracted to the midhumeral head in 33.5% of patients.^{31,32}

Results

2-Year Follow-Up Data Effectiveness of Physical Therapy

The first article reporting our results was based on 422 patients for whom we had follow-up data at a minimum of 3 months and with up to 2 years of follow-up for 90% of the cohort (N = 381).³¹ Of this group, 319 patients had data available (84% follow-up). Overall, 82 patients (26%) decided to have surgery. As noted in Table 1, statistically and clinically significant improvements were noted over the 12-week period of treatment for the ASES, WORC, and SANE scores. No clinically important change was noted for the SF-12 domains or the Shoulder Activity Scale scores.

Kaplan-Meier survivorship analysis (Figure 1) revealed that patients who elected to undergo surgery generally did so within the first 12 weeks. If a patient avoided surgery in the first 12 weeks, he or she was unlikely to undergo surgery later, up to 2 years.

The conclusions from this study were as follows: (1) Physical therapy is highly effective in reducing pain and improving patient-reported outcome scores in a population of patients with atraumatic symptomatic full-thickness rotator cuff tears. (2) Only 26% of the patient cohort elected to have surgery. (3) Patients who elected to have surgery did so in the first 12 weeks. (4) The effectiveness of physical therapy seemed to last for up to 2 years.³¹

Predictors of Having Surgery

To better define the indications for surgery, we sought to know what features predicted failure of nonsurgical treatment.³² For this study, all 433 patients in the cohort had reached their 1-year time point, for which we had follow-up data on 94%. Multivariate modeling found patient expectations regarding the effectiveness of physical therapy to be the most significant predictor of

Table 1. Inception and 6-Week and 12-Week Outcome Scores After Initiation of Physical Therapy

Assessment Tool	Baseline	6 wk	12 wk
SF-12 MCS	40.3	40.6	40.8
SF-12 PCS	35.3	35.6	36.1
ASES score	54.5	78.0	83.1
WORC score	47.2	62.5	69.7
SANE score	46.6	62.7	70.3
Activity Scale	9.9	10.2	10.0

ASES = American Shoulder and Elbow Surgeon, WORC = Western Ontario Rotator Cuff, SANE = Single Assessment Numeric Evaluation, SF-12 = Short Form 12

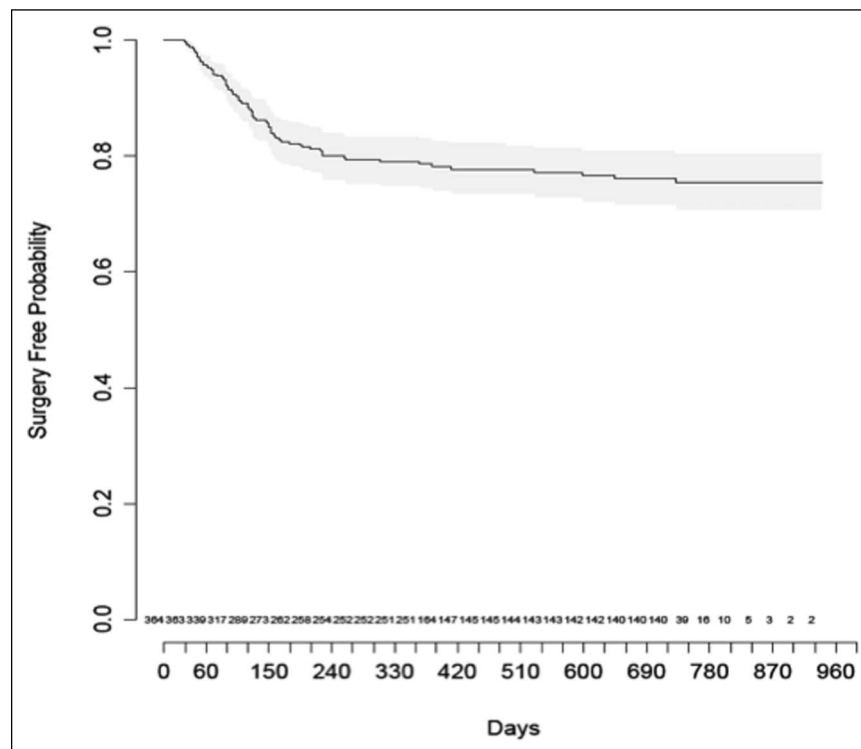
Values in bold are significant both statistically and clinically (exceeding MCID for scores). (From Kuhn JE, et al. Effectiveness of physical therapy in treating atraumatic full-thickness rotator cuff tears: a multicenter prospective cohort study. *J Shoulder Elbow Surg.* 2013 October;22(10):1371-9. doi: 10.1016/j.jse.2013.01.026. Epub 2013 March 27. PMID: 23540577; PMCID: PMC3748251).

failure of rehabilitation and ultimate surgical intervention ($P < 0.00001$). Patients with a higher activity level ($P = 0.011$) and nonsmoking patients ($P = 0.023$) were also more likely to undergo surgery. The effect size of patient expectations as a driver for surgery was large. Essentially, if someone thought that physical therapy would be effective, it was. If someone thought that therapy would not be effective, it was not. Structural

factors (tear size, retraction), VAS pain score, and weakness were not predictors of having surgery.

10-Year Follow-Up Data

We know from natural history studies that many rotator cuff tears enlarge over time.³³⁻³⁶ This has led many surgeons to recommend surgery to prevent progression and later difficulties^{37,38} and to prevent the possible need for

Figure 1

Plot demonstrating the Kaplan-Meier curve for surgery for the cohort over 2 years. For every patient who had surgery, the curve drops. Note that most surgeries occur early in the course of treatment. (Adapted with permission from Kuhn JE, et al. Effectiveness of physical therapy in treating atraumatic full-thickness rotator cuff tears: a multicenter prospective cohort study. *J Shoulder Elbow Surg.* 2013;22(10):1371-9. doi: 10.1016/j.jse.2013.01.026. Epub 2013 March 27. PMID: 23540577; PMCID: PMC3748251).

reverse total shoulder arthroplasty should the tear become irreparable with notable loss of function. To investigate these concerns, we followed the cohort for 10 years to see whether the effect of physical therapy is transient (as would be documented by more surgeries and worsening PROMs over time) and to identify the nature of the surgeries performed. In addition, because our first 2 years of follow-up demonstrated that early surgery was driven primarily by patient expectations,³² we wanted to know whether patients who had later surgery (6 months to 10 years) had different predictors of the need for surgery. These data have recently been published.³⁹

Of the 452 patients in the original cohort, 30 patients withdrew before the 10-year follow-up, leaving 422 available for analysis. 37 patients (9.1%) died before 10 years, and 40 others (9.0%) were lost to follow-up. 115 patients (25.4%) were known to have had surgery over the 10-year follow-up period. Of those patients who had surgery, most (56.9%) had surgery within 6 months of enrollment (Figure 2). The others (43.1%) had surgery between 6 months and 10 years after enrolling in the study.³⁹

Patient-Reported Outcome Measures

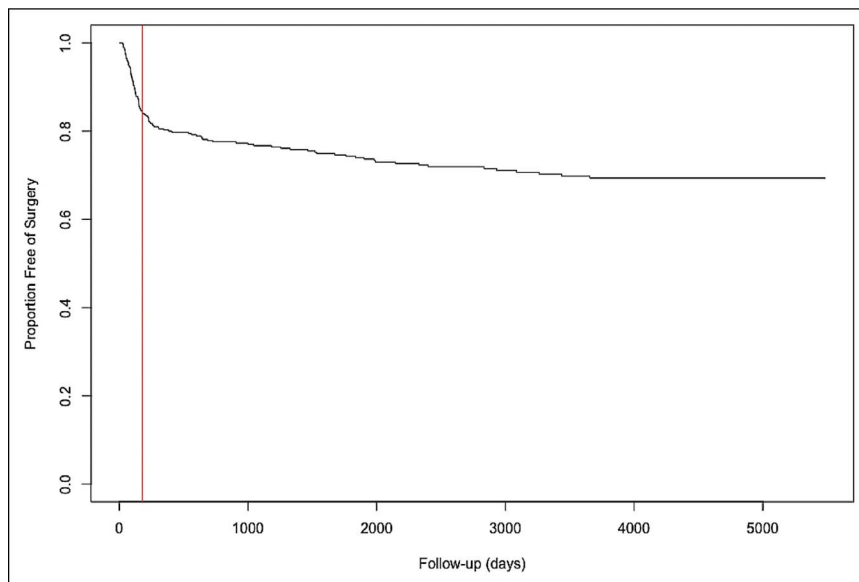
The WORC, ASES, SANE, VAS pain, and Shoulder Activity Scale scores were collected at patient enrollment

($T = 0$) and 1, 2, 5, 7, and 10 years of follow-up (Figure 3). The following observations are notable: (1) When patients entered the study, their PROM scores were severely abnormal but improved significantly (statistically and clinically) with physical therapy. (2) Over a span of 10 years, the PROMs did not deteriorate, showing minor variation over time, with no changes approaching the minimal clinically significant difference for any score. (3) Shoulder activity declined slightly with age that is consistent with normative data for the score.⁴⁰ Interestingly, shoulder activity level has not been shown to correlate with rotator cuff tear progression by others.⁴¹

Predictors of Early Versus Late Surgery

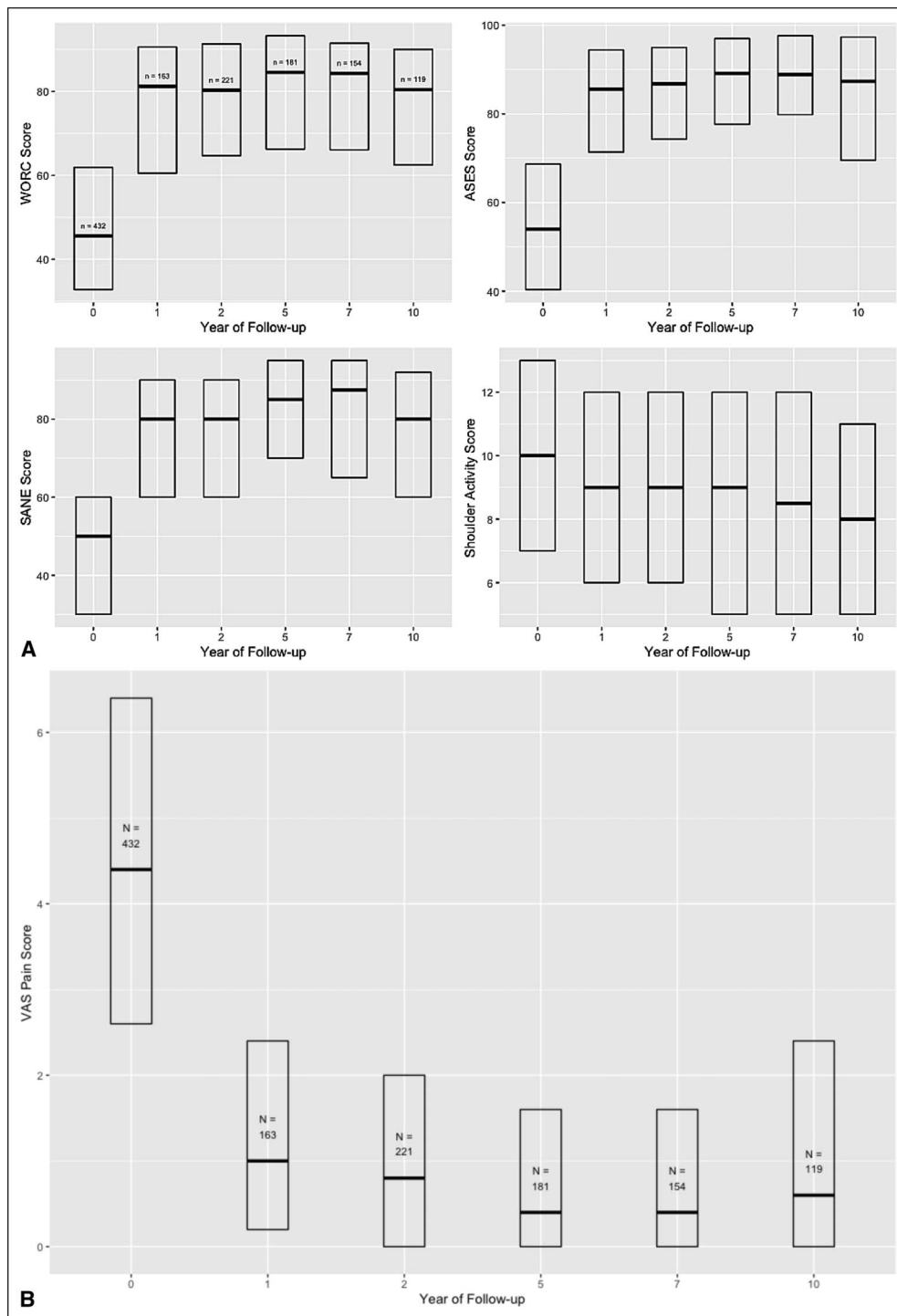
When comparing patients who had early surgery with those who had surgery after 6 months,³⁹ we found that the early-surgery patients were driven by patient expectations (Figure 4) as previously described.³² When comparing those who had surgery before 6 months with those who had surgery between 6 months and 10 years, workers' compensation status and activity level were more important in predicting the need for later surgery (Figure 5). Interestingly, symptom severity and symptom duration had no notable effect on the likelihood for early or late surgery. Rotator cuff tear retraction was a

Figure 2



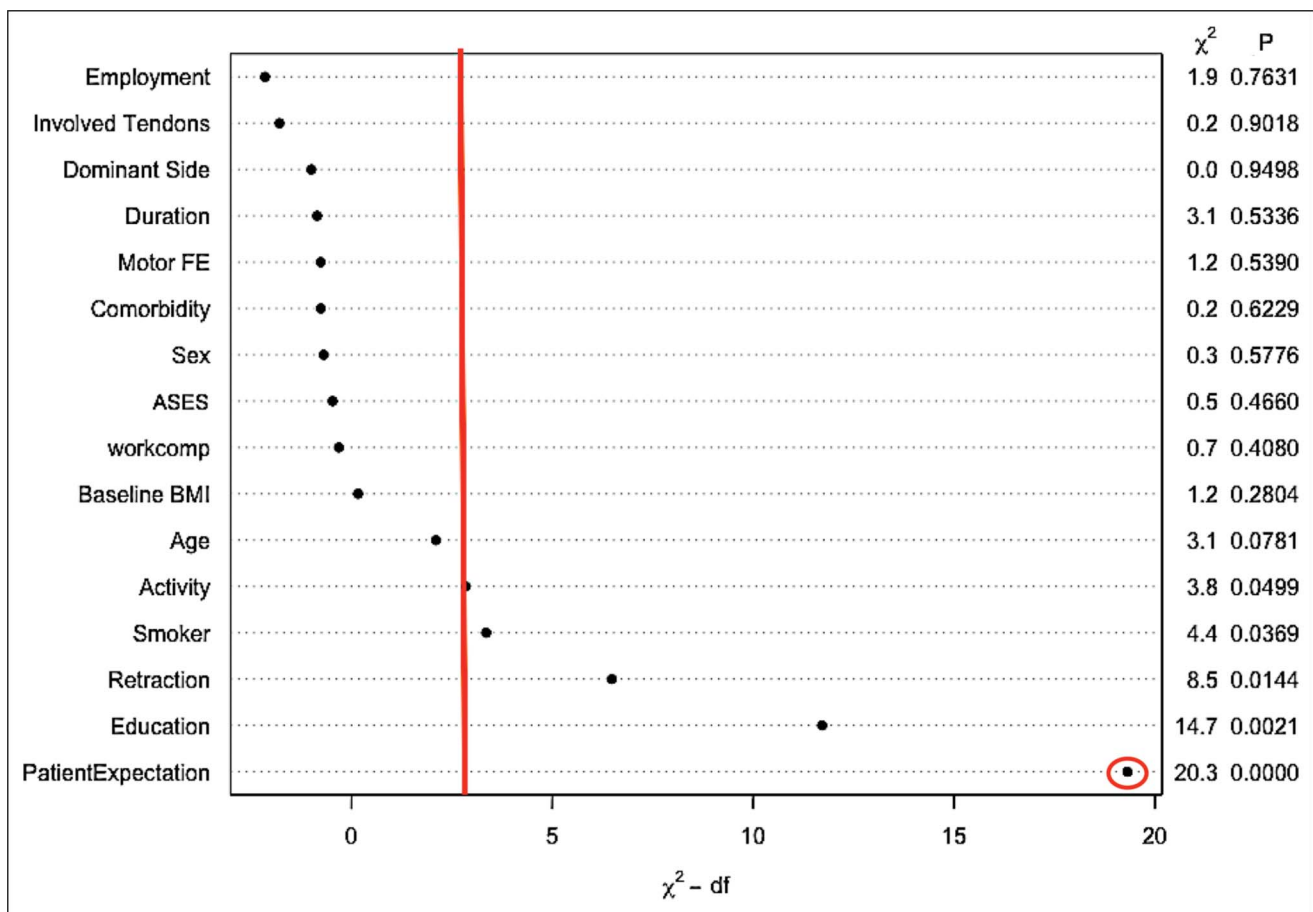
Plot demonstrating the Kaplan-Meier curve for surgery over 10 years. Overall, >70% of patients did not have surgery at 10 years of follow-up. The vertical red line marks the 6-month point. Of those who had surgery, most (56.9%) had surgery within the first 6 months. The rest (43.1%) had surgery between 6 months and 10 years, suggesting that patients who had early surgery are different from those who had later surgery. (Adapted with permission from Kuhn JE, Dunn WR, Sanders R, Baumgarten KM, Bishop JY, Brophy RH, et al. The predictors of surgery for symptomatic, atraumatic full-thickness rotator cuff tears change over time: Ten-year outcomes of the MOON shoulder prospective cohort. *J Bone Joint Surg Am* 2024. doi: 10.2106/JBJS.23.00978. Epub ahead of print. PMID: 38980920).

Figure 3



Plots demonstrating patient-reported outcome measures at inception and 1, 2, 5, 7, and 10 years. The horizontal line in each bar reports the median score with 25th and 75th quartiles for each time point with N for each time point in the WORC and VAS pain score boxes. Note that the WORC, ASES, SANE, and VAS pain scores all improved with therapy and did not change over the 10-year follow-up. (Adapted with permission from Kuhn JE, Dunn WR, Sanders R, Baumgarten KM, Bishop JY, Brophy RH, et al. The Predictors of surgery for symptomatic, atraumatic full-thickness rotator cuff tears change over time: Ten-year outcomes of the MOON shoulder prospective cohort. *J Bone Joint Surg Am* 2024. doi: 10.2106/JBJS.23.00978. Epub ahead of print. PMID: 38980920).

Figure 4



Plot demonstrating predictors of having early surgery (inception to 6 months). The strength of each predictor is represented by how far it exists along the x-axis. The solid line represents statistical significance at $P < 0.05$. Note that low patient expectations regarding the effectiveness of physical therapy is an extremely impactful predictor of early surgery. (Adapted with permission from Kuhn JE, Dunn WR, Sanders R, Baumgarten KM, Bishop JY, Brophy RH, et al. The predictors of surgery for symptomatic, atraumatic full-thickness rotator cuff tears change over time: Ten-year outcomes of the MOON shoulder prospective cohort. *J Bone Joint Surg Am* 2024. doi: 10.2106/JBJS.23.00978. Epub ahead of print. PMID: 38980920).

statistically significant predictor of early surgery; however, patients with less severe cuff disease (smaller tears) were more likely to have surgery than those with larger tears (Figure 6), and this phenomenon only applied to the patients who decided to have surgery early. Rotator cuff tear retraction was not a notable predictor of later surgery.³⁹

Types of Surgery Performed

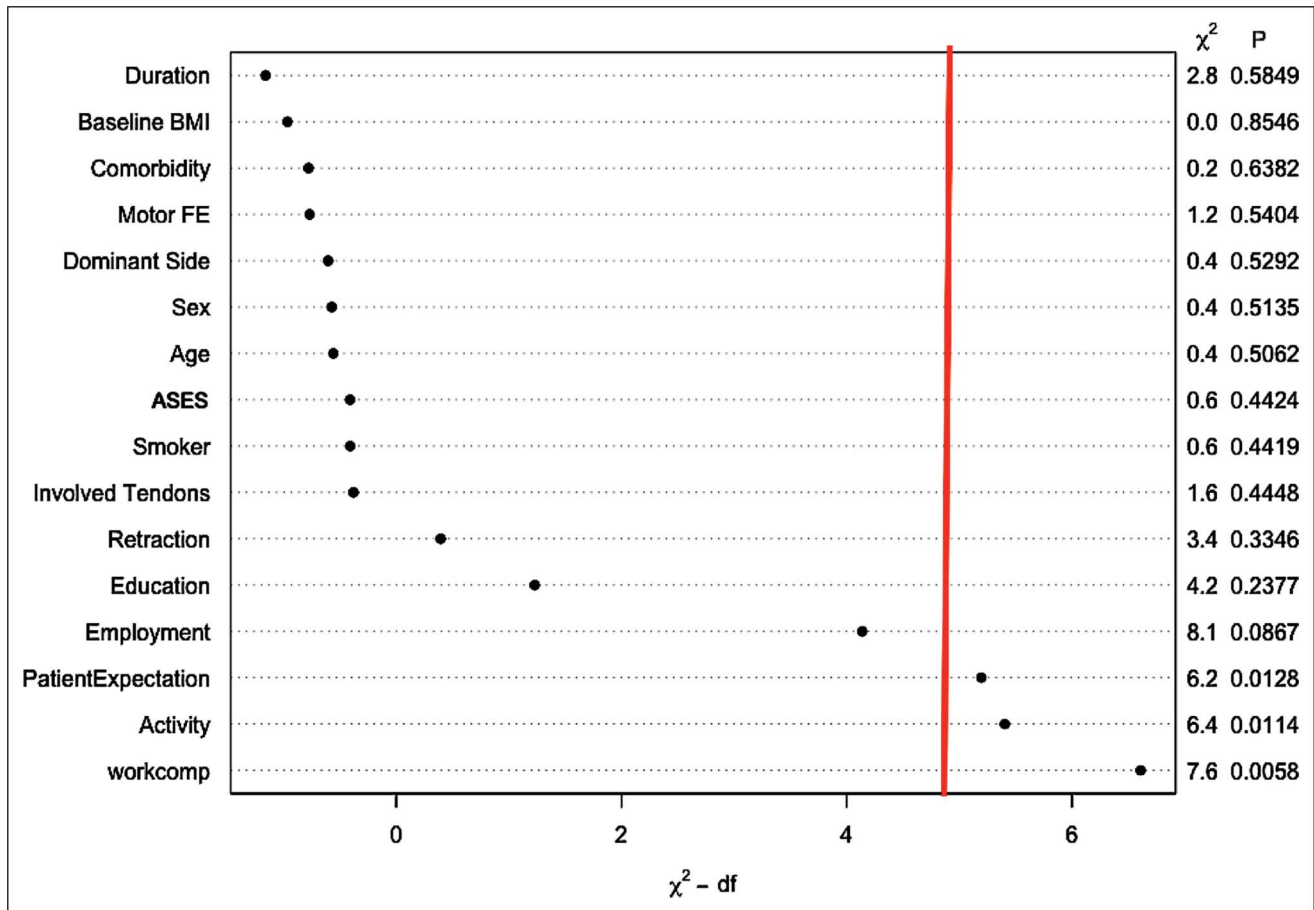
Of the entire cohort of 452 patients over the 10-year follow-up, surgery was performed in 115 patients, of which data regarding the surgery were available for 105. Of those who had surgery, rotator cuff repair was performed in 103 patients (98%; 1 partial repair and 1 augmented with graft). Concomitant biceps surgery was performed in 37 patients (35%; 23 tenodesis, 12

tenotomy, 2 débride ruptured tendon stump). 20 patients (19%) had concomitant distal clavicle excisions. 1 patient had lysis of adhesions and manipulation under anesthesia. Only 1 patient of the entire cohort (0.2%) had a reverse total shoulder arthroplasty.³⁹

Indications for surgery were listed in 89 of the 105 surgical reports. 10 patients reported a traumatic event injuring the rotator cuff. Other indications listed included failure of nonsurgical treatment (67), pain (42), weakness or functional loss (11), biceps problems (3), adhesive capsulitis (2), and tear enlargement (2).³⁹

In summary, despite our concern that rotator cuff tear progression is expected in nearly half of the cohort,³³⁻³⁶ it would seem based on unchanging PROMs that for most patients, progression of the cuff tear may not be clinically important. In our cohort patients with symptomatic

Figure 5



Plot demonstrating predictors of having later surgery (between 6 months and 10 years). The strength of each predictor is represented by how far it exists along the x-axis. The solid line represents statistical significance at $P < 0.05$. Workers' compensation and activity level become stronger predictors of later surgery. (Adapted with permission from Kuhn JE, Dunn WR, Sanders R, Baumgarten KM, Bishop JY, Brophy RH, Carey JL, et al. The predictors of surgery for symptomatic, atraumatic full-thickness rotator cuff tears change over time: Ten-year outcomes of the MOON shoulder prospective cohort. *J Bone Joint Surg Am* 2024. doi: 10.2106/JBJS.23.00978. Epub ahead of print. PMID: 38980920).

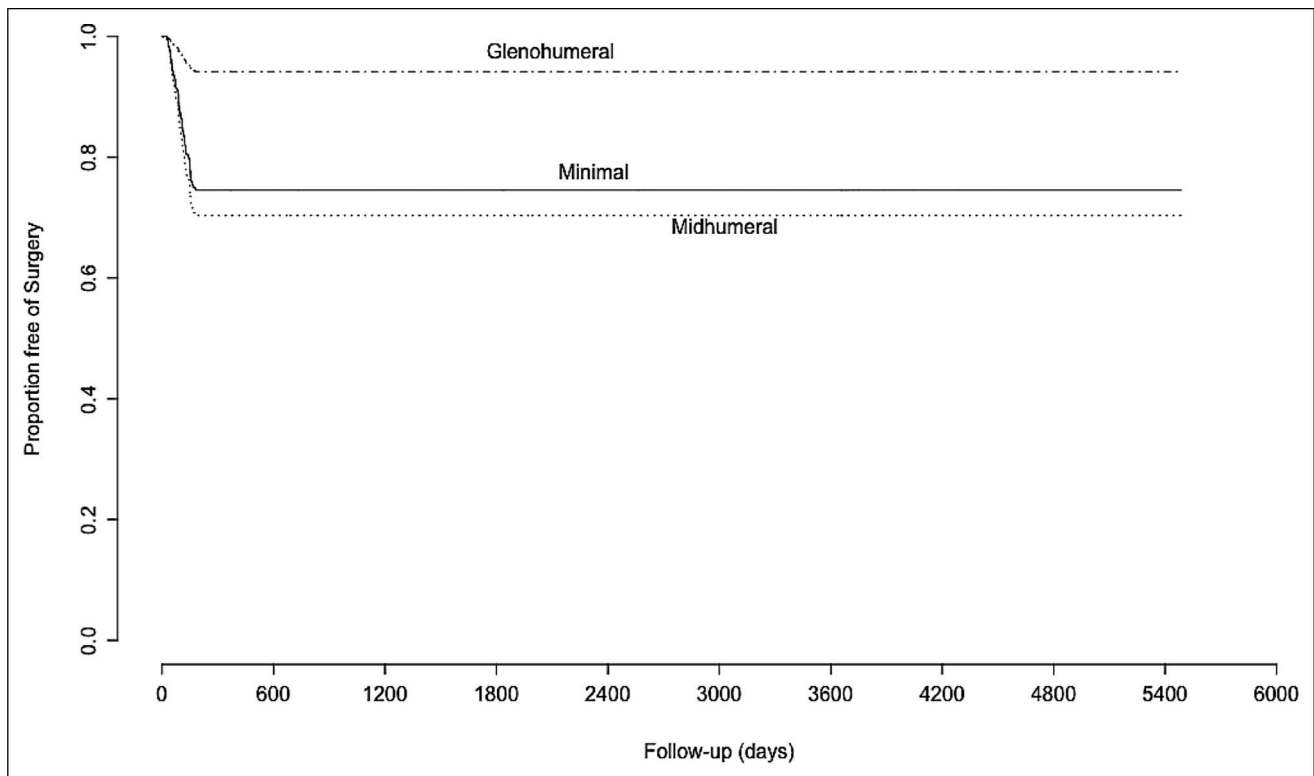
atraumatic full-thickness rotator cuff tears, >70% were treated successfully with physical therapy at 10 years. Patients who decided to have surgery within 6 months were driven primarily by their expectations of the effectiveness of physical therapy. This may be a modifiable variable through education, and while we did not intervene in this cohort, it is likely that if patients were made aware of the effectiveness of physical therapy, the success rate would be even higher. For patients who had surgery after 6 months, workers' compensation status and shoulder activity level were stronger predictors of the need for surgery.³⁹ Patient-reported outcome measures did not deteriorate over 10 years. Finally, the risk of death in this cohort of older patients was 9.1% over 10 years, whereas the risk of needing a reverse arthroplasty was 0.2%.³⁹

The Relationship Between Symptoms and the Anatomy Is Not Robust

The concept that physical therapy would be so effective and that the predictors of needing surgery were statistically not related to the patient's symptoms or rotator cuff tear anatomy represented a paradigm shift in thinking about rotator cuff tears. The finding suggested that the anatomy may not be related to patient's symptoms. We sought to use our data to investigate this concept.⁴²⁻⁴⁵

Pain Is Not Related to Rotator Cuff Tear Severity

With most orthopaedic disorders, the disease severity should correlate with the severity of pain and symptoms.

Figure 6

Plot demonstrating smaller rotator cuff tear size as a statistically significant predictor of early surgery. Rotator cuff tear retraction was a statistically significant predictor of having early surgery; however, patients with larger tears were less likely to have surgery than those with small-size or medium-size tears. (Adapted with permission from Kuhn JE, Dunn WR, Sanders R, Baumgarten KM, Bishop JY, Brophy RH, et al. The predictors of surgery for symptomatic, atraumatic full-thickness rotator cuff tears change over time: Ten-year outcomes of the MOON shoulder prospective cohort. *J Bone Joint Surg Am* 2024. doi: 10.2106/JBJS.23.00978. Epub ahead of print. PMID: 38980920).

We investigated which patient-related and anatomical features were associated with pain level in the MOON Shoulder cohort.⁴² A multivariable linear multiple regression model was used with the continuous VAS pain score as the dependent variable. Independent variables included in the model were age, sex, body mass index (BMI), duration of symptoms, activity level, handedness, education, occupation, race, smoking status, patient expectations, tendons torn, retraction, humeral head migration, and amount of atrophy in the supraspinatus.

We found that greater pain was associated with an increased number of comorbidities ($P = 0.002$), a lower education level ($P = 0.004$), and race ($P = 0.041$). Measures of rotator cuff tear severity, including the number of tendons involved ($P = 0.5$), amount of retraction ($P = 0.9$), presence of superior humeral head migration ($P = 0.3$), and amount of fatty degeneration of the supraspinatus ($P = 0.4$), were not associated with pain level.⁴²

Patient-Reported Outcome Measures Do Not Correlate With Cuff Severity

PROMs were also not strongly related to rotator cuff tear severity. We found that lower initial WORC and ASES scores were associated with male sex ($P = 0.001$), atrophy of the supraspinatus ($P = 0.04$) and infraspinatus ($P = 0.003$), and presence of scapulothoracic dyskinesia ($P < 0.001$). Age, tear retraction, duration of symptoms, and humeral head migration were not statistically significant predictors of the WORC score. Similarly, tear size and humeral head superior migration did not correlate with patient-reported outcome scores.⁴³ Interestingly, the finding that scapular dyskinesia (which is treated with physical therapy) was related to poor initial PROMs may in part explain why physical therapy was effective.

Duration of Symptoms Is Not Related to Rotator Cuff Tear Severity

It would seem logical that patients with larger tears should report longer duration of symptoms. We tried to correlate

the duration of symptoms with the severity of the rotator cuff tear.⁴⁴ Interestingly, the severity of the rotator cuff tear showed no correlation with the duration of symptoms. The patient-reported level of pain did not correlate with the duration of symptoms. Physical examination tests for strength and range of motion showed no correlation with the patient's duration of symptoms, except for forward elevation, which was 10° greater in patients with symptoms for 7 months or more. The duration of symptoms was not correlated with PROMs.⁴⁴

Activity Level Is Not Related to Rotator Cuff Tear Severity

Finally, one might expect that patients with larger rotator cuff tears should have lower activity scores. Like pain and duration of symptoms, in our cohort, shoulder activity level was not associated with the severity of the rotator cuff tear, but it was negatively associated with age ($P = 0.0001$) and female sex ($P = 0.001$). The only other factor associated with shoulder activity level in this cohort was occupation ($P = 0.0006$).⁴⁵

These studies demonstrate that the relationship between anatomical severities of the rotator cuff tear does not predict the need for surgery, is not associated with pain or duration of symptoms, and is not strongly related to patient-reported outcome measures. These concepts have since been corroborated by others,⁴⁶⁻⁵² and it is becoming clear that the assumption that many surgeons make, namely the objective findings on the MRI are responsible for the patient's symptoms, may not be accurate.

There are some important limitations to recognize with this work. First, 53% of the eligible patients who were potential candidates for this study declined to participate. This could introduce selection bias because these patients may have been more symptomatic. Second, we excluded any patient with a history of any trauma, which also limits the generalizability of our findings to only those patients with atraumatic symptomatic rotator cuff tears. Finally, the average age of the cohort was 62.6 years, and while the findings are appropriate for a *population* of patients with atraumatic, symptomatic, full-thickness rotator cuff tears, there may be some specific patients for whom surgery would be a better option.

Clinical Importance of This Work

Before the publication of our work, the presence of a rotator cuff tear was an indication for surgery. Notable

geographic variation was observed in the treatment of rotator cuff tears, and the rotator cuff repair rates were climbing at unprecedented rates.^{8,9} The 10-year MOON Shoulder rotator cuff tear cohort has produced the following important findings: (1) Physical therapy is highly effective at treating atraumatic symptomatic full-thickness rotator cuff tears for at least 10 years. (2) The relationship between rotator cuff tear severity and symptoms is not robust. (3) Low patient expectations regarding the effectiveness of physical therapy (a variable that may be modifiable through education) drive decisions for early surgery while the anatomy of the rotator cuff tear does not. (4) The indications for surgery should consider patient activity and workers' compensation status and should not be influenced by age, symptoms, or the anatomy of the cuff tear. (5) While rotator cuff tear progression is common,³³⁻³⁶ the fact that the effectiveness of physical therapy lasts at least 10 years with no change in PROMs over that time would suggest that fear of progression may not be a strong indication for surgery for most of the population with rotator cuff tears. (6) Finally, the idea that patients who do not have surgery are destined for reverse arthroplasty is unfounded because only 1 patient in the entire cohort (0.2%) had reverse arthroplasty surgery.

Despite these findings, clinicians do see patients who have notable disability related to their rotator cuff tears. Given the high prevalence of rotator cuff tears in the population, this group likely represents a very small subset of the population of people with rotator cuff tears. This group of patients likely has a genetic predisposition⁵³⁻⁵⁶ for early and rapid progression of rotator cuff disease and may be likely to develop tears at a younger age, have bilateral tears, and fail surgical repair.⁵⁷ Identifying and treating these patients remains a challenge and clearly deserves additional study.

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