A value-based care analysis of magnetic resonance imaging in patients with suspected rotator cuff tendinopathy and the implicated role of conservative management

Alejandro Cortes, BS, BA[a,]*, Noah J. Quinlan, MD[b], Mark R. Nazal, MPH[c],
Shivam Upadhyaya, MD[d], Kyle Alpaugh, MD[e], Scott D. Martin, MD[c]

[a]Harvard Medical School, Boston, MA, USA
[b]Department of Orthopaedic Surgery, University of Utah Orthopaedic Residency Program, Salt Lake City, UT, USA
[c]Sports Medicine, Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston, MA, USA
[d]Department of Orthopaedic Surgery, Harvard Combined Orthopaedic Residency Program, Boston, MA, USA
[e]Department of Orthopaedic Surgery, University of Massachusetts Memorial Medical Center, Worcester, MA, USA

Background: Magnetic resonance imaging (MRI) is often used to evaluate the integrity of the rotator cuff in patients with suspected full-thickness rotator cuff tears or other cuff tendinopathies. The value of advanced imaging value comes into question when it is used as the initial musculoskeletal imaging test before a trial of conservative therapy in patients with atraumatic shoulder pain, minimal to no strength deficits on examination, and suspected cuff tendinopathy.

Methods: A prospective study of a group of patients suspected to have cuff tendinopathy based on clinical findings was performed. Every patient underwent MRI and was offered an initial trial of conservative management. Patients had an average follow-up of 28.3 ± 5.3 months after imaging to determine whether surgery was performed.

Results: A total of 51 patients were included in this study. Of this cohort, 46 (90.2%) patients did not go on to surgical intervention, whereas 5 (9.8%) patients did at an average 68.3 days after imaging. These results suggest that over 90.2% of patients (46 of 51) had premature MRI, posing an unnecessary economic burden of $181,619 in advanced imaging charges.

Conclusions: The use of MRI before a trial of conservative management in patients with atraumatic shoulder pain, minimal to no strength deficits on physical examination, and suspected cuff tendinopathy other than full-thickness tears provides negative value in the management of these patients, at both the individual and population level.

*Reprint requests: Alejandro Cortes, BS, BA, Suite 400, 175 Cambridge Street, Boston, MA 02114, USA.
E-mail address: axcortes527@gmail.com (A. Cortes).

Shoulder pain is one of the most common musculoskeletal concerns driving patients to seek medical care.[28,30,36] Four and a half million people visit their physician's office with complaints of shoulder pain annually, with up to 70% accounted for by disease of the rotator cuff.[5,25] Although the exact frequency of rotator cuff tears (RCTs) is difficult to determine, the overall prevalence has been reported as 20.7%.[39] However, even in an asymptomatic population, full-thickness RCTs may be identified in 15% to 23% of patients, and up to 34% when including partial-thickness RCTs.[32,35] More alarming, the incidence dramatically increases with age, reaching 25.6% in the seventh decade and rising to 50% by the ninth decade.[39] Despite this high prevalence, clear guidelines regarding the evaluation and management of RCTs are lacking.[33] Although practices vary by country and region, in the United States, it is common for a shoulder magnetic resonance imaging (MRI) to be obtained at the initial presentation of suspected tendinopathy or shortly thereafter, before the completion of a trial of conservative therapy.

Although acute and large full-thickness tears are often treated surgically, nonsurgical management of atraumatic RCTs can be highly effective for individuals who do not exhibit weakness on clinical examination or progressively worsening weakness.[10,24,33] In addition, isolated partial-thickness and full-thickness supraspinatus tears (no concomitant lesions on the other rotator cuff tendons) often respond well to nonsurgical management with a low risk for progression.[7,10,17,20,33] However, accurately identifying the type of shoulder injury in a patient with pain and slight physical deficits is exceedingly difficult based on clinical examination alone.[10-14] Therefore, advanced imaging such as MRI is often used to evaluate the integrity of the rotator cuff. Although MRI is a commonly obtained and useful tool for surgical planning in patients with acute and full-thickness tears, its value comes into question when used as the initial musculoskeletal imaging test before a trial of conservative therapy in patients with atraumatic shoulder pain and minimal to no strength deficits on examination.[40]

In a shifting medical environment toward value-based care where accountable care organizations, integrated health care delivery models, bundled payments, and value-contingent reimbursements are becoming the standard, determining cost-effective management of high-volume conditions such as RCTs is critical. The goal for providers must be to increase the value of care by improving outcomes while reducing costs.[29] Although MRIs serve as an exceptionally powerful diagnostic tool, they have a high cost and must provide actionable information that impacts management to translate into value. Recognizing this potentially large health care utilization, and determining if it is warranted, is essential. In a recent article, Black et al[3] emphasize the importance of developing evidence-based guidelines for common shoulder pathologies, and that those guidelines will decrease the high variability of shoulder care, improving outcomes and decreasing costs.

The high prevalence of RCTs, as well as their accompanying economic utilization, necessitates an analysis of the appropriateness of the resources used in the evaluation and treatment of shoulder pain. The purpose of this study was to examine the value of MRI in the initial management of patients with atraumatic shoulder pain, suspected cuff tendinopathy based on clinical findings, and minimal to no strength deficits on examination. It has been reported that full-thickness tears are associated with weakness even in patients with asymptomatic RCTs; therefore, a full-thickness tear was thought to be unlikely in patients with relatively well-preserved strength testing.[16] We hypothesized that initial MRI in this population would prove premature, as a majority of patients would not go on to surgical intervention. In this population, initial MRI would not provide value, because of not altering patient management and added significant financial costs.

Materials and methods

We prospectively followed a group of consecutively sampled patients who presented to a sports medicine clinic of a senior orthopedic surgeon and met the following inclusion criteria: age 18 years or older, chief complaint of shoulder pain (located in anterolateral shoulder, worsened by overhead activities, nighttime pain), able to tolerate physical examination, strength test minimum of 4 of 5, no inciting traumatic event, and screening radiographs of the symptomatic shoulder exhibiting no to mild glenohumeral arthritis (no noticeable joint space narrowing and no significant osteophytes), and no cuff arthropathy (well-centered head with no superior migration).

Exclusion criteria included previously diagnosed RCT based on MRI, prior shoulder surgery, physical inability to tolerate physical examination, implanted MRI incompatible device, injury to the ipsilateral hand or wrist, contralateral shoulder injury, and prior shoulder dislocation. Patients were also excluded if they had documented steroid injections or physical therapy for the current episode of shoulder pain.

A total of 162 patients were screened, of whom, 84 patients attended their enrollment visit during the study period. A total of 33 patients were excluded: 9 patients due to prior shoulder surgery, 7 patients due to contralateral shoulder injury, 4 patients due to prior shoulder dislocation, 3 patients due to physical inability to tolerate physical examination, 2 patients due to implanted MRI incompatible device, and 1 patient due to previously diagnosed RCT based on MRI. Seven patients declined to participate. A total of 51 patients met inclusion criteria and were enrolled.

All patients were suspected to have cuff tendinopathy based on clinical findings and completed a subjective shoulder questionnaire. The questionnaire included: duration of symptoms, insidious versus acute onset, night pain, baseline pain, worsening symptoms, and arm dominance. Patients underwent standardized physical examination. Objective range of motion and strength testing with a goniometer and dynamometer, respectively, was performed on each shoulder in both the coronal and scapular/glenohumeral (30°) planes. The percent deficit of the injured extremity in comparison with the contralateral was determined.

All patients underwent an MRI or magnetic resonance arthrogram (MRA), which was read by both a musculoskeletal (MSK) fellowship trained radiologist and the senior author. Rotator cuff injuries were classified as a complete, full-thickness tear: tear of the full cross-section of the tendon spanning the full width of the tendon; focal full-thickness tear: tear of the full cross-section of the tendon but spanning on part of the width of the tendon; partial-thickness tear: tear of less than the full cross-section of the tendon; tendinopathy, or no rotator cuff injury. These classifications were mutually exclusive with patients categorized based on the most severe aspect of their injury. Concomitant labral pathology (tear, degeneration, blunting, fraying) was noted. Patients included in this study had to have an MRI/MRA at least 2 months before the conclusion of the study, when chart review was conducted.

All patients were offered the same initial trial of conservative management for a minimum of 2 months, which consisted of patient education, activity modification, nonsteroid anti-inflammatory drugs, and physical therapy. Physical therapy followed a standardized protocol and was performed at one of 3 outpatient physical therapy clinics. The protocol included rotator cuff and periscapular strengthening, range of motion exercises with pendulum swings and light stretching, along with icing, heating, and light massage. Patients with severe pain were offered an intra-articular steroid injection. An intra-articular injection was used instead of a subacromial injection, because the majority of partial RCTs occur on the articular side, not the bursal side.[6] After a minimum of 2 months of physical therapy and a trial of the aforementioned conservative modalities, patients who continued to endorse unsatisfactorily symptoms or symptom progression consist of suspected cuff tendinopathy were given the option of rotator cuff repair surgery.

Patient information, surgical reports, and demographics were obtained from the medical record. Statistical testing included independent sample t-tests for continuous variables and Fisher's exact tests for categorical variables. Association testing was performed to examine the relationship between various factors and conversion to surgery, for continuous variables logistic regression was used, whereas for categorical variables the χ^2 test of independence was used. A P value less than .05 indicated a significant difference. Analysis was completed with SPSS Statistics Version 24 (IBM Corp, Armonk, NY, USA).

A post hoc power analysis was performed to validate that a sufficient sample size had been obtained. The primary outcome measure of this study was progression to surgery. We adopted an alpha (type I error rate) of 0.05. Comparing the rate of progression with surgical intervention between the full tear group and all other injuries (focal full tears, partial tears, and no rotator cuff injury), the power analysis found a post hoc power of greater than 90%.

Results

A total of 51 patients were included in this study; 33 were male (64.7%) and 18 were female (34.3%). The average age was 51.1 ± 11.9 years. The baseline pain was 4.5 ± 3.1 on a 10-point visual analog scale (VAS) scale, and patients had symptoms for 11.6 ± 24.2 months before presentation. The average time from presentation to MRI/MRA was 10.4 ± 11.8 days. The demographics and physical examination findings were compared between the surgical and nonsurgical group, which was notably only for age being borderline statistically significant ($P = .052$). The mean age difference was 10.7 years, with an average age of 60.8 years in the surgical group and 50.1 years in the nonsurgical group. The rest of the clinical and physical examination findings are presented in Table I.

The mean follow-up, from the MRI/MRA study to the time of chart review, was 28.3 ± 5.3 months, and was not significantly different between the nonsurgical and surgical groups ($P = .826$). Regarding MRI/MRA findings, 30 (58.8%) of patients were found to have an RCT, consisting of 8 full-thickness tears (15.7%), 7 focal full-thickness tears (13.7%), 15 partial tears (29.4%), and 21 without RCT (41.2%) (Table II).

In this cohort, 46 (90.2%) patients did not go on to surgical intervention, whereas 5 (9.8%) patients did at an average 68.3 days after MRI/MRA (1 patient pursued surgery with another provider at an unknown time). This suggests that 46 patients had premature MRI/MRAs that did not affect management. The reported charge of a shoulder MRI at 1 institution is $4181, dropping to an allowable amount of $612 under Medicare.[21] Based on this, these premature MRIs posed an unnecessary economic burden of $181,619 (3 patients were over age 65 years and incorporated based on the Medicare rate) in our series of just 51 patients.

Comparing the surgical and nonsurgical groups, of those undergoing surgery, 4 had full-thickness tears compared with 4 nonoperative patients who had full-thickness tears (80.0 vs. 8.7%) (Fig. 1). Analysis of factors associated with conversion to surgery found statistical significance for 1 variable, presence of a full-thickness tear on MRI, $X2(1) = 17.34$, $P \leq .001$. A positive correlation with age was found to be borderline significant, $r = 0.274$, $P = .0518$. Thirty-three (64.7%) patients had concomitant labral pathology

Table I Demographics, questionnaire responses, and objective physical examination measurements for the entire cohort, then divided into nonsurgical and surgical groups

	All (%)	Surgery (%)	No surgery (%)	P value
Male	33	5 (15.2)	28 (84.8)	.148
Female	18	0 (0)	18 (100)	
Age (yr)	51.1 ± 11.9	60.8 ± 7.0	50.1 ± 11.8	.052
BMI	28.1 ± 5.5	30.9 ± 6.5	27.8 ± 5.4	.247
Baseline pain (0-10)	4.5 ± 3.1	4.0 ± 3.6	4.6 ± 3.1	.686
Right arm injured	28 (54.9)	2 (40.0)	26 (56.5)	.647
Dominant arm injured	28 (56.0)	2 (40.0)	26 (57.8)	.643
Insidious onset	33 (64.7)	3 (60.0)	30 (65.2)	>.999
Symptom duration at presentation (mo)	11.6 ± 24.2	17.4 ± 25.8	10.9 ± 24.3	.572
Progressive nature of symptoms	25 (50.0)	4 (80.0)	21 (46.7)	.349
Symptoms awaken from sleep	29 (56.9)	1 (20.0)	28 (60.9)	.152
Coronal plane strength compared with contralateral, %	68.2 ± 26.8	64.2 ± 20.1	68.6 ± 27.6	.730
Scapular plane strength compared with contralateral, %	77.2 ± 25.0	72.3 ± 22.0	77.8 ± 25.4	.648
Coronal plane ROM compared with contralateral, %	92.4 ± 14.0	94.4 ± 10.1	92.2 ± 14.4	.735
Scapular plane ROM compared with contralateral, %	98.6 ± 10.3	96.5 ± 11.9	98.8 ± 10.2	.635

BMI, body mass index; *ROM*, range of motion.

Unavailable data: BMI (n = 1, nonsurgical), dominant arm (n = 1, nonsurgical, patient was ambidextrous), symptom duration (n = 2, nonsurgical), progressive symptoms (n = 1, nonsurgical), scapular plane ROM (n = 1, nonsurgical).

(superior labrum from anterior to posterior , Bankart lesions, degeneration, blunting, or fraying), but no difference was observed between the surgical and nonsurgical group $X^2(1) = 0.71$, $P = .400$ (Table II).

Recognizing that 80% of the patients requiring surgery had full-thickness tears, clinical and physical examination data were re-examined to identify differences between patients with full-thickness tears and all other shoulder injuries. However, there were no significant differences (Table III).

Discussion

The purpose of this study was to assess the value of MRI before a trial of conservative management in 51 patients with suspected cuff tendinopathy based on clinical findings. In this cohort, advanced imaging revealed that 8 patients had full-thickness tears (15.7%), 7 had focal full-thickness tears (13.7%), 15 had partial RCTs (29.4%), and 21 had no RCT (41.2%). Interestingly, 46 of the 51 (90.2%) patients

had not undergone surgery at an average of 28.3 ± 5.3 months of follow-up. This supports our hypothesis that MRI before a trial of conservative therapy poses a significant unnecessary cost that does not impact management in a majority of patients presenting with atraumatic shoulder pain and minimal to no strength deficits on clinical examination.

Recent studies have focused on the societal and economic value of rotator cuff repairs, whereas others have evaluated the costs associated with the evaluation of RCTs.[22,37,40] These studies suggest that MRI is the most expensive component of all preoperative costs, accounting for over 56% of expenditures in the management of RCTs.[40] There has been an increased focus on providing value-based care as the percentage of the United States gross domestic product spent on health care expenditure continues to grow, and is projected to reach 19.9% by 2022.[4] Porter defined value as outcome relative to costs, whereas emphasized the importance of evaluating value over the entire care cycle of meeting a patient's need for a particular health condition. Outcomes refer to results that

Table II Rotator cuff tear (RCT) type observed in the surgical vs. nonsurgical groups

	Full	Focal full	Partial	No RCT	Labral pathology
Surgery, %	4 (80.0)	1 (20.0)	0 (0)	0 (0)	4 (80.0)
No surgery, %	4 (8.7)	6 (13.0)	15 (32.6)	21 (45.7)	29 (63.0)

MRI, magnetic resonance imaging.

Rotator cuff groups are mutually exclusive, and patients were grouped based on the most severe aspect of tear. Reported based on MRI read from a radiologist. Labral pathology includes acute tears and chronic tears, degeneration, and fraying. Labral pathology was not significant between surgical and nonsurgical groups (P = .645).

Table III Demographics, questionnaire responses, follow-up times, and objective physical examination measurements for the entire cohort, then divided into full-thickness rotator cuff tears and all other injuries

	All (%)	Full tear (%)	All other (%)	P value
Male	33	6 (18.2)	27 (81.8)	.696
Female	18	2 (11.1)	16 (88.9)	
Age (yr)	51.1 ± 11.9	56.1 ± 7.4	50.2 ± 12.4	.202
BMI	28.1 ± 5.5	30.3 ± 5.9	27.7 ± 5.4	.224
Baseline pain (0-10)	4.5 ± 3.1	3.2 ± 3.3	4.8 ± 3.1	.182
Right arm injured	28 (54.9)	3 (37.5)	25 (58.1)	.442
Dominant arm injured	28 (56.0)	4 (50.3)	24 (57.1)	.718
Insidious onset	33 (64.7)	7 (87.5)	26 (60.5)	.233
Symptom duration at presentation (mo)	11.6 ± 24.2	16.1 ± 20.4	10.7 ± 25.0	.567
Progressive nature of symptoms	25 (50.0)	6 (75.0)	19 (45.2)	.247
Symptoms awaken from sleep	29 (56.9)	3 (37.5)	26 (60.5)	.268
Coronal plane strength compared with contralateral, %	68.2 ± 26.8	69.0 ± 12.5	68.0 ± 28.8	.921
Scapular plane strength compared with contralateral, %	77.2 ± 25.0	74.3 ± 17.5	77.8 ± 26.2	.720
Coronal plane ROM Compared with contralateral, %	92.4 ± 14.0	96.6 ± 4.1	91.6 ± 15.0	.353
Scapular plane ROM compared with contralateral, %	98.6 ± 10.3	97.9 ± 9.7	98.7 ± 10.5	.841

BMI, body mass index; *ROM*, range of motion.

Unavailable data: BMI (n = 1, nonsurgical), dominant arm (n = 1, nonsurgical, patient was ambidextrous), symptom duration (n = 2, nonsurgical), progressive symptoms (n = 1, nonsurgical), scapular plane ROM (n = 1, nonsurgical).

are important to the patient, including survivability, satisfaction, and quality of life.[3] The emphasis on eliminating non–value-adding utilization at the patient level is to allow for a more efficiency health care system at the population level. Efficiency, or providing the right care at the right time, is part of the definition of quality according to several medical policy groups including the Institute of Medicine, and the Agency for Healthcare Research and Quality.[1,8]

There is pressure to use MRI arisen from recommendations to treat reparable tears in the first few months after injury with the hope of better outcomes, and due to concern for tear progression.[20,27,31] However, our results also suggest that in patients with shoulder pain and minimal to no strength deficits, an MRI was only needed in 9.8% of cases, as the remaining 46 patients were
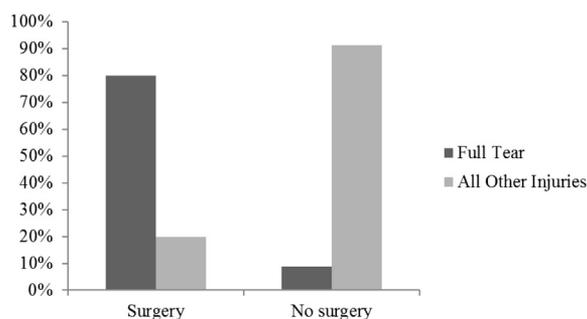

Figure 1 Proportional tear distribution in patients undergoing surgery compared with those who did not. "All Other Injuries" includes focal full tears, partial tears, and no rotator cuff injury. This was a statistically significant difference by Fisher's exact test (P = .001).

successfully treated nonsurgically. In addition, the surgical cohort underwent operation at an average 68.3 days after MRI, indicating that even these patients did not need imaging at first presentation. A trial of conservative treatment of 60-day duration followed by MRI after failure to improve (unsatisfactorily symptomatic or symptom progression) would have yielded similar results and posed a lesser financial burden.

In our series, the management of 90.2% of patients was not affected by the MRI, resulting in an unnecessary overall expense of $181,619.[10,17,20,24,33] In other words, MRI did not change the outcome (numerator in the calculation of value) in over 90% of the patients, but increased medical management costs (denominator in the calculation of value) substantially. Therefore, MRI before a trial of physical therapy generated negative value for the patient as well as the overall health care system. Although not incorporated into this study, further consideration should also be given to indirect outcomes and costs such as travel, parking, opportunity cost of lost work wages, and follow-up appointments, which further decrease the outcome measures and increase the cost measures.

Not surprisingly, of the patients who underwent surgery, 80.0% had a full-thickness tear compared with 8.7% of the conservative group, a statistically significant difference, suggesting that patients requiring surgery are far more likely to have larger tears. Association testing between the presence of a full-thickness tear and conversion to surgery was found to be statistically significant. An argument may be made for imaging on initial presentation to determine a baseline so tear progression and fatty infiltration can be monitored.[20] Indeed, studies have suggested that RCTs can progress in size and degree of fatty infiltration.[11,20,24]

However, the patient population we are addressing had minimal strength deficits, with relatively low suspicion for full-thickness tears. As previously mentioned, there is good support in the literature for conservative management for atraumatic, partial thickness, and focal full-thickness tears.[10,17,20,24,33] Although tears are likely to progress, this should be observed with caution given the rising prevalence with age and reports suggesting that even asymptomatic RCTs may progress without symptoms.[23,35,38,39] Furthermore, in this study, patients received surgery at an average of 68.3 days after MRI. In retrospect, they could have trialed conservative management initially, undergone an MRI if symptoms persisted or progressed, and received surgery within the same time frame. This may be a more reasonable approach, as symptom progression has been associated with tear progression.[19]

It is also important to note that there was a borderline statistically significant difference in age between the surgical and nonsurgical groups. The surgical group was on average 10.1 years older than the nonsurgical group. Although this difference cannot be explained by this study, potential implications include conservative therapy being less efficacious in older patients, tears are less likely to heal in older patients, or tears are more likely to progress in older patients. Further study with larger sample sizes is needed, but this may point toward obtaining an MRI earlier in the management of older patients.

Ultrasound (US) is a potential alternative to MRI for the diagnosis and characterization of the RCTs. Comparatively, US is a low-cost, relatively fast, well-tolerated diagnostic modality that is easily accessible during the same clinical visit as the history and physical examination, making it more convenient that a separate MRI appointment. However, the largest challenge in the use of US in the evaluation of RCTs is that US is immensely operator dependent, with a long learning curve.[9,15,34] This would require either the orthopedic surgeon or another practitioner to devote a substantial amount of time to acquiring the necessary procedural volume to become proficient at shoulder US. Furthermore, US is inherently harder for orthopedic surgeons to review, and provides less information of muscle atrophy, degree of tendon retraction, and assessment of surrounding structures, including the glenoid labrum, joint capsule, and bone, thereby is less useful for management and surgical planning.[2,26,34] In comparing the diagnostic ability, both MRI and US performed by an experienced operator have been reported to have similar positive productive values, whereas US may have a lower negative predictive value, thereby making it a poor screening tool.[9] Furthermore, US may have a much lower sensitivity in detecting partial RCTs.[18,34] Teefey et al[34] found that expert MSK radiologists had similar accuracy for diagnosing and measuring RCT using both MRI and US, and that the decision of which modality to use should be based on imaging

expertise available and the clinical information being sought while considering the strengths of weaknesses of each modality.

Studies suggest that operative repair of RCTs is cost-effective for society, and surgeons may use this as justification for early interventions. Notable among these studies, Mather et al[23] estimated the lifetime societal savings of the approximately 250,000 rotator cuff repairs performed in the United States per year was $3.44 billion. Although this number is impressive and a powerful impetus for surgical intervention of RCTs, it is important to consider the limitations, assumptions, and conclusions of this study. In contrast to our study, they estimated only the costs associated with symptomatic full-thickness RCTs, thus excluding a large percentage of individuals with smaller tears. The study also concluded that it would be most cost-effective to surgically treat patients under 61 years. Because a large portion of RCTs occur in individuals over 61, the results of their study cannot be generalized to the overall population as the prevalence of RCTs steadily increases with age.[39] Finally, the study assumed all patients had been unresponsive to a 6-week trial of nonsurgical treatment before entering the model. Our study identified patients without prior management, but with symptoms concerning for a RCT. As our study showed, most patients with atraumatic shoulder pain and minimal to no strength deficits will not require surgical intervention at an average of over 28 months of follow-up.

There are several limitations to our study. First, the study was performed at the specialized care of a sports medicine clinic, of a single, large tertiary hospital. This could lead to a more homogeneous or higher acuity sample population, due to referral patterns or patients seeking more advanced care. Although there is inherent selection bias in this sample of patients as there was some degree of patient-selected treatment, we believe that the diversity of the population under study should reinforce the generalizability of the study's findings. Second, the senior author reviewed the MRI scans before making a decision to offer the patient the option to proceed to surgery; this could have influenced the proportion of full-thickness RCTs that converted to surgery. Third, our results are limited to short-term follow-up, with an average follow-up of 28.3 ± 5.3 months. Results, including conversion to rotator cuff repair surgery, could change with mid-term and long-term follow-up. Fourth, our follow-up was based on chart review of 1 tertiary hospital system; there is a possibility that some patients sought care elsewhere and underwent surgery without our knowledge. Finally, small subcohorts make it challenging to form definitive conclusions about prognostic indicators, given how few patients went on to have surgery or had full-thickness tears in our cohort.

The results of our study suggest that MRI before a trial of conservative therapy provides little value in the context

of a patient with atraumatic shoulder pain, minimal-to-no strength deficits on physical examination, and suspected cuff tendinopathy other than full-thickness tears, because most of these patients will not undergo surgery. Our findings suggest that, in these patients, an MRI should be acquired after conservative therapy fails, and not before. We recognize the difficulty in assessing rotator cuff pathology in the clinic, and that MRI can provide a clearer picture of the state of the rotator cuff. However, given the tremendous cost MRI studies have on our health care system, an effort should be made to develop alternative diagnostic methods, and to better identify patients who will respond well to nonsurgical management. Currently, there is a paucity of definitive risk factors that predict symptomatic progression of injury, probability of failed conservative treatment, and surgical repair failure. With this study we hope to expose the need for more sensitive and specific diagnostic criteria and physical examination maneuvers to differentiate RCTs. This would allow providers to feel more confident treating nonsurgical rotator cuff injuries without an MRI.

Conclusion

According to the Institute of Medicine, quality is providing the right care at the right time. In our series, 90.2% of these patients did not require surgical intervention, representing an unnecessary MRI cost of $181,619. Given the exceedingly high prevalence of RCTs in the population and the excessive cost of MRI studies even in this small sample size, extrapolation of these results to even a small subset of the general population could impact the health care outcomes and resource utilization of many patients. Therefore, the optimal use of MRI during the evaluation of patients with atraumatic shoulder pain, with minimal to no strength deficits on physical examination requires careful consideration. In conclusion, the use of MRI before a trial of conservative management in patients with atraumatic shoulder pain, minimal to no strength deficits on physical examination, and suspected cuff tendinopathy other than full-thickness tears provides negative value in the management of these patients, at both the individual level and population level.

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