Original Article

Conservatively Treated Symptomatic Rotator Cuff Tendinopathy May Progress to a Tear

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Purpose: To determine the likelihood of, and risk factors for, progression of rotator cuff tendinopathy to tear on magnetic resonance imaging (MRI) in patients treated conservatively for minimum 1 year. **Methods:** Patients in the Veterans Health Administration (VHA) Corporate Data Warehouse with a diagnosis of rotator cuff injury and sequential MRI of the same shoulder at least 1 year apart were identified. Presenting MRIs were reviewed to select patients with tendinopathy, while excluding those with a normal appearing cuff, tear, or prior repair. Tear progression was defined as development of a partial or full-thickness tear on follow-up MRI. Chart review was performed for demographic and clinical data. Descriptive statistics and inter-observer and intra-observer reliability were calculated. Discrete and continuous variables were compared between patients who progressed and those who did not using chi-square, Fisher's Exact, Student's *t*, and Mann-Whitney *U*-test. **Results:** In the VHA database, 135 patients had an initial MRI demonstrating rotator cuff tendinopathy. On subsequent MRI at mean 3.4 year follow-up, 39% of patients had progressed to a tear. When grouped on the basis of time between scans as 1 to 2 years, 2 to 5 years, or over 5 years, the rate of progression was 32%, 37%, and 54% respectively. No factors were associated with progression. **Conclusions:** Among patients with symptomatic rotator cuff tendinopathy that remained symptomatic at a minimum of 1 year and obtained a follow-up MRI, 39% progressed to a partial or full-thickness tear. None of the factors evaluated in this study correlated with progression from tendinopathy to tear. When patients were grouped based on time between scans as 1 to 2 years, 2 to 5 years, or more than 5 years, the rate of progression from tendinopathy to tear was 32%, 37%, and 54%, respectively.

Introduction

Rotator cuff pathology is an increasingly common cause of shoulder pain as patients age. The prevalence of rotator cuff disease has been well studied with estimates that 10% of people under the age of 20 years may have rotator cuff abnormalities steadily rising to 62% of those over the age of 80 years.[1] For tears, treatment varies from operative to conservative measures based on acuity of the injury, tear size and retraction, muscle quality, current function and symptoms, concomitant pathology, and patient goals. To appropriately indicate patients for repair, there has been an effort to determine which patients are at greatest risk for tear progression in terms of size and symptoms.[2-9] While the progression of tears has been well described, there has been limited investigation on the progression of rotator cuff tendinopathy.

Among patients with rotator cuff symptoms, but no evidence of tear (partial or full-thickness) on magnetic resonance imaging (MRI), the rotator cuff tendons may

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demonstrate increased intrasubstance signal, indicating tendinopathic changes. First-line treatment for tendinopathy includes conservative modalities. Surgery is reserved for refractory cases and involves debridement, bursectomy, and acromioplasty, if necessary[10,11]. Of particular interest is whether rotator cuff tendinopathy is a precursor to tear and, if so, with what frequency and in what setting. Throughout the literature, it has been proposed that rotator cuff injuries may be attributed to a degenerative process with tendinopathy preceding tear. Although this is inherently logical, there is limited data on the progression of tendinopathy.[1,11-13]

The purpose of this study was to determine the likelihood of, and risk factors for, progression of rotator cuff tendinopathy to tear on MRI in patients treated conservatively for minimum 1 year. Our hypothesis was that a large portion of patients with symptomatic tendinopathy on their initial MRI would progress to rotator cuff tear on repeat imaging and that age, tobacco use, and diabetes would be associated with progression from tendinopathy to tear.

Methods

The work for this article was performed at the University of Utah and Veterans Health Administration Salt Lake City in Salt Lake City, UT. Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

Patient Selection

With a University of Utah-approved protocol (Institutional Review Board 00111481), a retrospective MRI and chart review study of the full Veterans Health Administration (VHA) Corporate Data Warehouse was performed. On the basis of International Classification of Diseases (ICD) diagnosis codes, ICD procedure and surgery codes, and Current Procedural Terminology codes/modifiers, patients from the outpatient domain with a diagnosis of rotator cuff injury from October 1999 to March 2020 were identified. This was then narrowed to patients who had sequential MRIs on the same shoulder at least 1 year apart without interval surgery, which was confirmed on independent imaging review. We excluded patients who underwent a rotator cuff repair prior to, or between, MRIs or had less than 1 year between scans. Patients with MRIs that were unavailable or incomplete were also excluded. MRIs were performed at various sites across the country and done under the protocols specific to that institution. All patients were assumed to have had imaging performed for symptomatic shoulder issues and repeat imaging due to persistent or recurrent rotator cuff-related symptoms.

Measurements

MRIs were independently reviewed by two orthopedic surgery residents (N.J.Q., J.J.F.). At the outset, imaging for 67 patients (134 MRIs) were interpreted by each reviewer twice to determine inter-observer and intra-observer reliability. After confirming reliability, imaging for the remainder of patients in the cohort was interpreted by either one of the reviewers. Imaging was reviewed for evidence of prior surgery, laterality, presence of rotator cuff tendinopathy or tear (partial or full-thickness), Goutallier classification of the supraspinatus and infraspinatus, and presence of full-thickness and width subscapularis tear. If a tear was not present, the patient was deemed to have a normal rotator cuff or tendinopathy that was graded as mild, moderate, or severe (Fig 1).[14] Because of poor inter-observer reliability of tendinopathy grade (Table 1), this distinction was removed from further analysis as patients with any degree of disease, in the absence of a tear, were combined into one tendinopathy cohort. If a tear was identified, it was further divided into full-thickness, partial articular, partial bursal, or partial intrasubstance. Intrasubstance tears were identified as a clear deficit in the tendon, whereas tendinopathy was identified when the tendon was intact but with abnormal signal. For partial and full-thickness tears, the following were also recorded: lateral to medial tendon retraction from the footprint, anterior to posterior tear length, and distance of the anterior cable remaining intact, i.e., the distance from the anterior aspect of the tear to the biceps. We defined progression from tendinopathy on initial MRI as the presence of a partial or full-thickness tear on the subsequent MRI.

Chart Review

Chart review was performed to collect the following information: age at subsequent MRI, gender, body mass index (BMI), and tobacco use. The following concomitant diagnoses were also noted: diabetes mellitus, osteoporosis, hyperlipidemia, and hypogonadism. These factors have previously been investigated for their association with rotator cuff injury or healing following repair.[15-18]

Statistical Methods

Descriptive statistics were calculated. Both inter- and intra-observer reliability were calculated. For discrete variables, we calculated the kappa statistic and a priori set 0.6 as the minimum acceptable reliability. For continuous variables, we calculated the intraclass correlation coefficient (ICC) and a priori set 0.75 as the minimum acceptable reliability. For the progression analysis, patients with 1 to 2 years follow-up were considered to have a minimum of 1-year follow-up, patients with 2 to 5 years follow-up were considered to have a minimum of 2 years follow-up, and patients

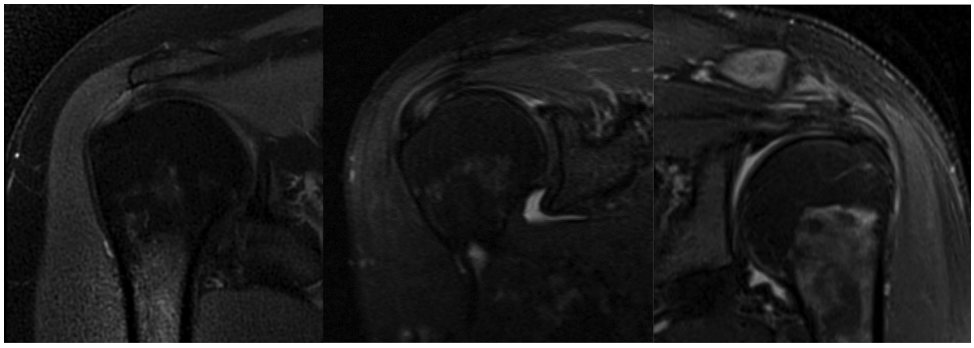

Fig 1. Tendinopathy grading on coronal magnetic resonance imaging (MRI). Left two images are of the right shoulder and right-most image is of the left shoulder. From left to right: mild indicates a focal area of increased signal, moderate indicates a more diffuse area of increased signal though still localized, and severe indicates diffuse signal change throughout the majority of the tendon.

with greater than 5 years follow-up were considered to have a minimum of 5 years follow-up. Discrete variables were compared between patients who progressed and those who did not progress using chi square and Fisher's exact tests as appropriate based upon cell volumes. Continuous variables were compared between those that progressed and those that did not progress using Student's *t* tests and Mann Whitney *U*-tests as appropriate, depending upon data normality as determined using the Kolmogorov-Smirnov test.

Results

Included Patients

On the basis of code query, 808,180 patients in the database had a rotator cuff-related diagnosis of which 1,316 had two shoulder MRIs at least 1 year apart. Of these patients, 596 did not have a prior rotator cuff repair, and repeat MRI was of the same shoulder. On independent imaging review of this cohort, 373 patients were confirmed to have two MRI scans of the same shoulder, although 21 patients were excluded because of interval rotator cuff repair, and 4 were excluded because there was less than a year between scans. Of the remaining 348 patients, 206 had a partial or full-thickness tear and 7 had normal appearing tendons at the time of the initial scan, so they were, thus, excluded, leaving 135 patients with confirmed tendinopathy on presenting MRI as the final cohort (Fig 2). Regarding this final cohort, average age was 54 ± 12 years, BMI was 29.7 ± 5.1, and 86% were male. Average follow-up time of the subsequent MRI for the final cohort was 3.4 ± 2.0 years (range: 1.0 to 10.3 years).

All included imaging measures had acceptable inter- and intra-observer reliability statistics, except grading of tendinopathy, which was removed from further analysis (Table 1).

Rotator Cuff Tendinopathy Progression

Overall, 39% of the cohort was considered to have progressed with evidence of either a partial (24%) or full-thickness (14%) rotator cuff tear on subsequent MRI (Table 2). No patients had fatty atrophy or infiltration in either the supraspinatus or infraspinatus on the first scan (all Goutallier grade 0), and only a single

Table 1. Reliability Statistics

Variable	Inter-observer	Intra-observer 1	Intra-observer 2
κ			
Cuff pathology	.801	.989	.773
Goutallier supraspinatus	.756	.774	.947
Goutallier infraspinatus	.795	.560	.492
Sagittal view	.862	.918	.884
Subscapularis tear	.795	.716	.49
Tendinopathy grade	.214	.709	.549
Intraclass Correlation Coefficients			
Tendon retraction	.981 [0.972 to 0.987]	.995 [0.993 to 0.996]	.971 [0.957 to 0.980]
AP tear length	.954 [0.933 to 0.968]	.992 [0.984 to 0.998]	.878 [0.826 to 0.916]
Anterior cable width	.757 [0.626 to 0.846]	.849 [0.775 to 0.900]	.754 [0.618 to 0.847]

For the variable "cuff pathology" patients were categorized as tendinopathy, partial-thickness tear, or full-thickness tear. AP, anterior to posterior.

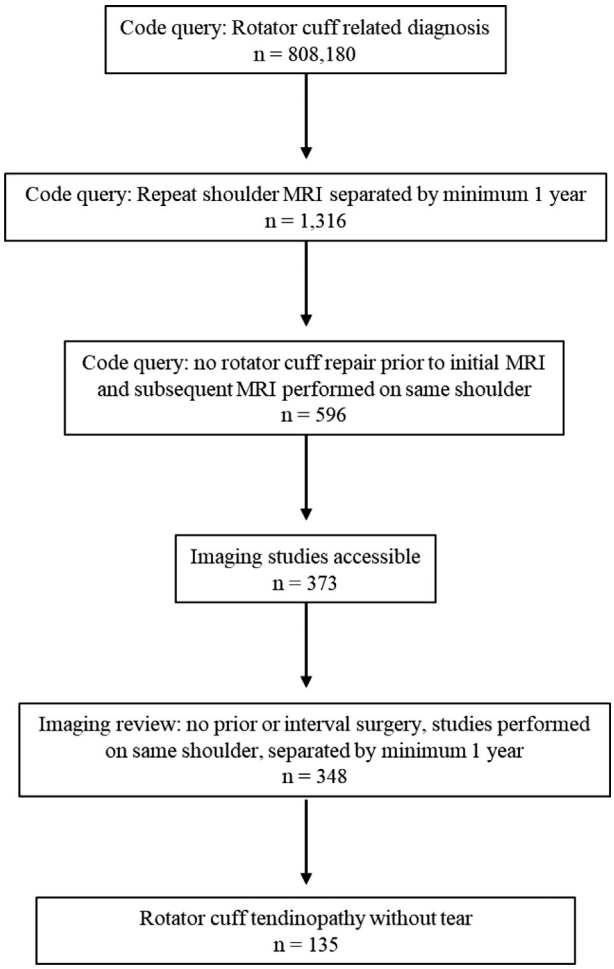

Fig 2. Attrition of patients by the inclusion criteria. MRI, magnetic. resonance imaging. *n*, numbers of patients.

patient had high-grade fatty atrophy (Goutallier grade 3) in both the supraspinatus and infraspinatus at the second scan. Only a single patient had a full-thickness subscapularis tear at the second timepoint. When patients were grouped on the basis of time elapsed between MRIs, there was a trend toward higher rate of progression with greater intervals. Progression from tendinopathy to tear between 1 and 2 years was 32%, 2 to 5 years was 37%, and over 5 years was 54% (Table 3).

The likelihood of progression was not different between sexes, diabetes, osteoporosis, tobacco use, hyperlipidemia, hypogonadism, body mass index, age, or time between scans (Table 4). Multivariate analysis was not conducted because no factors were associated with progression.

Discussion

In our series, symptomatic rotator cuff tendinopathy progressed to rotator cuff tear based on MRI in 39% of cases at minimum 1-year follow-up, with average follow-up of 3.4 years. This suggests that tendinopathy may be on the spectrum of rotator cuff pathology preceding tear and may progress to a tear if the shoulder remains persistently painful. There were no risk factors found to be associated with progression to tear.

Rotator cuff disease has been proposed to be a degenerative process with both intrinsic and extrinsic factors leading to progressive injury over time. Indeed, analysis of damaged tendons demonstrates physiological and histologic changes. Although this would imply that tendinopathy is on the spectrum of rotator cuff injury leading to tear, there is limited literature on the progression from tendinopathy to tear.[13] This process of degenerative tendon changes is consistent throughout the body, which may allow for extrapolation of risk for rupture, although this literature remains limited. An 8-year follow-up study of 83 patients with Achilles tendinopathy reported that 24 (29%) ultimately underwent an operation, but only one was for acute rupture.[19]

Few recent studies have reported on treatment outcomes specific to rotator cuff tendinopathy. Chen et al. published a meta-analysis of 11 studies evaluating the effect of corticosteroid injection on rotator cuff tendinosis compared to a placebo. While corticosteroid injection did provide some temporary pain relief, there was no significant difference at 3 months.[20] Kwong et al. performed a randomized controlled trial

Table 2. Cohort Characteristics and Second Timepoint Tear Measurements

Variable	Value
Demographics	
Right side	69% (93/135)
Age (years)	54 ± 12
BMI	29.7 ± 5.1
Time between scans (years)	3.4 ± 2.0
Male sex	86% (116/135)
Risk factors	
Diabetes	17% (23/135)
Osteoporosis	3% (4/135)
Tobacco	26% (35/135)
Hyperlipidemia	64% (87/135)
Hypogonadism	9% (11/116)
2nd Timepoint tear measurements	
Progressed	39% (52/135)
Full tear	14% (19/135)
Partial tear	24% (33/135)
Tendinopathy	61% (83/135)
Articular partial tear	61% (20/33)
Bursal partial tear	33% (11/33)
Intrasubstance partial tear	6% (2/33)
Cable intact	27% (37/135)
Tendon retraction (mm)	11 ± 11
Tear width (mm)	12 ± 11

Discrete variables are displayed as % (*N*) and continuous variables are displayed as means ± SD. BMI, body mass index.

Table 3. The Percent and Number of Patients With Tear Progression at Each Time Point

Time (years)	Progressed	Progressed to Partial	Progressed to Full
1	32% (14/44)	18% (8/44)	14% (6/44)
2	37% (23/63)	27% (17/63)	10% (6/63)
5	54% (15/28)	29% (8/28)	25% (7/28)

comparing platelet-rich plasma (PRP) to corticosteroid injection for partial thickness rotator cuff tears or tendinopathy. The PRP group demonstrated improved pain and outcome scores at 3 months but no difference at 12 months.[21] Regarding surgical treatment, Carr et al. performed a randomized controlled trial comparing arthroscopic acromioplasty with and without concomitant PRP injection for chronic rotator cuff tendinopathy. While PRP did change some of the tissue characteristics, it did not affect clinical outcomes up to 2 years though both groups did significantly improve over this time.[22]

While tendinopathy progression is not well understood, a number of studies have reported on tear progression. Regarding symptomatic patients with rotator cuff tears, there are a few key consistent findings. In their series of 59 tears, Maman et al. reported that 52% of full-thickness tears progressed compared to 8% of partial thickness tears. Tear progression was more common after 1.5 years follow-up, in patients over 60, and with worse initial fatty infiltration.[5] Safran et al. followed patients under age 60 with full-thickness tears. They observed that 49% increased in size at average 29 months, and pain was associated with progression.[8] In 49 patients followed for an average 8.8 years, Moosmayer et al. found that full-thickness tears increased in size by an average 8.3 millimeter (mm) in the anterior to posterior direction, and 4.5 mm in the medial to lateral direction. Overall, 16% of tears increased at least 2 centimeters (cm) in size. Worse function was associated with this increase of 2 cm and progression of fat atrophy.[6] Yamamoto et al. followed a series of all rotator cuff tears by MRI. At 19 months, 47% had progressed by an average 5.8 mm in length and 3.1 mm in width. Progression was associated with initial full-thickness tears, medium compared to small or massive tears, and smoking.[9] Similarly, Nakamura et al. reported a tear width progression of 5 mm at average 22 months based on MRI, and those less than 1 cm or over 4 cm were less likely to progress.[7] Fucentese at al. followed 24 patients with small to medium full-thickness tears and found that average tear size did not increase. There were slight changes in fat atrophy, but none past grade 2.[2]

While the previous studies include full-thickness tears, few reports are specific to symptomatic partial thickness tears, which may be more similar to the population in our study. In 26 patients who underwent arthroscopic debridement and acromioplasty for a partial-thickness rotator cuff tear, Kartus et al. observed that 9 (35%) progressed to a full-thickness tear based on ultrasound evaluation at average 8-year follow-up[3]. Kong et al. reported on 81 patients who underwent repeat MRI at average 20 months for high-grade, partial-thickness rotator cuffs treated nonoperatively. Progression, defined as at least 20% increase in tear involvement, was seen in 16% of patients. Interestingly, 25% decreased in size by 20%, while no change was reported in the remaining 59% of patients.[4] In their series of 195 patients with asymptomatic rotator cuff tears, Mall et al. observed that 44 became symptomatic. Among these, 6 of the 34 (18%) with full-thickness tears progressed at least 5 mm in size, and 4 of the to 10 (40%) with partial tears developed a full-thickness tear[23].

Among patients that progressed from tendinopathy to tear in our series, the majority developed partial-thickness tears, and only 1 patient developed severe fat atrophy. This would suggest that although there is progression, many of the patients, even if they progress, may still be treated nonoperatively because they have only partial tears. In addition, the likelihood of progression from tendinopathy to an irreparable tear or a large atrophic tear with a low likelihood of healing was very low. There was a trend toward increased likelihood of progression to tear in patients with a greater duration between their MRIs. This is likely because the incidence of rotator cuff tear in the general population increases with age, and longer time between imaging implies more opportunity for shoulder injury. It also suggests that with even longer follow-up, there would be an even greater frequency of progression, although future studies with longer follow-up would be necessary to confirm.

Although 39% of cases progressed from tendinopathy to tear, this study does not prove causality. Whether tendinopathy is a precursor to or a risk factor for tear requires further investigation. Additionally, in patients that have not progressed to tear, whether tendinopathy

Table 4. Risk Factors for Progression

Variable	Nonprogressed	Progressed	*P* Value
Male sex	87% (72/83)	85% (44/52)	.729
Diabetic	13% (11/83)	23% (12/52)	.140
Osteoporotic	4% (3/83)	2% (1/52)	.573
Tobacco use	22% (18/83)	33% (17/52)	.156
Hyperlipidemia	66% (55/83)	62% (32/52)	.577
Hypogonadism	7% (5/72)	14% (6/44)	.233
Age (years)	53 ± 13	56 ± 10	.109
BMI	30 ± 5	30 ± 6	.728
Time between scans (years)	3.2 ± 1.8	3.8 ± 2.1	.08

BMI, body mass index.

is a stepwise progression to worsening disease or, alternatively, demonstrates some degree of interval resolution is not well understood. Therefore, in patients who continue to exhibit symptoms consistent with rotator cuff disease in the setting of known tendinopathy, surveillance is warranted given the high rate of progression as seen here.

Limitations

There are a few limitations of the study. First, this is a retrospective chart and imaging review. Patients were identified by code database queries leading to inherent risks of inadequate identification of all patients appropriate for inclusion. Similarly, demographic and clinical data were obtained from chart review, and, therefore, it is limited regarding what was reported and available. The retrospective nature of the study also means that patients had MRI follow-up at differing time points. All continued to have symptomatic shoulders, but the clinical course between MRIs differs between patients. Second, the study was performed within the VHA and so is inherently specific to this population. Third, a comparison cohort of patients with healthy rotator cuffs was not available. Whether there is a difference in progression to tear between patients with and without tendinopathy is unknown. We also lack data on patients that presented with tendinopathy but improved and did not require a repeat MRI. A prospective power analysis was not performed. On post hoc power analysis to detect a difference with a chi square test using a medium effect size of 0.3, alpha of 0.05, 1 degree of freedom and cohort size of 135 the computed achieved power was 0.94. This indicates the study was appropriately powered. Finally, there is an inherent risk of selection bias given the study design.

Conclusions

Among patients with symptomatic rotator cuff tendinopathy that remained symptomatic at a minimum of 1 year and obtained a follow-up MRI, 39% progressed to a partial or full-thickness tear. None of the factors evaluated in this study correlated with progression from tendinopathy to tear. When patients were grouped based on time between scans as 1 to 2 years, 2 to 5 years, or over 5 years, the rate of progression from tendinopathy to tear was 32%, 37%, and 54%, respectively.

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