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ORIGINAL ARTICLE

# Radiographic progression of arthritic changes in shoulders with degenerative rotator cuff tears

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**Background:** Very little longitudinal information has been available regarding the relationship of cuff tears and arthritis. The purpose of this study was to determine the midterm risk of and risk factors for rotator cuff tear arthropathy progression in a cohort of subjects with an asymptomatic rotator cuff tear.
**Methods:** Baseline (visit 1), 5-year (visit 2), and most recent follow-up (visit 3) radiographs were reviewed in a cohort of 105 subjects enrolled for longitudinal surveillance of asymptomatic degenerative rotator cuff tears and 33 controls. The radiographs were assessed in a blinded, randomized fashion by 3 observers who graded glenohumeral arthritic changes using the Hamada scores, Samilson-Prieto (SPO) scores, and acromiohumeral interval (AHI).
**Results:** Osteoarthritis (SPO classification), cuff tear arthropathy (Hamada classification), and AHI progressed between visits 1 and 3 (median, 8 years; $P < .001$ in all cases). SPO progression was not significantly different for partial- vs. full-thickness vs. control baseline tear types ($P = .19$). Both full-thickness and partial-thickness tears had greater progression in Hamada scores than controls did in the first 5 years of follow-up ($P = .02$ and $P = .03$, respectively), but scores did not differ between partial- and full-thickness tears. Tears with and without enlargement did not differ in progression in SPO grade, Hamada grade, or AHI.
**Conclusions:** Glenohumeral arthritic changes progress significantly but remain minimal within an 8-year period in early to moderate degenerative cuff disease. Whereas the presence of a rotator cuff tear influences progression in Hamada grade, the magnitude of radiographic progression is not influenced by tear severity or enlargement at midterm time points.
**Level of evidence:** Level II; Prognosis Study


**Keywords:** Rotator cuff tear; rotator cuff tear arthropathy; osteoarthritis; natural history; shoulder pain; degenerative joint disease

The time line and risks of progression of degenerative rotator cuff disease to advanced rotator cuff tear arthropathy (RCTA) are unknown. An improved understanding of the risk factors for radiographic progression of cuff tears may improve treatment paradigms for patients with degenerative cuff tears. For many patients, rotator cuff tears progress over time in both size and symptoms.[12,17,19] The end stage of this

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progression is the development of a characteristic set of degenerative changes including proximal humeral migration, acromial acetabularization, and glenohumeral chondral and bone loss, collectively described as RCTA.[10,20,21] Although historically few reliable surgical options existed for this condition,[5] the release of modern reverse total shoulder arthroplasty has led to an ever-increasing number of patients undergoing arthroplasty for the degenerative sequelae of rotator cuff tears.[6,15,25]

RCTA was originally described by Neer >3 decades ago[20]; however, the natural history remains poorly understood. Small, retrospective studies have described worsening radiographic deterioration in 39% to 92% of patients with long-term follow-up of surgically treated patients with massive rotator cuff tears.[8,21,31,32] Alternatively, some retrospective series with long-term follow-up have described durable clinical results with rotator cuff repair.[1,3,7,23,26] No study has prospectively examined rotator cuff tears radiographically to describe the progression of RCTA in a nonsurgical cohort. The risk factors for progression thus remain unknown.

Understanding the likelihood of progression of RCTA and the clinical attributes that modulate this progression is of fundamental importance to defining the natural history of rotator cuff disease. Identification of tear-related risk factors that correlate with arthropathy progression may help focus preventive treatment and direct appropriate counseling of the patient regarding the potential need for shoulder arthroplasty. The purpose of this study was to determine the rate of progression of RCTA in a cohort of subjects with an asymptomatic rotator cuff tear and to analyze factors associated with arthropathy progression.

## Methods

The subjects included in the study are part of a larger cohort of patients with asymptomatic rotator cuff tears who presented for evaluation of shoulder pain secondary to rotator cuff disease in the contralateral shoulder.[12,16] Control subjects with ultrasound scans demonstrating a normal rotator cuff in the study shoulder and a painful rotator cuff tear in the contralateral shoulder were also enrolled. Inclusion criteria for study subjects were (1) bilateral shoulder ultrasonography performed to investigate unilateral rotator cuff–based pain, (2) painful rotator cuff disease in the symptomatic shoulder, (3) a rotator cuff tear in the asymptomatic shoulder at the time of study enrollment, (4) no history of trauma to either shoulder and no traumatic episode through the study period, and (5) a minimum of 5 years of radiographic follow-up. Exclusion criteria were (1) any past or current pain in the "asymptomatic" shoulder at the time of enrollment, (2) continuous use of narcotic or nonsteroidal anti-inflammatory drugs in the 3 months before enrollment, (3) a traumatic episode affecting the symptomatic shoulder, (4) inflammatory arthritis, (5) radiographic evidence of osteoarthritis in the asymptomatic shoulder at the time of enrollment, (6) upper extremity weight-bearing demands, and (7) a subscapularis tendon tear in the asymptomatic shoulder.

### Study protocol

Subjects were enrolled from the clinical practices of 3 surgeons during a 30-month period. The study protocol has been described in depth in previous studies.[12,16] In brief, a trained research nurse performed annual standardized physical examinations with measurement of active range of motion and isometric strength. Patients completed standardized outcome scores including a visual analog scale for pain, the American Shoulder and Elbow Surgeons score, and the Simple Shoulder Test. Patients were specifically questioned about pain at each visits and asked to contact the study coordinator if they developed any new onset shoulder pain. Subjects also underwent standardized annual ultrasound examinations to describe tear width, length, type, fatty atrophy, and enlargement as previously defined.[12] Shoulder ultrasonography, as previously described,[14,16,29] was performed for each shoulder at baseline and annually thereafter. Sonographic data used for this study included baseline, 5-year, and final follow-up data. Tear enlargement was defined as increase in tear width or length of ≥5 mm from baseline values for full-thickness tears only.

### Radiographic analysis

Radiographs were standardized as previously described[13] by specifically selected and trained technicians. Radiographs were saved in the picture archiving and communication system (Siemens, Munich, Germany). Baseline, 5-year, and final follow-up radiographs were analyzed. Our radiology department then randomized and anonymized both the initial and final follow-up radiographs to eliminate bias. These images were then exported into the raw Digital Imaging and Communications in Medicine (DICOM) format. Each radiograph was then evaluated in this anonymized and randomized fashion by 3 independent observers (2 fellows [P.N.C. and D.H.S.] and one attending surgeon [J.D.K.]) in a DICOM viewer (OsiriX; Pixmeo, Geneva, Switzerland).

Each radiograph was graded using the Hamada classification of RCTA.[10] Each radiograph was also graded using the Samilson and Prieto (SPO) classification of glenohumeral osteoarthritis.[22] This classification has been demonstrated to be reliable.[4] Acromiohumeral interval (AHI) was also measured on each true anteroposterior radiograph. The radiograph was performed with the shoulder in slight abduction and neutral rotated but was not fluoroscopically controlled. This distance was defined as the shortest measurable distance between the sclerotic line of the undersurface of the acromion and the superior humeral head articular surface. In those cases in which a traction enthesophyte at the origin of the coracoacromial ligament could be visualized on the scapular Y view, all attempts were made to measure from the native acromion with this enthesophyte excluded. AHI has been demonstrated to have an acceptable if imperfect interobserver reliability.[2,18,24,30]

### Statistical analysis

For SPO and Hamada scores, interobserver reliability was calculated using weighted $\kappa$ values, and consensus scores were used in the analysis. For AHI, interobserver reliability was calculated using intraclass correlation coefficients, and mean values were used in the analysis. Radiographs were divided into baseline (visit 1), 5-year follow-up (visit 2), and most recent follow-up (visit 3). Progression in SPO and Hamada scores over time was statistically compared using generalized estimating equations with a multinomial distribution, a cumulative logit link function, and an independent correlation structure; progression in AHI was analyzed using a mixed model repeated-measures analysis of variance with a heterogeneous autoregressive covariance structure. Using similar models, progression