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ORIGINAL ARTICLE

# A new scale measuring translation of the humeral head as a prognostic factor for the treatment of large and massive rotator cuff tears

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**Background:** Failure rates after rotator cuff repair remain high in patients with massive tears. Although superior translation of the humeral head has been used to assess the severity of rotator cuff tears, the relevance of anterior migration of the humeral head to clinical outcomes has not been established. The purpose of this study was to investigate the potential role of the T-scale, a measure of the anterolateral translation of the humeral head, as a prognostic factor for rotator cuff repair.

**Methods:** One hundred twenty consecutive patients with full-thickness rotator cuff tears underwent primary rotator cuff repair. The T-scale and acromiohumeral interval (AHI) were measured preoperatively on axial computed tomography scans and radiographs, respectively. The correlations of the T-scale and AHI with previously published scores and active forward elevation (FE) were investigated. The outcome of rotator cuff repairs was compared between patients with positive and patients with negative preoperative T-scale values.

**Results:** The preoperative T-scale but not AHI correlated significantly with postoperative FE and clinical scores in patients with large to massive tears but not in those with small to medium tears. Postoperative FE and clinical scores were significantly higher in patients with positive T-scale values than in those with negative T-scale values. The relative risk of retear was 2.0 to 7.9 times greater in patients with negative T-scale values.

**Conclusion:** Patients with large to massive tears and negative T-scale values had poorer clinical outcomes and higher retear rates. A negative T-scale value represents a useful prognostic factor for considering reverse shoulder arthroplasty in patients at greater risk of retear after rotator cuff repair.

**Level of evidence:** Level II; Retrospective Design; Prognosis Study

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**Keywords:** Large and massive rotator cuff tears; anterolateral migration of humeral head; translation of humeral head scale; acromiohumeral interval; cuff repair integrity; reverse shoulder arthroplasty

Ethics committee approval for this study was obtained from the University of Miyazaki Ethical Review Board (2016-073).

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Massive rotator cuff tears present a particularly complex and difficult challenge for orthopedic surgeons. Patients with rotator cuff–deficient shoulders present with variable combinations of pain and dysfunction for which multiple treatment options are available. Joint-preserving techniques for massive rotator cuff tears have been reported with varying results. These techniques include débridement with acromioplasty, partial repair, primary arthroscopic repair, mini-open repair, tissue augmentation, and tendon transfer.[2,3,7,13-16,22,23]

However, the overall outcome after the repair of a massive tear is both less predictable and unsatisfactory, with a high failure rate even after complete repair. When appropriate force couples cannot be adequately re-established, the fulcrum for humeral head rotation is rendered unstable.[3,11] Persistent abnormal superior translation of the humeral head leads to shoulder pseudoparalysis and eventually to anterior-superior escape of the humeral head.[17] In this setting, a reverse shoulder arthroplasty (RSA) prevents superior translation of the humerus, restores deltoid tension, and provides stability to the glenohumeral joint. However, it is difficult to justify arthroplasty in the absence of significant cartilage disease.[17]

Several studies have attempted to identify preoperative factors affecting healing after rotator cuff repair. Higher fatty infiltration of the infraspinatus has been reported to negatively affect rotator cuff healing.[5] The acromiohumeral interval (AHI) has been proposed as a reliable measure of the superior migration of the humeral head.[9] In cases of failed massive rotator cuff repair, reduction in the postoperative AHI was reported as a determinant of the patients' eventual functional outcome. The AHI should thus be considered when ascertaining prognoses and when planning further treatments.[5] However, to date, no preoperative factor has been reported to predict a poor functional outcome. Given the high failure rates of repair after massive rotator cuff tears, identifying patients who are at greater risk of poor outcomes will help surgeons select the most appropriate treatment strategies.

We recently developed a new method of quantifying the anterolateral migration of the humeral head (T-scale) after rotator cuff tear and repair. The purpose of this study was to investigate the potential role of the T-scale in predicting clinical outcomes after rotator cuff repair. An accurate and reliable prognostic marker might serve as a predictive tool to determine the best strategy to treat large to massive tears.

## Materials and methods

### Patient selection

This was a prognosis study with a retrospective design of 120 consecutive patients with chronic full-thickness rotator cuff tears in whom conservative treatment had failed and who underwent primary rotator cuff repair between January 2010 and March 2016. Conservative treatment included medication and injections but no physical therapy. The patients (45 women and 75 men) had a mean age of 65.5 years (range, 40-86 years) at the time of surgery, which was performed by 2 of the authors (N.T. and N.S.). The criteria for surgical repair included patients who (1) had a full-thickness rotator cuff tear and complained subjectively of unacceptable pain or disability after failed nonoperative treatment for at least 6 months, (2) expressed a desire to elevate the arm at or above the level of the head, (3) understood the need to follow the postoperative treatment regimen, and (4) agreed to undergo a clinical and functional evaluation of tendon healing at least 12 months postoperatively. Patients were excluded if they had a history of dislocation or fracture of the shoulder, degenerative or inflammatory arthritis, infection, or neuropathic changes; had undergone prior surgical procedures on the shoulder; or had postoperative follow-up of less than 12 months.

### Surgical techniques

During the surgical procedure, acromioplasty was performed with resection of the coracoacromial ligament as described by Ellman.[8] The tears were classified intraoperatively using the system described by DeOrio and Cofield[6]: small, less than 1 cm; medium, 1 to 3 cm; large, 3 to 5 cm; and massive, greater than 5 cm or involvement of 2 tendons. Patients with small to medium tears underwent arthroscopic single-row repair, the suture bridge method, or the surface-holding method.[4,24,26,29] Patients with large to massive tears underwent repair by the arthroscopic suture bridge and surface-holding methods or open surface-holding repair.[29] The surface-holding method is a modified transosseous-equivalent procedure performed using medial anchors and lateral transosseous sutures.[26,30] In some cases, bone marrow stimulation was applied after anchor insertion.[27] For postoperative rehabilitation, an abduction pillow was used for 6 weeks in patients with small to medium tears or 8 weeks in those with large to massive tears.[26,27]

### Clinical assessment

All patients underwent a physical examination before surgery. Postoperative evaluations were performed at a minimum of 1 year postoperatively on an outpatient basis. The Japanese Orthopaedic Association (JOA) shoulder score (100-point scoring system)[25]; the University of California, Los Angeles (UCLA) rating scale (35-point scoring system)[9]; and the range of active forward elevation (FE) were recorded at each time point.

### Evaluation

The following imaging studies were performed preoperatively and at the last follow-up visit: a true anteroposterior radiograph was taken in neutral shoulder rotation with the patient standing, and the AHI was evaluated as described by Iannotti et al.[19] In the presence of superior escape in which the line tangential to the top of the humeral head was higher than the line parallel to the undersurface of the acromion, the AHI was represented as a negative value. All patients were also imaged preoperatively by axial computed tomography (CT) scanning. In the supine position, the shoulder was held with the long axis of the scapular body and the long axis of the humeral shaft parallel to each other. CT scans were taken perpendicular to the long axis of the scapular body. The T-scale was measured using merged slices of the anterolateral edge of the acromion and the lateral edge of the coracoid process on axial views, and a line was drawn between the 2 portions (Fig. 1). The center of the humeral head was defined by fitting a circle to the articular surface on the CT slice at the level

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