J Shoulder Elbow Surg (2017) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Critical shoulder angle is associated with full-thickness rotator cuff tears in patients with glenohumeral osteoarthritis

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Background: Higher critical shoulder angle (CSA) is correlated with rotator cuff tears (RCTs), whereas lower CSA is associated with glenohumeral osteoarthritis (OA). Our goal was to investigate whether patients with concurrent glenohumeral OA and full-thickness RCTs demonstrate a higher CSA than patients with OA alone.

Methods: Using a 2-surgeon shoulder arthroplasty registry, we identified 31 patients with glenohumeral OA and full-thickness RCTs confirmed by plain radiography and magnetic resonance imaging, respectively. Sixty-two age- and gender-matched controls (1:2 ratio) with glenohumeral OA and an intact rotator cuff were identified from the same registry. Two independent observers evaluated the radiographs for CSA and acromiohumeral index.

Results: The average CSA was 30° in the OA control group and 35° in the concurrent RCT and OA group ($P < .0001$). Acromiohumeral index was comparable between the groups ($P = .13$). Interobserver reliability of the independent reviewers was excellent ($\kappa = 0.89$; $P = 0.95$). The receiver operating characteristic curve for CSA demonstrated that a value >35° was 90% specific and 52% sensitive for a full-thickness RCT in the setting of OA (area under curve = 0.84).

Conclusion: Concurrent glenohumeral OA and full-thickness RCT are associated with greater CSA values compared with patients with glenohumeral OA alone. The CSA measurement may be useful in determining the need for magnetic resonance imaging to assess rotator cuff integrity in the arthritic population.

Level of evidence: Level IV; Case-Control Design; Diagnostic Study

Keywords: Critical shoulder angle; glenohumeral osteoarthritis; rotator cuff tear; shoulder radiograph; arthroplasty; magnetic resonance imaging (MRI)

The critical shoulder angle (CSA) is defined as the angle between the plane of the glenoid and the connecting line to the most lateral border of the acromion on the true anteroposterior (AP) radiograph of the shoulder (Figs. 1 and 2). The measurement is simple and can be obtained from plain radiographs. In the original paper by Moor et al,[19] a smaller

This study was approved by the Institutional Review Board of New England Baptist Hospital: No. 971784.

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http://dx.doi.org/10.1016/j.jse.2017.05.020

CSA was associated with glenohumeral osteoarthritis (OA) and a larger CSA was associated with rotator cuff tear (RCT). Additional clinical studies have corroborated these findings.[2,21] Biomechanical investigations also support the theory that higher CSA is associated with a greater risk for development of an RCT. Gerber et al demonstrated an increase in supraspinatus load with CSAs >38°.[11] Furthermore, Moor et al[20] demonstrated that CSAs >35° resulted in an increased risk of humeral head translation, and Engelhardt et al[5] found a strong positive correlation between CSA and humeral head translation, which is believed to be a factor in the development of RCTs.

Preoperative imaging is critical in planning for shoulder arthroplasty. Computed tomography (CT) scan has been the standard for preoperative assessment of glenoid morphology as bone stock, wear pattern (ie, Walch classification), and version are critically important considerations for implant selection, fixation, and glenoid reaming. However, magnetic resonance imaging (MRI) is the preferred modality for evaluating rotator cuff integrity as the sensitivity and specificity of MRI for diagnosis of RCTs have been shown to be >90%.[3,29] Given the reported incidence of concurrent RCT and glenohumeral OA in the range of 8%-9%,[4,10] it is important that surgeons planning for shoulder arthroplasty rule out rotator cuff disease, which may be an indication for reverse shoulder arthroplasty.[6,7,12] Nevertheless, for patients with glenohumeral OA and no superior humeral head migration on initial radiographs, it is commonplace for surgeons to obtain a CT scan over an MRI, as the incidence of RCTs in this population is considered relatively low.

To our knowledge, no study has looked at CSA values in patients with both glenohumeral OA and full-thickness RCTs. Given that research has demonstrated a positive correlation between CSA and RCT, we hypothesized that these patients would have a significantly higher CSA than those with only glenohumeral OA. We believe CSA may prove to be a useful tool to help surgeons determine when it is necessary to order a preoperative MRI study to evaluate the rotator cuff.

Materials and methods

Subjects were identified from a prospectively maintained, 2-surgeon (A.J. and D.P.E.) registry of patients who underwent shoulder arthroplasty dating back to April 2011. Patients were included in the experimental group if they were noted to have glenohumeral OA without superior humeral head migration on a plain radiograph (true AP view) as well as a nontraumatic, full-thickness tear of the supraspinatus tendon (RCT) as verified by an MRI study (Fig. 1). In all cases, glenohumeral OA was characterized by extensive degenerative changes warranting shoulder arthroplasty, such as osteophyte formation and severe joint space narrowing. Both surgeons routinely use MRI for preoperative imaging before shoulder arthroplasty to evaluate both the rotator cuff and glenoid morphology.[18]

An age- and gender-matched control group was identified from the registry in a 1:2 ratio as a method of increasing power, given the limited number of subjects who were identified for the experimental group. Patients were included in the control group if they had glenohumeral OA on a true AP radiograph of the shoulder, no apparent superior humeral head migration, and no evidence of RCT on MRI (Fig. 2).

Patients were excluded from both groups if they did not have an adequate preoperative true AP radiograph or MRI scan or if they reported having previous ipsilateral shoulder surgery. Other criteria for exclusion were diagnoses of avascular necrosis, inflammatory arthritis, and rotator cuff arthropathy.

CSA was measured from true AP radiographs using the technique described by Moor et al.[19] The angle was formed between a line drawn from the superior to inferior border of the glenoid and a line from the inferior border of the glenoid to the lateral aspect of the acromion (Fig. 2). Two board-certified orthopedic surgeons (M.T.M. and R.N., not the original operating surgeons) independently assessed the CSA and acromiohumeral index (AHI) of each patient using true AP radiographs. Only radiographs with visible joint space and minimal overlap of the posterior and anterior rim of the glenoid were included. The observers were blinded to each other's measurements and the patients' MRI results. All measurements were performed electronically on a picture archiving and communication system workstation.

AHI was measured according to the technique described by Lehtinen et al.[16] The distance measured is derived from a vertical

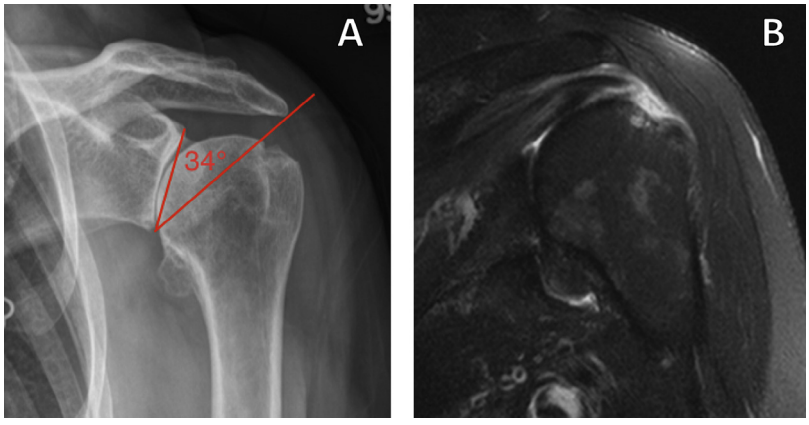

Figure 1 Example of patient with (**A**) glenohumeral osteoarthritis on plain radiograph annotated with the critical shoulder angle (CSA) measurement and (**B**) a full-thickness rotator cuff tear visualized on magnetic resonance imaging. The CSA for this radiograph was 34°, and the average CSA of patients with concurrent osteoarthritis and rotator cuff tear in this study was 35°.