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ORIGINAL ARTICLE

Glenoid component loosening associated with increased critical shoulder angle at midterm follow-up

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Background: Glenoid component loosening is a common failure mode of total shoulder arthroplasty (TSA). A larger critical shoulder angle (CSA) may cause superior glenoid component loading and more rapid component loosening. The purpose of this study was to define the relationship between the CSA and glenoid component loosening in midterm follow-up after TSA.

Methods: We conducted a retrospective study of 61 primary TSAs for osteoarthritis with an average follow-up of 5.0 ± 2.2 years without surgical revision. Standard true anteroposterior radiographs postoperatively and at longest follow-up were graded in a blinded and repetitive nature for pegged glenoid radiolucent lines and measured for the CSA. An "at-risk" glenoid was defined as grade 3 or higher lucency.

Results: The average CSA was 32° ± 5°, median midterm lucency grade was 2 (range, 0-5), and median progression of lucency grade was 1 (range, −1 to 4). At midterm follow-up, 20% of TSAs were grade 3 or higher mean glenoid lucency, with an average CSA of 36°. There was a statistically significant correlation between CSA and both glenoid lucency grade (odds ratio, 1.20 per degree CSA) and progression of lucency grade (odds ratio, 1.24). An increase in CSA of 10° was associated with a 6.2-fold increased odds of having an at-risk glenoid.

Conclusion: This study identifies the CSA as a risk factor for glenoid component loosening after TSA. Our findings suggest that the CSA may be a modifiable factor during surgery to improve glenoid component outcomes.

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

Keywords: Total shoulder arthroplasty; critical shoulder angle; glenohumeral arthritis; shoulder radiograph; glenoid component; loosening; radiolucent lines; arthroplasty

Glenoid loosening remains one of the most common modes of failure in total shoulder arthroplasty (TSA) resulting in revision surgery.[9] Whereas factors contributing to glenoid loosening have been identified, including component edge loading from malposition, soft tissue imbalance, rotator cuff tear, and inadequate fixation or loss of subchondral bone support, risk factors are continuing to be defined that predict implant loosening and failure. Many studies using both

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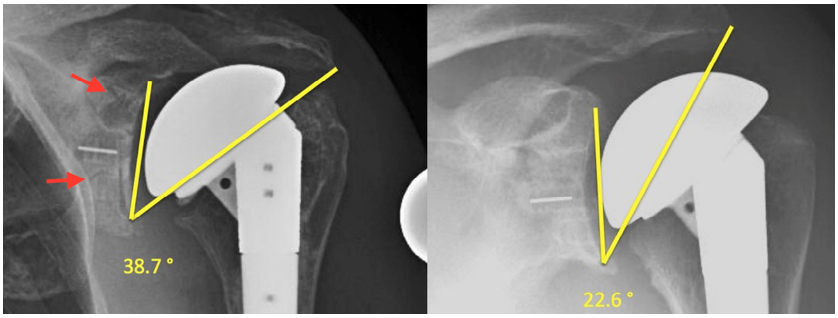

Figure 1 Critical shoulder angle (CSA) measurement after total shoulder arthroplasty. Total shoulder arthroplasty with high CSA (*left*) with glenoid lucency (*arrows*) and low CSA without glenoid lucency (*right*).

radiography and computed tomography (CT) have been performed to identify measurements that may accurately describe the orientation and morphology of the glenoid and potentially provide insight into glenohumeral biomechanics that place the glenoid implant at risk.[1-5,8,10,11,13,16] Glenoid inclination and version have been shown to be critical in both preoperative planning and correction during surgery and to predict outcomes after TSA.[6] The critical shoulder angle (CSA), a radiographic parameter initially described by Moor et al, takes into account both glenoid inclination and acromial index and is an indirect measure of the deltoid force vector in relation to the glenohumeral joint.[14] CSA is defined as the angle between a line drawn from the inferior to superior glenoid rim and a line drawn from the inferior glenoid component edge to the inferolateral aspect of the acromion on a true anteroposterior (AP) radiograph[11] (Fig. 1). Substantial research has been published describing the relationship between CSA and both the development of glenohumeral osteoarthritis and rotator cuff disease.[1,11,12,14] Decreased CSA (<30°) has been shown to correlate with the development of glenohumeral osteoarthritis, whereas increased CSA (>35°) has been associated with increased incidence of rotator cuff tears.[11] After TSA, we hypothesize that a higher CSA angle may cause increased superior glenoid component edge loading and more rapid glenoid component loosening. The purpose of this study was to define the relationship between the CSA and glenoid component loosening in midterm follow-up after TSA.

Materials and methods

We performed a retrospective study of all primary TSA patients treated for osteoarthritis between 1998 and 2009 who had immediate postoperative radiographic follow-up and >3 years of clinical and radiographic follow-up and who were treated with a pegged glenoid component. Patients who had prior surgery on the ipsilateral shoulder or had any subsequent surgical procedure on the ipsilateral shoulder were excluded from the study.

After applying inclusion and exclusion criteria, we had a study cohort of 61 primary TSAs performed in 55 patients with an average follow-up of 5.0 ± 2.2 years. There were 30 men (33 shoulders) and 25 women (28 shoulders) with a mean age of 65.2 years (25-87 years) at the time of surgery. Demographic data can be found in Table I. The TSA was performed by 2 senior shoulder surgeons with the same in-line pegged cemented all-polyethylene glenoid component among all study patients (Zimmer BF Pegged Glenoid Component, Warsaw, IN, USA). Both surgeons preferred to partially ream the high side of the glenoid and to perform a partial retroversion correction in the cases of B-type glenoids while attempting to maintain subchondral and glenoid vault bone. Both surgeons cemented the glenoid components in a similar manner by filling the 3-peg holes with cement and then repeatedly pressurizing the cement with a 3-peg–shaped impactor. Standard true AP radiographs were retrospectively graded by 2 surgeons for pegged glenoid radiolucent lines as described by Lazarus and measured for CSA. True AP radiographs (Grashey view) were taken per our radiology department's clinical protocol by aiming the beam 30° to 45° or approximately perpendicular to the plane of the scapula. No specific measures were taken to control for angular radiographic projection. Measurement of CSA after TSA has never been defined, so we defined it relative to the glenoid component articulating surface on a true AP radiograph rather than the remaining glenoid bone, which may be complicated by inferior or superior osteophytes and not represent the inclination of the glenoid component face. Therefore, the CSA after TSA was defined as the angle between a line drawn from the inferior to superior glenoid component lateral rims and a line drawn from the inferior glenoid component lateral rim to the inferolateral aspect of the acromion on a true AP radiograph. Glenoid wear was assessed using the Walch classification.[15] Immediate postoperative radiographs were graded for radiolucent lines to serve as a baseline to evaluate for lucency progression and then again using radiographs obtained at the patient's longest follow-up office visit (Fig. 2). The observers measured

Table I Demographic data and descriptive statistics

No. of patients in study	61 shoulders (55 patients)
Age, mean (SD)	65.2 (12.1) years
Sex	45.5% female
	54.5% male
Dominance	80% right hand
	18.2% left hand
	1.8% ambidextrous
Follow-up, mean (SD)	5.0 (2.2) years
CSA, mean (SD)	32° (5°)
Lucency grade, mean	1.8 (SD, 1.1; range, 0-5)
Lucency progression, mean	1.1 (SD, 1.2; range, −1 to 4)

SD, standard deviation; *CSA*, critical shoulder angle.