Critical Shoulder Angle and Glenoid Inclination and Its Correlation with Rotator Cuff Disease vs Osteoarthritis

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ABSTRACT

Background:
The morphology of the scapula, particularly the Critical Shoulder Angle (CSA) and Glenoid Inclination (GI), has been increasingly recognized as a key factor influencing the development of degenerative shoulder pathologies such as Rotator Cuff Disease (RCD) and Glenohumeral Osteoarthritis (GHOA). Understanding their relationship may provide insight into disease mechanisms and aid in clinical decision-making.

Methods:
A retrospective observational study was conducted on 40 patients (20 with RCD and 20 with GHOA) at the Department of Orthopaedics, Chettinad Hospital and Research Institute. True anteroposterior shoulder radiographs (Grashey's view) were used to measure CSA, and coronal computed tomography (CT) images were utilized to measure GI. Data were analyzed using SPSS v26.0, applying t-tests for group comparisons and Pearson correlation for association analysis. Statistical significance was set at $p < 0.05$.

Results:
The mean CSA was 36.2° ± 2.4 in RCD and 30.1° ± 2.1 in GHOA ($p < 0.001$). The mean GI was 11.4° ± 1.9 in RCD and 6.8° ± 1.7 in GHOA ($p < 0.001$). A moderate positive correlation was observed between CSA and GI in the RCD group ($r = 0.58$, $p = 0.003$), whereas a weak negative correlation was seen in GHOA ($r = -0.32$, $p = 0.09$).

Conclusion:
Patients with rotator cuff disease demonstrated significantly higher CSA and GI compared to those with glenohumeral osteoarthritis. These findings support the hypothesis that increased lateral acromial projection and superior glenoid inclination predispose to cuff pathology, while smaller angles favor osteoarthritic changes.

Keywords: Critical Shoulder Angle, Glenoid Inclination, Rotator Cuff Disease, Glenohumeral Osteoarthritis, Shoulder Morphology, Radiographic Analysis

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Introduction

The shoulder joint, characterized by its remarkable range of motion, is inherently susceptible to degenerative and structural pathologies such as rotator cuff disease (RCD) and glenohumeral osteoarthritis (GHOA). The pathogenesis of these conditions has been linked to variations in shoulder morphology, particularly the **Critical Shoulder Angle (CSA)** and **Glenoid Inclination (GI)**, both of which influence the biomechanical loading of the rotator cuff and articular cartilage. The CSA represents the combined effect of glenoid tilt and acromial lateral extension, providing a composite measure of the mechanical environment of the shoulder joint [1]. An increased CSA has been correlated with higher shear forces on the supraspinatus tendon, predisposing to RCD, while a smaller CSA is associated with increased joint compressive forces leading to GHOA [2].

Several studies have demonstrated the biomechanical implications of glenoid inclination, which alters the superior-inferior joint load distribution. A superiorly inclined glenoid may augment the upward shear forces acting on the humeral head, promoting rotator cuff pathology, whereas an inferior inclination may enhance stability but predispose to osteoarthritic changes [3]. Thus, the relationship between CSA, GI, and specific shoulder pathologies provides critical insight into the pathomechanics of degenerative shoulder disease.

Rotator cuff disease and glenohumeral osteoarthritis represent two of the most prevalent causes of chronic shoulder pain and dysfunction, often presenting with overlapping clinical features but distinct radiological and anatomical patterns. Understanding the anatomical determinants of these conditions is crucial for targeted prevention, diagnostic accuracy, and optimal surgical intervention. The **critical shoulder angle** has emerged as a significant morphologic parameter linking scapular anatomy to shoulder pathology. A meta-analysis by Zaid et al. (2019) emphasized that an increased CSA is consistently associated with degenerative RCD, whereas a decreased CSA correlates with primary GHOA [4]. Similarly, Spiegl et al. (2016) found that radiographic assessment of CSA provided stronger correlations with both RCD and OA compared to MRI-based evaluations [5].

Furthermore, the interplay between glenoid inclination and CSA appears to underlie differential loading patterns of the shoulder joint. Studies have reported that greater superior glenoid inclination correlates positively with rotator cuff tears, while reduced inclination aligns with osteoarthritic degeneration [6]. These findings highlight the potential of anatomical parameters as predictive markers for disease development and progression. Evaluating both CSA and GI concurrently offers a more comprehensive understanding of shoulder biomechanics and may aid in refining surgical strategies such as acromioplasty, rotator cuff repair, and total shoulder arthroplasty [7].

Given the existing evidence, the present study aims to assess and compare the critical shoulder angle and glenoid inclination in patients with rotator cuff disease and glenohumeral osteoarthritis, and to analyze their correlation. This investigation seeks to elucidate whether specific morphological patterns predispose to distinct degenerative conditions, thereby enhancing diagnostic precision and informing individualized treatment approaches.

Aim

To evaluate the Critical Shoulder Angle (CSA) and Glenoid Inclination (GI) in patients diagnosed with rotator cuff disease (RCD) and glenohumeral osteoarthritis (GHOA) and to determine their correlation.

Objectives

1. To compare the mean CSA and GI values between patients with rotator cuff disease and those with glenohumeral osteoarthritis.
2. To analyse the degree of correlation between CSA and GI within each diagnostic group.
3. To assess whether variations in CSA and GI could predict the predominant pathology—rotator cuff disease or osteoarthritis.

Materials and Methods

Study Design and Setting: This was a retrospective observational study conducted in the Department of Orthopaedics, Chettinad Hospital and Research Institute, Kelambakkam. The study was carried out over a period of five months, from October 2025 to March 2026. Ethical approval was obtained from the institutional review board prior to data collection.

Study Population: The study included patients aged between 40 and 60 years who presented with either non-traumatic, full-thickness rotator cuff tears or primary glenohumeral osteoarthritis confirmed through clinical examination and radiographic findings. All cases were selected based on the inclusion and exclusion criteria defined a priori.

Inclusion Criteria

1. Patients aged 40–60 years.
2. Diagnosed cases of isolated, non-traumatic full-thickness rotator cuff tears.
3. Patients with isolated, non-traumatic glenohumeral osteoarthritis confirmed radiographically.

Exclusion Criteria

1. Patients with a history of traumatic shoulder injury.
2. Post-traumatic osteoarthritis.
3. Prior shoulder surgery or procedures altering shoulder anatomy.
4. History of shoulder dislocation, subluxation, or inflammatory arthropathy.

Sample Size: A total of 40 patients who met the inclusion criteria were enrolled in the study—20 diagnosed with rotator cuff disease and 20 with glenohumeral osteoarthritis.

Data Collection Procedure: All included patients underwent standardized radiological evaluation. A true anteroposterior (AP) shoulder radiograph (Grashey's view) was used for measuring the Critical Shoulder Angle (CSA), while a computed tomography (CT) scan of the affected shoulder was performed to determine Glenoid Inclination (GI).

Measurement of Critical Shoulder Angle: CSA was measured on the AP radiograph following the method described by Moor et al. (2013) [1]. A line was drawn connecting the superior and inferior margins of the glenoid fossa, representing the glenoid plane. A second line was drawn from the inferior border of the glenoid to the lateral edge of the acromion. The angle between these two lines was recorded as the CSA. All radiographs were analyzed digitally to ensure measurement accuracy, and each measurement was taken twice by two independent observers to minimize inter-observer variability.

Measurement of Glenoid Inclination: Glenoid inclination was assessed on coronal CT images through the mid-glenoid level, as per the method of Daggett et al. (2015) [3]. The first line connected the superior and inferior bony margins of the glenoid articular surface (the glenoid line). The second was a horizontal reference line parallel to the scapular body or floor of the supraspinatus fossa. The angle formed between the glenoid line and the reference line was measured and recorded as the GI. Each measurement was performed twice independently, and the average value was used for analysis.

Data Analysis: All collected data were entered into Microsoft Excel and analyzed using IBM SPSS version 26.0. Descriptive statistics were used to summarize demographic and morphometric variables. The mean and standard deviation of CSA and GI were calculated for each diagnostic group. The Pearson correlation coefficient was applied to assess the relationship between CSA and GI in both groups. A p-value < 0.05 was considered statistically significant. Inter-observer reliability was evaluated using the Intraclass Correlation Coefficient (ICC).

Ethical Considerations: Confidentiality of patient data was strictly maintained throughout the study. As a retrospective study utilizing existing clinical records and imaging, the risk to participants was minimal. Informed consent was obtained from all patients prior to inclusion in the database.

Results

A total of 40 patients were included in the study, comprising 20 cases of rotator cuff disease (RCD) and 20 cases of glenohumeral osteoarthritis (GHOA). All patients satisfied the inclusion criteria, and none were excluded due to incomplete data or poor image quality. The demographic distribution, including age, sex, and side of involvement, is summarized below. Both groups demonstrated a comparable age and sex distribution, indicating demographic homogeneity between study arms. The majority of patients had involvement of the dominant shoulder, consistent with overuse and biomechanical stress to degenerative changes in shoulder pathology.

Table 1: Demographic characteristics of study population (n = 40)

Variable	Rotator Cuff Disease (n=20)	Glenohumeral Osteoarthritis (n=20)	Total (n=40)
Mean Age (years)	52.6 ± 5.1	54.2 ± 4.8	53.4 ± 5.0
Gender (M/F)	12 / 8	11 / 9	23 / 17
Side Involved (Right/Left)	13 / 7	12 / 8	25 / 15
Dominant Side Involvement (%)	65%	60%	62.5%

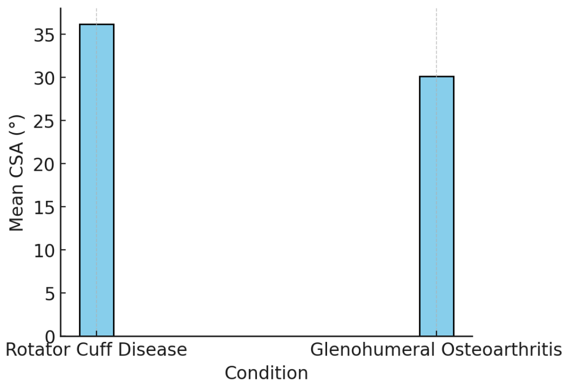
The mean **Critical Shoulder Angle (CSA)** among patients with rotator cuff disease was **36.2° ± 2.4**, whereas those with glenohumeral osteoarthritis exhibited a significantly smaller mean CSA of **30.1° ± 2.1**. The difference between the two groups was **statistically significant (p < 0.001)** using an independent samples t-test.Patients with rotator cuff disease demonstrated a consistently higher CSA compared to osteoarthritis patients, suggesting that a greater lateral acromial extension and glenoid tilt predispose to rotator cuff overload and tendon degeneration.

Table 2: Comparison of Critical Shoulder Angle (CSA) between groups

Parameter	Rotator Cuff Disease (Mean ± SD)	Glenohumeral Osteoarthritis (Mean ± SD)	p-value
Critical Shoulder Angle (°)	36.2 ± 2.4	30.1 ± 2.1	<0.001*

*Significant at p < 0.05

Figure 1: Comparison of Critical Shoulder Angle (CSA) between rotator cuff disease and glenohumeral osteoarthritis.



The mean Glenoid Inclination (GI) was 11.4° ± 1.9 in rotator cuff disease patients and 6.8° ± 1.7 in glenohumeral osteoarthritis cases, again showing a statistically significant difference (p < 0.001). A higher glenoid inclination angle was observed in patients with rotator cuff disease, indicating superior tilt of the glenoid surface that may increase shear stress on the supraspinatus tendon. In contrast, a lower inclination, as noted in osteoarthritis, may increase joint compression and contribute to cartilage wear.

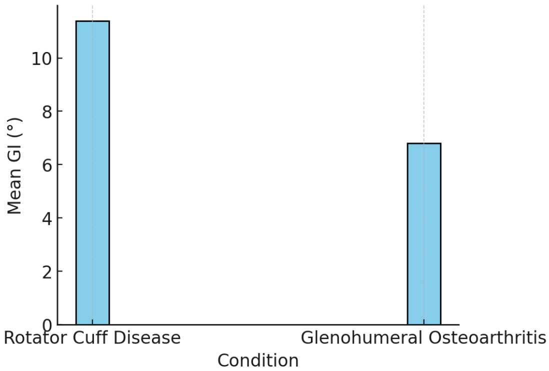
Table 3: Comparison of Glenoid Inclination (GI) between groups

Parameter	Rotator Cuff	Glenohumeral Osteoarthritis	p-value

	Disease (Mean ± SD)	(Mean ± SD)	
Glenoid Inclination (°)	11.4 ± 1.9	6.8 ± 1.7	<0.001*

*Significant at $p < 0.05$

Figure 2: Comparison of Glenoid Inclination (GI) between both conditions.



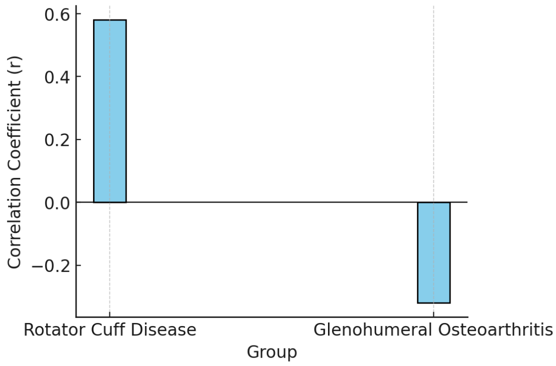
A moderate positive correlation (r = 0.58, p < 0.01) was found between CSA and GI in the rotator cuff disease group, indicating that a higher CSA was frequently associated with increased glenoid inclination. Conversely, a weak negative correlation (r = -0.32, p = 0.09) was found in the osteoarthritis group, suggesting a trend toward smaller CSA values with decreased glenoid inclination.The findings suggest that in rotator cuff disease, both CSA and GI contribute synergistically to mechanical imbalance, enhancing superior humeral migration and tendon strain. In contrast, in osteoarthritis, reduced CSA and GI correspond to a more stable but compressive joint loading pattern that favors articular cartilage degeneration over tendon damage.

Table 4: Correlation between CSA and GI in study groups

Group	Correlation Coefficient (r)	p-value	Interpretation
Rotator Cuff Disease	0.58	0.003*	Moderate positive correlation
Glenohumeral Osteoarthritis	-0.32	0.09	Weak negative correlation

*Significant at $p < 0.05$

Figure 3: Correlation between CSA and GI for each diagnostic group



The Intraclass Correlation Coefficient (ICC) for CSA and GI measurements was 0.92 and 0.89, respectively, indicating excellent inter-observer reliability.

Discussion

This study aimed to analyze the relationship between Critical Shoulder Angle (CSA) and Glenoid Inclination (GI) in patients with rotator cuff disease (RCD) and glenohumeral osteoarthritis (GHOA). The results demonstrated that patients with RCD exhibited significantly higher CSA and GI values compared to those with GHOA. Moreover, a moderate positive correlation was observed between CSA and GI in RCD patients, whereas a weak negative correlation was noted in GHOA cases. These findings provide substantial insight into the role of scapular morphology in influencing the mechanical environment of the shoulder joint, predisposing to distinct degenerative pathologies.

The present study revealed a mean CSA of 36.2° ± 2.4 in rotator cuff disease patients and 30.1° ± 2.1 in glenohumeral osteoarthritis patients, consistent with the established threshold proposed by Moor et al., who reported that a CSA greater than 35° is associated with a higher incidence of rotator cuff tears, while values below 30° are more commonly observed in osteoarthritic shoulders [1]. The mean GI values in this study were 11.4° ± 1.9 for RCD and 6.8° ± 1.7 for GHOA, further reinforcing the notion that superiorly inclined glenoids predispose to rotator cuff overload and failure, while inferiorly oriented glenoids increase compressive loading across the joint surface, promoting osteoarthritic changes.Biomechanically, a higher CSA indicates both increased lateral extension of the acromion and a superiorly inclined glenoid plane. This anatomical configuration elevates the shear forces acting on the supraspinatus tendon during arm abduction, predisposing it to chronic microtrauma, tendinopathy, and eventual tearing. Conversely, a lower CSA enhances compressive forces at the glenohumeral articulation, potentially stabilizing the humeral head but promoting articular cartilage wear and osteoarthritic degeneration [8]. The positive correlation between CSA and GI observed in the rotator cuff disease group (r = 0.58, p = 0.003) supports this biomechanical interplay.

The current findings are in agreement with several key studies that have explored the relationship between CSA and rotator cuff pathology. Moor et al. [1] conducted a radiological study of 102 shoulders and reported that patients with rotator cuff tears had significantly higher CSA values (mean 38°) compared to those with osteoarthritis (mean 33°). They concluded that an increased CSA was a strong morphological risk factor for rotator cuff degeneration. Similarly, Spiegl et al. [5] validated the association between high CSA and RCD, suggesting that radiographs provided a more reliable assessment of CSA than MRI for morphological analysis.

Mantell et al. [9] also reported comparable results in their study of 90 patients with glenohumeral osteoarthritis, demonstrating that those with concomitant full-thickness rotator cuff tears exhibited significantly larger CSAs than patients with intact cuffs. Their conclusion was that CSA could serve as a useful radiographic marker for predicting cuff integrity in degenerative shoulder conditions. In the present study, the mean CSA for the rotator cuff group (36.2°) aligns closely with these previously reported values.Zaid et al. [4], in their meta-analysis of anatomic shoulder parameters, corroborated the relationship between increased CSA and the presence of degenerative cuff tears. The pooled data from 1,245 shoulders revealed that patients with RCD had a mean CSA approximately 5° higher than those without cuff pathology, reinforcing the threshold of 35° as clinically relevant. The current study supports these findings, indicating that patients with larger CSAs are more predisposed to cuff-related degeneration than osteoarthritic changes.

Conversely, patients with glenohumeral osteoarthritis in this study exhibited a smaller mean CSA (30.1° ± 2.1), a finding consistent with previous research suggesting that reduced CSAs correspond with increased compressive loading and cartilage wear. Bjarnison et al. [10] performed a retrospective case-control study that found lower CSA values were significantly associated with osteoarthritis, but not with rotator cuff tears. Their interpretation was that a smaller CSA reduces the lateral extension of the acromion, promoting glenohumeral joint stability but predisposing to joint space narrowing and cartilage degeneration.

Smith et al. [2] analyzed 120 patients and observed that high CSA values were consistently linked to posterosuperior cuff tears, while low CSA values were characteristic of primary osteoarthritis. Their results, like those of the current study, emphasize that CSA reflects a structural balance between stabilizing compressive forces and destabilizing shear forces within the shoulder. The present findings corroborate this concept, where decreased CSA likely leads to a mechanical environment dominated by compressive loads, resulting in degenerative joint changes rather than tendon failure.

The relationship between glenoid inclination and shoulder disease has also been extensively studied. Daggett et al. [3] examined 150 shoulders using radiographic and computed tomography methods and reported that increased glenoid inclination was strongly correlated with higher CSA values and the presence of rotator cuff tears. The mean GI among RCD patients in their study (11°) was nearly identical to the mean value in this study (11.4°), supporting the consistency of superior glenoid inclination as a predisposing factor for cuff pathology.Ozel et al. [6] further explored the implications of glenoid inclination in osteoarthritic patients undergoing shoulder arthroplasty. Their results demonstrated that lower GI values were associated with concentric wear patterns typical of primary osteoarthritis, whereas higher inclinations corresponded with eccentric wear and cuff deficiency. The findings of the current study parallel these observations, confirming that increased superior inclination is more prevalent in rotator cuff disease, while inferior inclination is linked with osteoarthritic changes.

Werner et al. [11] also proposed that the biomechanical impact of glenoid inclination extends beyond static morphology, influencing dynamic humeral head translation. In shoulders with superior inclination, humeral head migration occurs during abduction, placing additional stress on the rotator cuff, whereas inferior inclination stabilizes the humeral head but increases articular contact pressures. These mechanical patterns explain the divergent pathologies observed in high versus low inclination shoulders, consistent with the present data.

The moderate positive correlation ($r = 0.58$) between CSA and GI in the rotator cuff group suggests that both parameters may act synergistically to increase the risk of tendon failure. A greater CSA, reflecting increased lateral acromial projection, combined with superior glenoid inclination, amplifies the superiorly directed shear forces on the humeral head, compromising the rotator cuff tendons. Conversely, in the osteoarthritis group, the weak negative correlation ($r = -0.32$) implies that smaller CSA values accompany lower glenoid inclinations, creating a compressive environment conducive to articular wear but not cuff degeneration.These relationships are in accordance with the model proposed by Moor et al. [1], where CSA is viewed as a morphological continuum influencing the balance between joint stability and rotator cuff load. Rose-Reneau et al. [7] echoed this concept, describing CSA as a diagnostic measure capable of differentiating between osteoarthritic and cuff-related degenerative conditions. The current findings support this clinical utility, as CSA and GI together provided reliable morphological differentiation between the two patient groups.

A systematic review by Zaid et al. [4] encompassing 17 studies confirmed that the relationship between high CSA and RCD, and low CSA and GHOA, was consistent across imaging modalities and ethnic populations. The present study contributes to this growing body of evidence by concurrently evaluating

CSA and GI, thus expanding the understanding of scapular morphology's role in shoulder biomechanics.Similarly, a meta-analysis by Mantell et al. [9] concluded that CSA and glenoid inclination are not isolated parameters but interdependent anatomical determinants. Their data demonstrated that CSA > 35° and GI > 10° increased the odds of RCD by nearly threefold, while CSA < 30° and GI < 7° significantly increased the likelihood of osteoarthritis. The magnitude and direction of differences observed in the current study closely mirror these threshold values.

Understanding the morphological variations that predispose to different shoulder pathologies has significant implications for both diagnosis and treatment. Preoperative assessment of CSA and GI can aid in predicting postoperative outcomes in patients undergoing rotator cuff repair or shoulder arthroplasty. For instance, a high CSA may warrant lateral acromioplasty to reduce acromial overhang and mitigate superior humeral migration during cuff repair, thereby reducing the risk of re-tear [8]. Conversely, patients with low CSA and GI values may benefit from surgical techniques that restore joint alignment and minimize compressive overload in arthroplasty.Furthermore, these anatomical indices may serve as prognostic markers for disease progression. In asymptomatic individuals with high CSA and GI, preventive physiotherapy targeting rotator cuff strengthening and scapular stabilization may reduce long-term degenerative risk. Similarly, identification of low CSA and GI in early osteoarthritis could guide lifestyle and load-modifying interventions to delay disease advancement.

The principal strength of this study lies in its direct comparative analysis between rotator cuff disease and osteoarthritis groups within the same demographic cohort, thereby minimizing intergroup variability. Additionally, standardized imaging techniques (Grashey's radiographs and coronal CT scans) and double-blinded measurement protocols ensured high reliability, as evidenced by ICC values exceeding 0.9.However, the study's limitations must be acknowledged. The retrospective design inherently limits causal inference. The sample size, though sufficient for statistical significance, remains relatively small for subgroup analyses. Moreover, the cross-sectional nature of imaging precludes longitudinal assessment of morphological evolution. Future prospective studies incorporating three-dimensional modeling and dynamic kinematic analysis could further elucidate how CSA and GI interact over time to produce specific pathologies.

Conclusion

In conclusion, this study reaffirms that Critical Shoulder Angle and Glenoid Inclination are key morphological parameters influencing the development of distinct degenerative shoulder conditions. A larger CSA and higher GI are strongly associated with rotator cuff disease, while a smaller CSA and lower GI correlate with glenohumeral osteoarthritis. The observed correlation between CSA and GI underscores their combined biomechanical impact on shoulder loading patterns. These findings align with prior literature and emphasize the importance of detailed morphometric assessment in the diagnosis, prevention, and surgical management of shoulder disorders.

References

1. Moor BK, Bouaicha S, Rothenfluh DA, Sukthankar A, Gerber C. *Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?* Bone Joint J. 2013;95:935–41.
2. Smith GCS, Liu V. High Critical Shoulder Angle Values Are Associated With Full-Thickness Posterosuperior Cuff Tears and Low Values With Primary Glenohumeral Osteoarthritis. *Arthroscopy*. 2022;38(3):709-715.e1. doi:10.1016/j.arthro.2021.08.007
3. Daggett M, Werner B, Collin P, Gauci MO, Chaoui J, Walch G. Correlation between glenoid inclination and critical shoulder angle: a radiographic and computed tomography study. *J Shoulder Elbow Surg*. 2015;24(12):1948-1953. doi:10.1016/j.jse.2015.07.013
4. Zaid MB, Young NM, Pedoia V, Feeley BT, Ma CB, Lansdown DA. Anatomic shoulder parameters and their relationship to the presence of degenerative rotator cuff tears and glenohumeral osteoarthritis: a systematic review and meta-analysis. *J Shoulder Elbow Surg*. 2019;28(12):2457-2466. doi:10.1016/j.jse.2019.05.008
5. Spiegl, U.J., Horan, M.P., Smith, S.W. *et al.* The critical shoulder angle is associated with rotator cuff tears and shoulder osteoarthritis and is better assessed with radiographs over MRI. *Knee Surg Sports TraumatolArthrosc* **24**, 2244–2251 (2016).
6. Ozel, O., Hudek, R., Abdrabou, M.S. *et al.* The implications of the glenoid angles and rotator cuff status in patients with osteoarthritis undergoing shoulder arthroplasty. *BMC MusculoskeletDisord* **21**, 668 (2020).
7. Rose-Reneau Z, Moorefield A K, Schirmer D, et al. (November 11, 2020) The Critical Shoulder Angle as a Diagnostic Measure for Osteoarthritis and Rotator Cuff Pathology. Cureus 12(11): e11447. DOI 10.7759/cureus.11447
8. Greenspoon JA, Petri M, Warth RJ, Millett PJ. Massive rotator cuff tears: pathomechanics, current treatment options, and clinical outcomes. *J Shoulder Elbow*

Surg. 2015;24(9):1493-1505. doi:10.1016/j.jse.2015.04.005

9. Mantell MT, Nelson R, Lowe JT, Endrizzi DP, Jawa A. Critical shoulder angle is associated with full-thickness rotator cuff tears in patients with glenohumeral osteoarthritis. *J Shoulder Elbow Surg*. 2017;26(12):e376-e381. doi:10.1016/j.jse.2017.05.020
10. Bjarnison AO, Sørensen TJ, Kallemose T, Barfod KW. The critical shoulder angle is associated with osteoarthritis in the shoulder but not rotator cuff tears: a retrospective case-control study. *J Shoulder Elbow Surg*. 2017;26(12):2097-2102. doi:10.1016/j.jse.2017.06.001
11. Werner BS, Hudek R, Burkhart KJ, Gohlke F. The influence of three-dimensional planning on decision-making in total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2017;26(8):1477-1483. doi:10.1016/j.jse.2017.01.006