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# The importance of glenoid version in patients with anterior dislocation of the shoulder

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**Background:** Although increased retroversion of the glenoid has been shown to be an important factor in posterior instability of the shoulder, there are few studies reporting glenoid bone structure as a risk factor in anterior dislocation of the shoulder. This study aimed to compare glenoid version in patients with anterior dislocation of the shoulder and individuals in a control group with no shoulder problems before undergoing computed tomography and to assess a possible relationship between demographic characteristics and glenoid version angle.
**Methods:** The study group comprised 63 patients (12 women and 51 men; mean age, 35.71 years) with 1 or multiple unilateral anterior dislocations of the shoulder (dislocated group), whereas 63 individuals (11 women and 52 men; mean age, 35.38 years) with no history of shoulder complaints and no signs of instability constituted the control group. The glenoid version angle was measured on an axial cut of the computed tomography scan.
**Results:** The glenoid version angles on the dislocated side in the study group were significantly more anteverted than those of the dominant ($P < .001$) and nondominant ($P = .023$) shoulders of the control group. The version angles of dislocated shoulders significantly differed from those of nondislocated shoulders of both men ($P = .041$) and women ($P = .049$). There was no significant relationship between the glenoid version angle on the dislocated side and dislocation mechanism ($P = .883$), age group ($P = .356$), or number of dislocations ($P = .971$).
**Conclusions:** Glenoid version is an important factor for the development of anterior dislocation of the shoulder.
**Level of evidence:** Level II; Retrospective Design; Prognosis Study
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**Keywords:** Anterior shoulder dislocation; glenohumeral joint; glenoid version; computed tomography; dominant/nondominant shoulder; demographic characteristics

The glenohumeral joint is the most commonly dislocated joint in the body,[4,29] typically developing as a result of force applied to the arm in external rotation–abduction or direct impact to the shoulder.[29] Traumatic glenohumeral dislocations of the shoulder are frequent and may lead to shoulder pain or dysfunction. The mean age for undergoing a dislocation

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of the shoulder is 20 years, with more male patients (85%-95%) than female patients affected, and the most common dislocation type is anterior (85%-95%).[1,11] In diseases characterized by episodes of seizures such as epilepsy, the head of the humerus is usually displaced posteriorly as a result of severe muscle contraction.[27] In some cases, such patients may undergo anterior dislocation of the shoulder following trauma to the shoulder or pull and/or strain.[32] In patients with a history of anterior dislocation of the shoulder at a young age, the injury is more likely to recur later in life.[15]

The importance of soft tissues such as the ligaments, labrum, capsule, biceps tendon, joint capsule, and rotator cuff in shoulder stabilization has been frequently emphasized in the literature.[18] Although increased retroversion of the glenoid has been shown to be an important factor in posterior instability of the shoulder,[3,10] there are few studies reporting glenoid bone structure as a risk factor in anterior dislocation of the shoulder.[14,26,28]

It is known that in normal shoulders, the glenoid version angles range from 2° anteversion to 9° retroversion.[6,9] Abnormalities in version play a prominent role in glenohumeral joint instability.[3] Increased glenoid anteversion has been shown to be an important risk factor in recurrent anterior dislocation of the shoulder.[14,31] Proper evaluation of glenoid version in shoulder arthroplasty surgery is essential for successful treatment.[13,25] Currently, computed tomography (CT) is the most popular method of evaluation.[9,24,30] The traditional measurement method for glenoid version was put forward by Friedman et al.[9]

This study aimed to compare glenoid version in patients with anterior dislocation of the shoulder and individuals in a control group with no shoulder problems before undergoing CT and to assess a possible relationship between demographic characteristics of patients and their glenoid version angle.

## Materials and methods

This study was designed as a retrospective case-control study. Patients presenting to the emergency department of our hospital with complaints of anterior dislocation of the shoulder whose diagnoses were finalized through imaging techniques with reduction of anterior shoulder dislocation performed in our hospital between the years 2011 and 2013 were included in the study. Our hospital is the largest trauma center in the area and provides mainly trauma surgery services. Patients aged between 20 and 60 years with a history of 1 or multiple unilateral anterior dislocations of the shoulder who were nonsurgically treated and in whom CT records for both shoulders were taken were considered suitable for the purposes of the research. The patients, whose contact information was obtained from hospital archives, underwent a control examination at our outpatient clinic, and thus, the study group comprised a total of 63 patients (12 women and 51 men; mean age, 35.71 years).

Among patients with a history of trauma in whom an upper back CT scan including both shoulders was taken because of dorsalgia or shoulder pain, those with no previous shoulder complaints including fracture or dislocation and no detected instability of the shoulder during the physical examination were included in the control group, which consisted of 63 patients aged between 20 and 60 years (11 women and 52 men; mean age, 35.38 years). For each patient in the study group, information on the dislocated side, the dominant and nondominant side of the upper extremities, the number of dislocations, a positive or negative epilepsy diagnosis, and the mechanism of dislocation were recorded on sheets, whereas only the dominant and nondominant side of the upper extremities and a negative epilepsy diagnosis were recorded for the patients in the control group.

CT scans for all patients in the study and control groups were performed according to the upper back and shoulder CT protocol of our hospital: The patient was placed in the supine position with both upper extremities positioned at the side, forearms supinated, and hands placed under the buttocks. One-millimeter slides of the area between the superior and inferior glenoid including axial and coronal images were obtained. On detection of the midglenoid level by obtaining the midpoint of all slices from the glenoid superiorly to inferiorly on the scout view, glenoid version was measured on the axial slice according to the Friedman guidelines (Fig. 1). All slices were thoroughly examined for any structural deformation in the bone structure, and the small number of osteophytes encountered was not taken as marginal. Angle measurements were made by 3 independent observers (1 orthopedist and 2 radiologists) over a period of 1 week.

In this study, all analyses were conducted using SPSS statistical package software (version 22.0; IBM, Armonk, NY, USA). To compare mean differences between the 2 groups, independent- and paired-samples *t* tests were used. The means for multiple groups were compared using analysis of variance. For the evaluation of the correlation between 2 different variables, the Spearman ρ correlation coefficient was used. $P < .05$ was considered statistically significant.

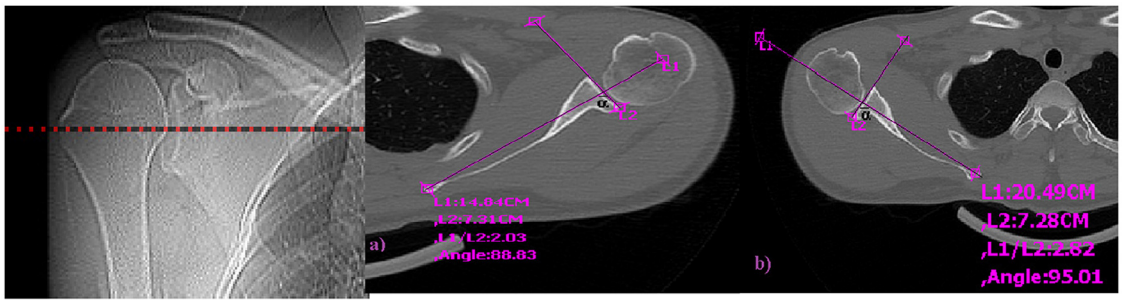


**Figure 1** Scout view and measurement of glenoid version according to Friedman method: normal shoulder **(a)** and dislocated shoulder **(b)**.

### Friedman method

The first line in the axial section is along the anterior and posterior margins of the glenoid. The second line is between the midpoint of the glenoid fossa and the medial end of the image of the scapula. The angle between the first line and the line perpendicular to the second line is the glenoid version angle. In other words, subtraction of 90° from the α angle (the angle between the first line and the second line) (α – 90°) gives the version angle; we used this calculation for the purposes of our research. If the resulting angle is negative, the glenoid is evaluated as retroverted; if positive, the glenoid is evaluated as anteverted.

## Results

In the control group, the dominant shoulders were more retroverted than the nondominant shoulders ($P < .001$), whereas there was no significant difference between dominant and nondominant shoulder angles in the study group ($P = .636$). The glenoid version angles of the study group subjects' dominant sides were significantly more anteverted than their control group counterparts ($P < .001$). The glenoid version angles for the shoulders on the nondominant side of the subjects in both the study and control groups did not significantly differ ($P = .060$) (Table I). The glenoid version angles on the dislocated side in the study group were significantly more anteverted than those of the dominant ($P < .001$) and nondominant ($P = .023$) shoulders in the control group (Table II).

When the glenoid version angles were analyzed for gender differences in the study group, the version angles of the dislocated shoulders differed significantly from those of the nondislocated shoulders of both men ($P = .041$) and women ($P = .049$) (Table III). The version angles of the dislocated shoulders of women were more anteverted than those of men, and an interesting finding was that the version angles of women's dislocated shoulders were more retroverted than the nondislocated side, whereas in men, the version angles of the dislocated shoulders were more anteverted than the nondislocated side.

Analysis of the dislocation mechanism showed that the most common cause of dislocation in patients who have had a dislocation of the shoulder only once was tripping, and for patients with a history of multiple dislocations, the most common cause of the first dislocation was tripping, and the subsequent dislocations were due to abnormal physical activity (Table IV). In the study group there was no significant relationship between the glenoid version angle on the dislocated side and dislocation mechanism of injury ($P = .883$), age group ($P = .356$), or number of dislocations ($P = .971$) (Table V).

Analysis of the glenoid version angles on the dislocated side of patients diagnosed with epilepsy showed that the angles did not differ significantly from the glenoid version angles

**Table I** Glenoid version angles of dominant and nondominant shoulders in control and dislocated groups

| | Control group | Dislocated group | *P* value |
|---|---|---|---|
| Dominant shoulder | | | < .001* |
| n | 63 | 63 | |
| Version, ° | | | |
| Mean ± SD | −5.8 ± 3.4 | −1.6 ± 4.7 | |
| 95% CI | −6.3 to −5.4 | −2.2 to −1.0 | |
| Nondominant shoulder | | | .060 |
| n | 63 | 63 | |
| Version, ° | | | |
| Mean ± SD | −3.2 ± 3.5 | −1.9 ± 4.5 | |
| 95% CI | −3.7 to −2.8 | −2.4 to −1.3 | |
| *P* value | < .001* | .636 | |

CI, confidence interval.
* Statistically significant.

**Table II** Comparison of glenoid version angles of dislocated shoulders with those of dominant and nondominant shoulders in control group

| | n | Version, ° | | *P* value |
|---|---|---|---|---|
| | | Mean ± SD | 95% CI | |
| Control dominant shoulder | 63 | −5.8 ± 3.4 | −6.3 to −5.4 | <.001* |
| Dislocated side | 63 | −1.5 ± 4.7 | −2.1 to −0.9 | |
| Control nondominant shoulder | 63 | −3.2 ± 3.5 | −3.7 to −2.8 | .023* |
| Dislocated side | 63 | −1.5 ± 4.7 | −2.1 to −0.9 | |

CI, confidence interval.
* Statistically significant.

**Table III** Relationship between glenoid version angle and gender in dislocated group

| | n | Version, mean ± SD, ° | | *P* value |
|---|---|---|---|---|
| | | Dislocated side | Nondislocated side | |
| Women | 12 | −1.0 ± 3.7 | 1.6 ± 3.4 | .049* |
| Men | 51 | −1.7 ± 4.9 | −2.8 ± 4.3 | .041* |

* Statistically significant.

**Table IV** Distribution of mechanism of dislocation by dislocation count

| Dislocation mechanism | Dislocation count of 1 | | Dislocation count >1 | |
|---|---|---|---|---|
| | n | % | n | % |
| Fall | 23 | 69.7 | 6 | 20.0 |
| Abnormal movement | 3 | 9.1 | 0 | 0.0 |
| Fall plus abnormal movement | 0 | 0.0 | 18 | 60.0 |
| Other (pull, strain, strike, convulsion) | 7 | 21.2 | 6 | 20.0 |

**Table V** Relationship between glenoid version angle on dislocated side and mechanism of dislocation, age group, and dislocation count

| | n | Version, mean ± SD, ° | *P* value |
|---|---|---|---|
| Dislocation mechanism | | | .883 |
| Fall | 29 | −1.5 ± 4.3 | |
| Abnormal movement | 3 | 0.3 ± 4.6 | |
| Fall plus abnormal movement | 18 | −2.0 ± 5.2 | |
| Other | 13 | −1.5 ± 5.4 | |
| Age group | | | .356 |
| 20-29 y | 23 | −1.9 ± 4.4 | |
| 30-39 y | 20 | −0.6 ± 5.1 | |
| 40-49 y | 7 | −0.2 ± 5.2 | |
| ≥50 y | 13 | −3.1 ± 4.4 | |
| Dislocation count | | | .971 |
| 1 | 33 | −1.6 ± 4.3 | |
| >1 | 30 | −1.5 ± 5.2 | |

of the non-epileptic dislocated group ($P = .310$) or from the version angles of the dominant ($P = .881$) or nondominant ($P = .293$) shoulders in the control group (Table VI).

Interclass correlation among the 3 observers (X, Y, and Z) was calculated to be 0.998, and the 3 Cronbach α values of the scale formed by the 3 observations were calculated at 0.99, indicating very high agreement among the observers. We also calculated pair-wise comparisons between the 3 observers. Rater X's correlation with rater Y was 0.998, and with rater Z, it was 0.99. The ratings of rater Z and rater Y were correlated at 0.998. All coefficients were significant at the .001 level. Thus, rater X's calculations were used as the basis for all the analyses reported.

## Discussion

The anatomic structure of the glenoid is an important factor to consider in instability or dislocation of the shoulder. In this study, glenoid version angles of patients with anterior dislocation of the shoulder were measured through CT and compared with those of the control group. This study contributes to the relevant literature in that it shows, with a high level of reliability, that glenoid version is an important factor in cases of anterior dislocation of the shoulder. To our knowledge, this study is a rare, detailed study that showed the links between glenoid version–anterior shoulder instability and gender, dislocation mechanism, number of dislocations, and age group, as well as their relationship with patients diagnosed with epilepsy.

Previous research has established the relationship between posterior shoulder instability and glenoid version. Brewer et al[3] showed the effects of extreme retroversion on nontraumatic recurrent posterior instability of the shoulder. They reported improved clinical healing through corrective osteotomy for version in 5 patients. In another study, a corrective osteotomy procedure was performed in 32 patients for posterior instability of the shoulder, and during the examination at 5 years postoperatively, the Constant-Murley and Rowe scores of most of the patients were good to excellent.[10] The applicability of corrective osteotomy for anterior instability of the shoulder is controversial, and more research is needed. The posterior bone block procedure used in the treatment of posterior instability of the shoulder is reported to be effective.[33] Although it has been shown that the Latarjet procedure used for glenoid bone loss in recurrent anterior instability of the shoulder proves effective,[8] developing preventive measures against anterior dislocation of the shoulder may avert complicated surgical procedures. Proper evaluation of glenoid version in shoulder arthroplasty is essential for the correct placement of the glenoid component.[13] It has been indicated that the increased glenoid anteversion in total shoulder arthroplasty leads to anterior translation of the humeral head and an eccentric load on the anterior edge of the glenoid.[25] It has also been reported that improper glenoid component version results in instability of the shoulder as well as premature bone loss.

The glenohumeral joint is stabilized by passive and dynamic stabilizers.[3,18] The shoulder girdle muscles, on the contrary, may contribute to instability. Cadaveric studies have shown that in cases of dislocation of the shoulder in which the humerus is abducted and is in external rotation, the pectoralis major muscle is passive.[18,20] For patients whose glenoid component version is not suitable, changing muscle kinematics through corrective osteotomy may decrease the incidence of dislocations. Owens et al[26] indicated that in addition to clinical risk factors such as the apprehension sign and relocation sign, anatomic risk factors may be critical in cases of shoulder instability. A cadaveric study emphasized the role of glenoid geometry in glenohumeral joint stability.[12] In addition, cadaveric studies have shown that harmony and

**Table VI** Comparison of glenoid version angle on dislocated side of patients diagnosed with epilepsy with shoulders of non-epileptic patients in dislocated and control groups

| Group | Epilepsy | n | Side | Angle, mean ± SD, ° | *P* value |
|---|---|---|---|---|---|
| Dislocated group | + | 10 | Dislocated side | −1.8 ± 5.5 | Reference group |
| Dislocated group | − | 53 | Dislocated side | −1.5 ± 4.6 | .310 |
| Control group | − | 63 | Dominant side | −5.8 ± 3.4 | .881 |
| Control group | − | 63 | Nondominant side | −3.2 ± 3.5 | .293 |

stability of the glenohumeral joint can be increased through surgical methods such as glenoplasty and bone grafting.[21,22]

A study that measured glenoid version on magnetic resonance imaging (MRI) took the supraspinatus muscle as one of the reference points and evaluated glenoid version in a similar way to the Friedman method.[14] Our study differs very little from similar studies on glenoid version measurement and therefore is of a comparable nature.[10,13,14,30] Bokor et al[2] have shown that scapular rotation in the coronal plane affects the glenoid version measurements on CT scans. Therefore, this study only included CT scans in which the glenoid surface was perpendicular to the plane of the CT cuts on the scout view. Moreover, we scanned and analyzed thinner cuts than those of similar studies in the literature, from the point of view that other studies in which CT cuts were larger[19,24,30] were not able to accurately determine the glenoid center.

Matsumura et al[19] found that the dominant side was more retroverted than the nondominant side in normal shoulders. Similarly, Crockett et al[7] reported the glenoid version of dominant shoulders of professional baseball pitchers to be more retroverted than their nondominant shoulders. Peltz et al[28] found no difference between the glenoid version angles of the nondominant and dominant shoulders of healthy volunteers. Then they compared the injured shoulders of patients with instability and the dominant shoulders of the volunteers and found that the injured shoulders of the patients with instability complaints had flatter glenoids in the anterior-posterior and superior-inferior directions than the healthy control subjects. However, they could not detect any difference regarding glenoid version between the dominant shoulders of the volunteers and the injured and uninjured contralateral shoulders of the subjects with instability. In another study evaluating glenoid version on MRI, the glenoid version angles of patients with anterior dislocation of the shoulder were found to be more anteverted than those of the control group.[14] In our study, we found no significant difference between the glenoid angles of the dominant and nondominant shoulders in the study group, whereas in the control group, the glenoid version angles of the dominant shoulders were more retroverted than those of the nondominant shoulders. This finding is coherent with the reports of the few relevant studies in the literature.[7,19] The fact that the glenoid version angles of the dominant shoulders of the subjects that were specifically unstable on physical examination in the study group were significantly more anteverted than those of their healthy counterparts, as well as our finding that the glenoid angles of the dislocated shoulders of the study group subjects were more anteverted than the dominant and nondominant shoulders of the control group, indicates that the glenoid version is an important factor in cases of anterior dislocation of the shoulder. The glenoid version may affect the functioning of structures contributing to shoulder stability such as the ligaments, labrum, joint capsule, and rotator cuff, thus increasing the risk of shoulder instability.

Friedman et al[9] reported the glenoid version of 63 healthy individuals to be 2° ± 5° anteverted (range, −12° to 14°) whereas the glenoid version of 20 patients with osteoarthritis and inflammatory arthritis was −11° ± 8° retroverted (range, −32° to 2°). Recent studies regard 3-dimensional (3D) reconstruction as the gold standard in imaging.[17,23] However, this technology is expensive and access is not easy. Furthermore, the measurements are more complex and need to be further developed. Budge et al[5] have shown that axial 2-dimensional (2D) CT images without correction were 5° to 15° different from their 3D CT–corrected counterparts in 47% of all measurements. Inui et al[16] have classified the glenoid shape as concave, flat, or convex in their study carried out in 40 volunteers with 3D MRI and have shown that the version angle at the most inferior part of the glenoid is more anteverted than the superior parts and most of this part is concave, thus raising the possibility that this case may be more related to instability. Rouleau et al[30] have shown that there is no advantage on 3D CT scans to assess version according to 2D CT, yet different glenoid morphologies (malformed, dysplastic, biconcave) could be better evaluated on 3D CT. For the purposes of our study, we used 2D CT, which is an adequate and easily accessible method of imaging.

As in previous studies,[1,11] most of the subjects with shoulder dislocation in our study were men. Even though the interesting finding that the glenoid version angles of female patients were more retroverted than the uninjured side and those of male patients were more anteverted may explain the difference in the prevalence of dislocation between genders, further studies are needed to determine the effects of other structures in the shoulder area on dislocation of the shoulder joint.

Most cases of acute dislocation of the shoulder are of traumatic origin,[29] which corresponds with the findings of this study. Although it has never been studied before to our knowledge, the fact that the mechanism of dislocation bears no significant relation to the glenoid version angle may indicate that the evaluation of such injuries needs to incorporate

dynamic and static structures. Similarly, the fact that there was no significant relationship between glenoid version and age group, as well as dislocation count, may signal that structures in the shoulder area rather than the glenoid version function at differing levels among age groups and that soft-tissue damage in patients with multiple dislocations may be a more important factor in recurrent dislocations.

It is known that individuals diagnosed with epilepsy are more prone to trauma compared with the general population and have serious injuries as a result,[34] one of which is dislocation of the shoulder. In our study, the glenoid version angle on the dislocated side of epileptic patients with anterior dislocation of the shoulder did not significantly differ from that of the dominant and nondominant shoulders of the control group. The humeral head is generally driven backward in epileptic patients,[27] and precautions taken against falls, pulls and/or strains, or convulsions particularly in epileptic patients with anterior dislocation of the shoulder may decrease comorbidity for this risk group. It is hoped that this study will be beneficial for the field through its informative nature of such risks as well as for future studies in that it investigates anterior rather than posterior dislocation of the shoulder in epileptic patients.

Even though it was considered more suitable to use CT rather than MRI to provide better imaging of bone structure for the purposes of this study, despite several advantages that it provides, the use of 2D CT instead of 3D CT may have caused some disadvantages in that it shows glenoid morphology in less detail. The major limitations in our study were as follows: Some patients in the control group did not choose to receive a complete physical examination and thus it was not possible to evaluate these patients for shoulder instability even if they did not have any complaints, and the population of female patients and epileptic patients with anterior dislocation of the shoulder was limited. However, the evaluation of glenoid version of such patients given in this study could provide a different point of view regarding dislocation of the shoulder joint.

## Conclusions

Glenoid version is an important factor in the development of anterior dislocation of the shoulder and should be evaluated in individuals at risk of development of dislocation of the shoulder as well as in the planning of shoulder surgery. Moreover, CT is an effective method for the evaluation of glenoid version.

## Disclaimer

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