Comparison of Magnetic Resonance Imaging and Computed Tomography Scans of the Glenoid Version in Anterior Dislocation of the Shoulder

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abstract

The glenoid version is an important factor in the etiology of anterior dislocation of the shoulder and plays a role in the planning of shoulder surgery. Few reports compare the magnetic resonance imaging (MRI) measurements of the glenoid version with those of computed tomography (CT). This study aimed to show that it is possible to use MRI instead of CT, which is accepted as the gold standard today, for the evaluation of the glenoid version. A total of 55 patients with a history of nonsurgically treated unilateral anterior dislocation of the shoulder who had both MRI and CT records for the dislocated shoulders constituted the study group. The glenoid version was measured in the axial plane on MRI and CT. Mean glenoid version measured by the observers was $-1.6^\circ \pm 4.7^\circ$ (95% confidence interval, $-2.3^\circ$ to $-0.8^\circ$) and $-1.8^\circ \pm 4.3^\circ$ (95% confidence interval, $-2.5^\circ$ to $-1.2^\circ$) by CT and MRI, respectively ($P = .126$). The evaluation of the CT and MRI measurements made by the 3 observers (X, Y, and Z) revealed no significant difference, as the $P$ values of X CT - X MRI, Y CT - Y MRI, and Z CT - Z MRI were .550, .406, and .238, respectively. Interclass correlation among the 3 observers for CT and MRI was 0.996 and 0.981, respectively. The imaging methods of MRI and CT can be interchangeably used in the evaluation of the glenoid version in cases of anterior dislocation of the shoulder. [Orthopedics. 2017; 40(4):e687-e692.]

Glenoid version plays an important role in the normal biomechanics of the shoulder and is an important factor to consider in cases of instability and arthritis of the glenohumeral joint (GHJ).\(^1\) Glenoid version angle in the normal shoulder ranges from $2^\circ$ to $9^\circ$ of retroversion.\(^{2,3}\) Some studies have reported glenoid morphology as an independent risk factor in primary and recurrent anterior instability of the shoulder.\(^{4,6}\) Increased glenoid anteversion has been shown to be a risk factor in recurrent anterior dislocation of the shoulder.\(^7\)

The glenohumeral joint is the most mobile, and therefore the most frequently dislocated, major joint in the body\(^8,9\); and dislocation of the glenohumeral joint may lead to shoulder pain or dysfunction. Changes in the glenoid version affect the structures in the shoulder, resulting in changes in the orientation of the forces of scapulohumeral muscles. Mean age for experiencing dislocation of the shoulder is 20 years, and 85% to 95% of the...
dislocation cases are anterior. Patients with a history of shoulder dislocation at a young age are more likely to experience recurrences later in life. Problems associated with the glenoid version also manifest themselves in shoulder arthroplasty. Proper evaluation of glenoid version in shoulder prosthesis surgery is essential for successful treatment. It has been suggested that improper glenoid component version results in instability of the shoulder and premature bone loss.

Computed tomography (CT) is the most common imaging modality for the evaluation of glenoid version, although magnetic resonance imaging (MRI) and radiography have also been used. The importance of soft tissues (labrum, capsule, ligaments, and the rotator cuff) for shoulder stability has been previously described in the literature. Although MRI provides excellent visualization for the evaluation of soft tissue structures of the shoulder, it may not give as much information as a CT scan regarding glenohumeral bone structure.

During shoulder arthroplasty, an MRI will visualize the rotator cuff but a CT scan provides detailed information regarding glenoid morphology. Glenoid version can be measured by MRI, but few reports compare this modality with CT scan. Among the several methods used for the evaluation of the glenoid version, the traditional measurement method with CT was defined by Friedman et al.

Based on a literature review, the current study represents an uncommon comparison of MRI and CT in the evaluation of the glenoid version after an anterior instability event. The authors hypothesized that MRI would demonstrate equivalent utility to CT when assessing glenoid version in a dislocated shoulder.

**MATERIALS AND METHODS**

This study received institutional review board approval and had a retrospective case-control design. Patients evaluated at the emergency department of the authors’ hospital with findings of a unilateral traumatic anterior dislocation of the shoulder between 2012 and 2014 were included in the study. Patients who completed both MRI and CT scans were considered suitable for the purposes of the research.

The study group contained 55 patients (8 women and 47 men; mean age, 34.2±11.6 years). The CT imaging procedure was performed with the patient in the supine position with both upper extremities positioned at the side, forearms supinated, and hands placed under the buttocks. Axial and coronal CT images (1-mm slice thickness) were obtained, and the glenoid version was measured in the axial slice according to the description by Tétreault et al (Figure 1B).

All CT slices were thoroughly examined for any structural deformation of the glenoid vault. Osteophytes were not considered as marginal. Patients whose MRI scans revealed bony Bankart lesions, glenoid or humeral chondral damage, or humeral avulsion of glenohumeral ligament were excluded from the study. Glenoid version measurements were made by 3 independent observers (U.A., T.D., H.S.) (2 orthopedists and a radiologist) during a period of 1 week.

In this study, all analyses were conducted using SPSS statistical package version 22.0 software (IBM, Armonk, New York). To compare mean differences between the 2 groups, a paired-samples t test was used. The means for multiple groups were compared using analysis of variance. Cronbach’s alpha was used to determine the reliability of the values obtained. P<.05 was considered statistically significant.

**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 short (α-90°).

**Tétreault Method**

The axial image immediately inferior to the supraspinatus muscle where the posterior border of the scapular neck is clearly visible is selected. The scapular axis is defined as a line joining the posterior glenoid neck and junction of the scapular body medially. A line is drawn along the axis of the glenoid surface. The glenoid version angle is calculated by subtracting 90° from the angle formed by the glenoid surface and the scapular body (B).
RESULTS

The mean glenoid version measured by the observers was \(-1.6°\) and \(-1.8°\) by CT and MRI, respectively (\(P=.126\)) (Table 1). The evaluation of the CT and MRI measurements of each observer revealed no significant difference (\(P>.05\)) (Table 2).

Interclass correlation among the 3 observers (X, Y, and Z) for CT and MRI was calculated to be 0.996 and 0.981, respectively. The 3 Cronbach \(\alpha\) values of the scale formed by the 3 observations for CT and MRI were calculated at 0.998 and 0.997, respectively, indicating very high agreement among the observers.

DISCUSSION

Changes in the glenoid version may lead to shoulder instability and arthropathy by resulting in changes in GHJ mechanics.\(^1\) In this study, the glenoid version angles of the dislocated side of patients with anterior dislocation of the shoulder were measured through MRI and CT, and the measurements were compared.

There are some limitations of the current study. First, this study focuses on the glenoid version angles of patients with only 1 anterior dislocation of the shoulder; patients with multiple dislocations may manifest with varying version angle measurements on CT and MRI due to further damage. Second, the higher mean age of the patients in the current study versus those in previous reports in the literature points to a limitation of the study sample in which the glenoid version angles of younger patients were not evaluated. However, the current authors believe that this difference did not significantly influence the study’s main findings. Third, the current authors were not able to compare the glenoid version angles of both sides as MRI scans for the healthy shoulders were not available, preventing the current authors from making a detailed examination of whether there was a significant difference between the measurements.

The GHJ dislocations typically develop as a result of force applied to the arm in external rotation-abduction or direct impact to the shoulder.\(^9\) Cadaveric studies have shown that in cases of dislocation of the shoulder where the humerus is abducted and in external rotation, the pectoralis major muscle is passive.\(^18,25\) For patients whose glenoid version is not suitable, changing muscle kinematics through corrective osteotomy may decrease the incidence of dislocations.\(^26\)

Using MRI scans, Owens et al\(^5\) indicated that in addition to clinical risk factors (such as apprehension sign and relocation sign), anatomical risk factors may be critical in cases of shoulder instability. Another cadaveric study emphasized the role of the glenoid geometry in GHJ stability.\(^27\) In addition, cadaveric studies have shown that harmony and stability of the glenohumeral joint can be increased through surgical methods, such as glenoplasty and bone grafting.\(^26,28\) Although it has been shown that the Latarjet procedure, used for glenoid bone loss in recurrent anterior instability of the shoulder, is effective,\(^29\) 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 glenoid component.\(^13\) Nyffeler et al\(^14\) showed that the increased glenoid anteversion in total shoulder arthroplasty leads to anterior translation of the humeral head and eccentric load on the anterior edge of the glenoid. They indicated that retroversion was associated with posterior displacement and posterior loading of the glenoid, as well as that a change in the rotation of the humeral component did not compensate for altered version of the glenoid component in total shoulder arthroplasty. They suggested that both instability and glenoid component loosening may be related to the version of the glenoid component.\(^14\)

The arthritic glenoid is generally retroverted, and it is suggested that it should be made neutral. Aligning the glenoid pros-
thesis to neutral version and ensuring adequate seating of the bone requires reaming to the depth of the maximum wear. The location of maximum wear, although generally in the posterior direction, may not always be consistent. Precisely identifying the location and depth of maximum wear is important for preoperative planning. Incorrect placement of the glenoid prosthesis may lead to joint instability and loosening of the glenoid implant because the implant and the cement–bone interface would be subjected to abnormal forces.

The evaluation of the GHJ is based on imaging methods, chiefly CT and MRI. Friedman et al measured the glenoid version of patients with severe arthritic changes in their shoulders on CT and found that the glenoid was more retroverted in the arthritic shoulders compared with the control group and that CT scans accurately revealed the extent and pattern of erosion of the bone. Nyffeler et al compared the axillary view radiography and CT measurements of the glenoid version of 25 patients with GHJ instability. They measured the glenoid version according to the Friedman method on 4-mm axial slices on CT and found that this method provided more reliable results with regard to the determination of the version angle compared to axillary radiography. They showed that glenoid retroversion was overestimated on plain radiographs.

Saha et al evaluated the glenoid version of 50 healthy shoulders using the standard radiographic beam technique and found that the mean glenoid version angle of 74% of the shoulders were retroverted (mean, -7.4°) and that 26% of the glenoids’ surfaces were anteverted from 2° to 10° with respect to the plane of the scapula.

Hohmann et al measured the glenoid version on MRI according to the Tétreault method and found the glenoid version of patients with anterior dislocation of the shoulder to be more anteverted than the control group. Parada et al showed that glenoid retroversion was significantly increased in patients with symptomatic posterior labral tears on MRI.

Lowe et al measured the glenoid version of 30 patients with primary shoulder osteoarthritis from axial view on MRI and CT (slice thickness, 3 and 1.25 mm, respectively) according to the Friedman method. They point out that MRI is largely comparable to CT scan regarding the measurement of the glenoid version and suggest that a CT scan may be unnecessary for preoperative planning of shoulder arthroplasty in the event that the surgeon decides conventional radiographs and MRI have provided sufficient visualization.

Graichen et al evaluated the glenoid version of patients with posterior instability of the shoulder using radiography, MRI, and CT with a similar method as Saha et al, and reported good-excellent results of corrective osteotomy.

Today, the use of MRI together with CT is common in shoulder surgery planning, which may mean higher hospital costs, as well as higher doses of radiation the patients are exposed to. It is hoped that this study could provide benefit for addressing these issues and for future studies with its contribution into the process of surgery planning.

Current studies regard 3-dimensional (3D) CT reconstruction as the gold standard in imaging for the measurements. Rouleau et al measured the glenoid version of 116 patients on CT using the Friedman method. As a result of the evaluation, they showed that there is no advantage for 3D CT scans to assess version according to 2-dimensional (2D) CT; however different glenoid morphologies (malformed, dysplastic, biconcave) could be better evaluated on 3D CT.

Budge et al evaluated glenoid version on CT according to the Friedman method and showed that axial 2D CT images without correction were 5° to 15° different from their 3D CT-corrected counterparts in 47% of all measurements. Plain radiography has been shown to be ineffective in the evaluation of the glenoid version due to varying radiographic techniques, complex and variable scapular anatomy, mobile scapula, and overlapping bones.

In their study evaluating the glenoid version on 2D CT according to the Friedman method, Hoekeke et al indicated that accurately measuring glenoid version requires a full 3D CT reconstruction. Inui et al evaluated 3D MRI measurements (2-mm section thickness) of the glenoid of 40 volunteers and found the version to be more anteverted in the inferior part of the glenoid compared to the superior part, and that the inferior part of the glenoid is mostly concave, which makes it an important contributor to shoulder instability.

Kanno et al investigated the reliability and validity of a 3D MRI bone model of the scapula by comparing the glenoid versions that were each measured in 3D CT images and in 3D MRI images. They showed that the 3D MRI bone model of the scapula measured like the 3D CT bone model of the scapula. However, 3D imaging technology is expensive and not easily accessible. Furthermore, the measurements are more complex and need to be further developed.

For the purposes of the current study, the authors used a 2D CT scan, which is an easily accessible method of imaging and proved effective in the evaluation of the glenoid version.

Bokor et al suggested that scapular rotation in the coronal plane affects the glenoid version measurements in CT scans. Therefore, this study only included CT scans in which the glenoid surface was perpendicular to the plane of the CT cuts in the scout view. Moreover, the current study can be considered superior in that the authors scanned and analyzed thinner cuts than those of similar studies in the literature because studies in which the CT cuts were larger were not able to accurately determine the glenoid center.

The use of 1-mm slides in MRI in the current study made the Tétreault method
more suitable for determining the origin. The current study is important because, by comparing 2 different methods, it has revealed that either of them could provide sufficient means for the evaluation of the glenoid version. Lowe et al evaluated the glenoid version on CT and MRI using the Friedman method. The procedures followed in CT and MRI are distinct, and the fact that Lowe et al used the Friedman method for either measurement may have affected the findings, as Friedman described his original method for measurements on CT. In addition, when compared with the same study in which the authors used thicker slices for measurement and therefore had difficulty determining the midpoint of the glenoid accurately, it can be said that the current study has provided more reliable findings.

Therefore, the current authors believe that the use of the Tétreault method on MRI for the evaluation of the glenoid version is more effective than the use of the Friedman method on MRI. Moreover, unlike several other studies, the current study evaluates the glenoid version in cases of nonarthritic dislocation of the shoulder and may provide a different point of view to preventive treatments for cases of anterior dislocation of the shoulder without any need for surgery.

**Conclusion**

The glenoid version is an important factor to consider in the etiology of anterior dislocation of the shoulder and the planning of shoulder surgery. In the current study, the glenoid version angle measurements of patients with anterior dislocation of the shoulder on MRI and CT did not significantly differ between the 3 observers. The fact that there is no significant difference between the MRI and CT measurements of each of the 3 observers supports the possibility that MRI can be a persuasive way of measurement, with high levels of reliability for the evaluation of the glenoid version. The imaging methods of MRI and CT can be used interchangeably in the evaluation of the glenoid version in cases of anterior dislocation of the shoulder.

**References**


