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Original Article

Are Metaversion and Glenoid Version Useful in Determining the Humeral Head Version

Enver Kılıç[1], Alper Deveci[2], Güzelali Özdemir[1], Deniz Sözmen Cılız[3], Olgun Bingöl[1], Niyazi Erdem Yaşar[1]

[1]Department of Orthopedics and Traumatology, Ministry of Health Ankara City Hospital, Ankara, Türkiye
[2]Department of Orthopedics and Traumatology, Private Ortadoğu Hospital, Ankara, Türkiye
[3]Department of Radiology, Ministry of Health Ankara City Hospital, Ankara, Türkiye

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ORCID iDs of the authors: E.K. 0000-0001-5475-8966, A.D. 0000-0001-6216-3030, G.Ö. 0000-0003-4279-0955, D.S.C. 0000-0003-3640-9273, O.B. 0000-0003-1720-1709, N.E.Y. 0000-0002-6740-6422.

ABSTRACT

Objective: This study aims to evaluate the relationship between the humeral head version and the cartilage- or bone-based glenoid version measurements on magnetic resonance imaging and to evaluate the usability of the glenoid articular surface and metaversion to determine the humeral head version.

Methods: Magnetic resonance imaging slices of 182 patients were evaluated in this retrospective study. Bone- and cartilage-based glenoid version angles, humeral head version angles, and metaversion angles were measured by 3 researchers. All measurements were made twice, with an interval of 2 months. Interrater and intrarater reliability were evaluated.

Results: The mean glenoid version angle was calculated as −3.58 ± 4.09° when measured from bone tissue and −5.79 ± 4.3° when measured from cartilage tissue. A non-linear correlation was determined between the measurements taken from bone and cartilage tissue for the glenoid version angle ($r = 0.423$). No statistically significant difference was determined between the inter- and intra-observer measurements ($P = .223$). No statistically significant difference was determined in the inter- and intrarater reliability for the humeral head version angle and metaversion angle measurements. A statistically significant relationship was observed between the humeral head version and the mean glenoid version measured from bone ($P = .019$). A negative correlation was observed between the bone-based glenoid version and the humeral head version ($P = .034$).

Conclusion: In cases in which the humeral metaphysis can be evaluated, metaversion is a good guide for the humeral head version. In cases in which the metaphysis cannot be evaluated, the glenoid version is a good option for determining the humeral head version. Further studies are needed to determine the humeral head version relative to the glenoid version.

Keywords: Glenoid version, humeral head version, metaversion

INTRODUCTION

The humeral head version angle is one of the variables evaluated in the planning of shoulder arthroplasty. It is very difficult to evaluate the humeral head version, especially in fragmented proximal humerus fractures, sequels of proximal humerus fractures, and severe humeral head deformation. The humeral head version is usually calculated using the forearm axis. According to the forearm axis, humeral retroversion is generally determined as 0-30°.[1] However, retroversion can vary from person to person. Therefore, it is important to determine the individual humeral version correctly in shoulder surgery. In cases in which the metaphysis is intact, the metaversion is an important determinant for humeral head version.[2] Determining the version is more difficult in cases in which the metaphyseal bone is lost. The opposite shoulder can be used in those cases. However, there are different studies showing that the versions of the right and left shoulder joints are different.[3] In the literature, there are studies indicating that there is or there is not a relationship between the humeral head version and the glenoid version.[3,4] Computed tomography (CT) was used for measurement in most of studies, and the glenoid version

Corresponding Author: Enver Kılıç, **E-mail:** enwerkilic@gmail.com

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differs in bone- and cartilage-based measurements on magnetic resonance imaging (MRI).[5] This suggests that the cartilage-based glenoid version, which forms the true articular surface, is related to the humeral head version.

The aim of the study is to answer the following questions:

1. Is there a relationship between the humeral head version and the cartilage- or bone-based glenoid version measurements on MRI?
2. If there is a significant relationship between the humeral head version and the cartilage-based glenoid version, can the glenoid articular surface be informative in determining the humeral head version in the absence of the humeral proximal metaphysis?

METHODS

Ethics committee approval was received for this study from the ethics committee of Ankara Numune Training and Research Hospital Clinical Research Ethics Committee (Date: August 09, 2018, Decision Number: E-18-2174). In this retrospective study, shoulder MRI images of 200 patients aged between 25 and 45 were evaluated. Pathologies that can change the glenoid and humeral versions and complicate the evaluation; cuff tear arthropathy, osteoarthritis, rheumatoid arthritis, glenoid and humerus fractures and their sequelae; patients with bilateral shoulder complaints, plexus pathology, cervical neuropathies, and instability cases with impaired glenohumeral joint relationship; and MRIs that were not taken with appropriate technique were excluded from the study. Magnetic resonance imaging sections of the shoulder with biceps pathologies, superior labrum anterior to posterior (SLAP) lesion, phase 1 adhesive capsulitis and stiff shoulder, calcific tendinitis, partial and minor cuff tears, acromioclavicular joint pathologies, and patients with no pathology on MRI were included in the study.

The MRI scans were taken with a 1.5 Tesla (T) whole-body MRI system (General Electrics, Milwaukee, Wis, USA) with a 33 mT/m maximum gradient capacity. Measurements were taken on suitable MRI slices in the Picture Archiving Communication Systems (PACS). The MRI slices of 182 patients were included in the study. All MRI scans were performed with the same position. The patient's arm was positioned in elbow extension, adduction, forearm supination, and the shaft of the humerus positioned parallel to the floor. All patients' demographic characteristics were evaluated such as age, gender, and shoulder side. On the axial slices of MRI T2 sequences in PACS, measurements were made from both bone and cartilage tissues for the glenoid version, the humeral head version, and the metaversion. The measurements were evaluated twice by 3 researchers (an orthopedic resident, an orthopedic surgeon specialized in shoulder surgery, and a radiologist specialized in musculoskeletal system radiology). After completing all of the first measurements, the second measurements were taken 2 months later. All the researchers performed the measurements on the same slices.

The Friedman method was used for glenoid version angle measurement.[6] The first axial slices passing immediately inferior to the base of the coracoid were used for evaluation. For the glenoid version angle measurement taken from the bone tissue, first the glenoid bone line and scapular line were identified. Then, the glenoid bone line was determined as the junction of the corner points of the anterior and posterior bone notches of the glenoid. The scapular line was formed by the line drawn joining the midpoint of the glenoid bone line and the most medial point of the scapula. The narrow angle between the scapular line and the glenoid bone line was evaluated as the glenoid bone version angle (Figure 1).

MAIN POINTS

- The glenoid and humeral head version angles are important variables affecting the stability and biomechanics of the shoulder.
- Humeral version at the metaphyseal level is defined as metaversion, and it can be used to predict humeral retroversion.
- In cases in which the metaphysis cannot be evaluated, the glenoid version is a good option for determining the humeral head version.

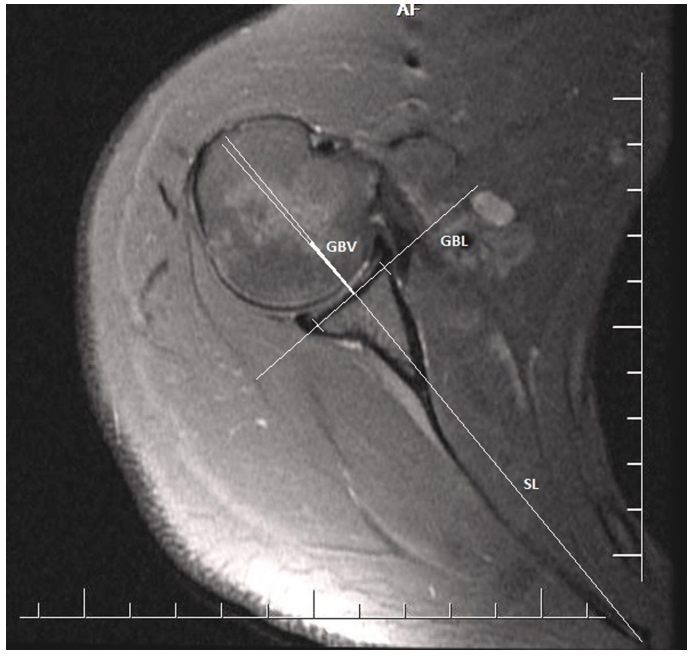

Figure 1. Bone-based glenoid version measurement. GBL, glenoid bone line; SL, scapular line.

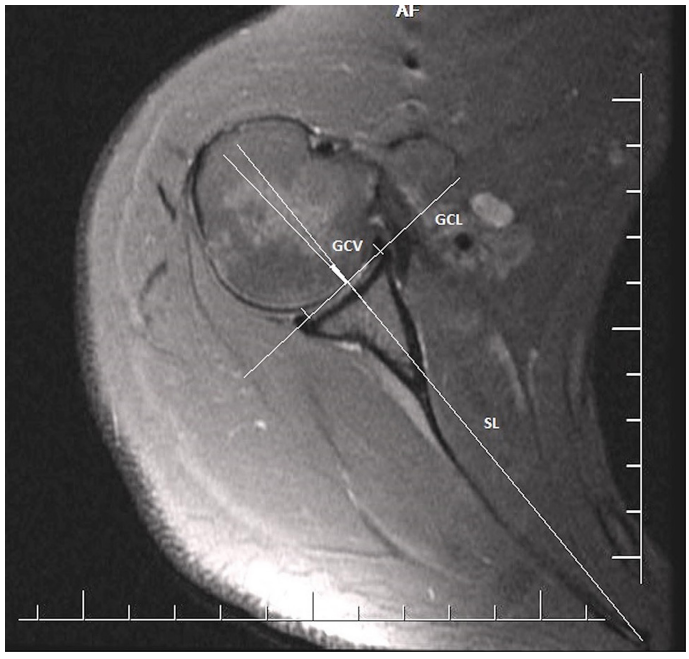

Figure 2. Cartilage-based version measurement. GCL, glenoid cartilage line; SL, scapular line.

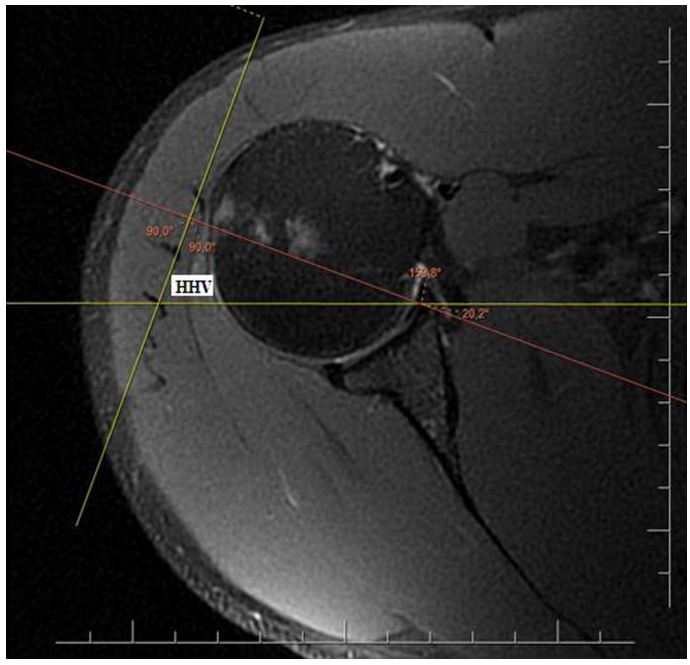

Figure 3. Humeral head version angle .

For the glenoid version of the measurement taken from cartilage tissue, the same slice was used. The subchondral bone layer and the cartilage layer were differentiated according to their hyperintensity. The glenoid cartilage line was formed by joining the anterior and posterior corner points of the glenoid. The scapular line was formed with the line drawn from the most medial point of the scapula to the midpoint of the glenoid cartilage line. The narrow angle between the scapular line and the glenoid cartilage line was evaluated as the glenoid cartilage version angle (Figure 2). Positive (+) values were defined as anteversion and negative (–) values as retroversion.

On the axial T2 slice where the humerus head was the widest, the anterior and posterior borders of the joint surface were determined and joined with a line drawn vertically. The angle formed by the MRI orientation line with this vertical line was evaluated as the humerus head version angle (Figure 3).[2]

In the measurement of metaversion, the first axial slice where the humerus head ended on the axial T2 slice was used. A line was drawn from the most medial point of the metaphyseal zone to divide the zone into 2. The angle formed with the MRI orientation line of this line was evaluated as the metaversion angle (Figure 4).[2]

Statistical Analysis

Statistical analyses of the data were performed using Statistical Package for the Social Sciences (SPSS) version 22.0 software (IBM Corp.; Armonk, NY, USA). Intrarater and interrater reliability was applied to statistically evaluate the relationship between the first and second glenoid version angle measurements of the researchers taken from the bone and cartilage tissues, as well as the relationship between mean glenoid version angle measurements from the bone and cartilage tissues. To determine differences between the metaversion and humerus head version mean measurements of the researchers, the Kruskal–Wallis test was applied. Pearson correlation analysis was performed to determine the relationship between

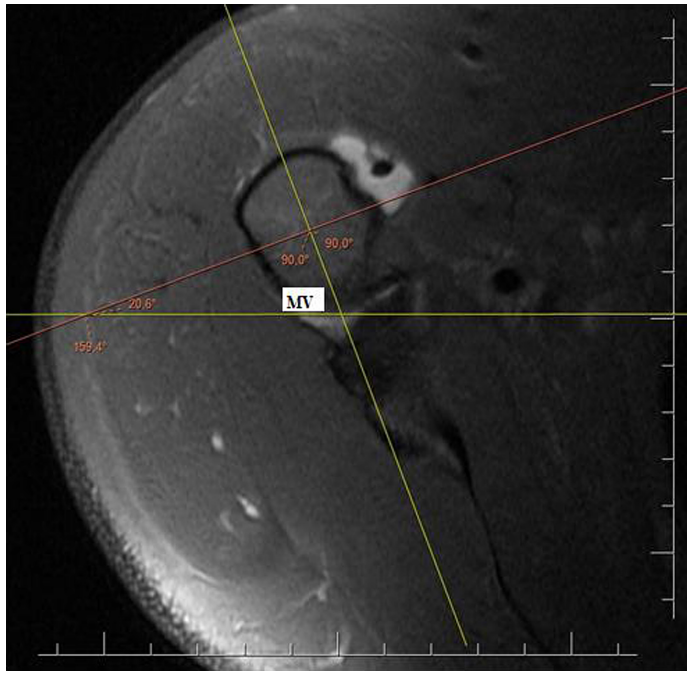

Figure 4. Metaversion angle .

the humerus head version and the glenoid version. A value of $P < .05$ was accepted as statistically significant.

RESULTS

The MRI scans of the patients (89 right shoulder, 93 left shoulder; 93 females, 89 males) with a mean age of 37.4 ± 6.12 (range 25-45) years were evaluated. There were no data about the dominant hand.

When the mean value of all the measurements was considered, the mean glenoid version angle was calculated as –3.58 ± 4.09° measured from the bone and –5.79 ± 4.3° measured from the cartilage. The measurement results of each researcher are shown in Table 1. Interclass correlation coefficients (ICCs) were used to determine intraobserver and interobserver variability. According to the results of the ICCs, there was a statistically significant concordance between each observer's first and second measurements and their average bone- and cartilage-based measurements. A statistically significant difference was determined between the glenoid version angle measurements taken from the bone and cartilage tissue for all researchers ($P < .05$). Pearson correlation analysis was applied to evaluate the relationship between the glenoid version angle measurements taken from 2 different tissues. A significant relationship was determined between the mean glenoid version angle measurements taken from the bone and cartilage tissues ($P < .05$). This correlation was not linear. We realized that while the retroversion value in the measurements made from bone tissue increased, the difference between the measurements made from the bone and cartilage tissues decreased.

The humeral head version and metaversion angles were measured for all patients in the study. The mean humeral head version angle was 69.36 ± 3.20°, and the mean metaversion angle was 68.89 ± 3.10°. No statistically significant difference was determined in the interrater reliability for the humeral head version angle and metaversion angle ($P = .719$, $P = .770$). In correlation analysis, a statistically significant relationship was observed between mean metaversion and humeral head version angles ($P < .01$). A statistically significant relationship was observed between the humeral head version and the mean glenoid version measured from bone ($P = .019$). A negative correlation was observed between bone-based glenoid version and the humeral head version ($P = .034$). There was no statistically significant difference between male and female glenoid version and humeral head measurements. No statistically significant difference was determined between left and right side measurements.

DISCUSSION

The first conclusion of this study is that there is a negative relationship between the humeral head version and the glenoid bone-based version. The second result is that in the absence of the humeral head, metaversion gives an idea about the humeral head version, and in the absence of the metaphysis, the glenoid bone articular surface gives an idea about the humeral head version.

The glenoid version and the humeral head version have an important role in the correct placement of the components in shoulder arthroplasty.[7,8] They are also important in instability surgery. Accurate evaluation of both the glenoid version and the humeral head version is important for stability and clinical, and functional outcomes. The glenoid version is retrovert in most of the studies.[9,10] In the current study, the glenoid version was found retrovert, with a mean measurement of –3.58° taken from the bone tissue and –5.79° taken from the cartilage tissue. These values are consistent with the literature.

Previous studies have shown that posterior instability is high in glenoid retroversion, whereas anterior instability is more common in patients with glenoid anteversion.[11] However, there are also studies that have shown no effect of glenoid retroversion on instability.[12] This wide-ranging variation in the glenoid version may not adversely affect normal shoulder function and stability. This situation can be explained by the differences in the measurements of the bone- and cartilage-based glenoid versions or variation of the humeral head version associated with the glenoid version. The difference of bone- and cartilage-based

Table 1. Cartilage-Based and Bone-Based Glenoid Version Measurements

		Patient Number	Mean	Minimum	Maximum
Cartilage-based measurement	First researcher	182	–5.93 ± 3.74	–14.15	3.60
	Second researcher	182	–6.01 ± 4.27	–14.20	7.60
	Third researcher	182	–5.43 ± 4.81	–15.90	7.65
Bone-based measurement	First researcher	182	–3.90 ± 3.84	–15.00	7.15
	Second researcher	182	–3.67 ± 3.95	–16.50	7.45
	Third researcher	182	–3.17 ± 4.43	–15.15	10.25

glenoid measurements has been demonstrated in previous MRI studies.[5] However, there is no MRI study evaluating the relationship between the humeral head version and the glenoid version. This is one of the reasons why we started this study.

According to most of the studies about shoulder arthroplasty, if the humeral retroversion is not calculated correctly, shoulder range of motion, functional outcome scores, and strength will not change. Despite internal rotation, scores will be better in 0° humeral retroversion, and internal rotation will increase if the humeral component is placed closer to native retroversion.[13,14] Correct detection of the humeral head version will affect surgical outcomes. In the literature, studies using MRI are limited.

Determining the humeral head version is not easy, especially in shoulder arthroplasty due to the proximal humeral fracture. In these cases, the contralateral shoulder may be evaluated preoperatively or the epicondylar axis may be used intraoperatively to determine the humeral head version. But if the metaphyseal region is intact, it helps us to determine the humeral head version intraoperatively and preoperatively. Metaversion is an angular parameter that can give valuable information for the surgical planning of shoulder arthroplasty, especially in patients with a previous fracture of the humeral head, severe degenerative changes in the humeral head, and multiple fragmented proximal humerus fracture.[15] Similar to the literature, in this study, no significant difference was found between the humeral head version angle and the metaversion angle. This indicates that metaversion is a measurement that can be used in the prediction of humerus head version.[2] In the current study, we demonstrated the relationship between metaversion and humeral head version in MRI sections. A statistically significant correlation was observed between the mean values of the metaversion and humeral head version angles.

In the surgical site is an important problem in complex cases in which the metaphysis could not be evaluated. A contralateral shoulder humeral head version can be used for that case. In the current study, there is no statistically significant difference between the right and left humeral head version angles. But, there are different studies showing that the versions of the right and left shoulder joints are different.[3]

In the shoulder arthroplasty cases in which the metaphyseal region cannot be evaluated, generally the use of epicondylar axis is preferred for determining the humeral head version. The glenoid and humeral head version angles have a wide range of distribution. Therefore, it may suggest that the glenoid and humeral head versions may be related. In the current study, we found a negative correlation between bone-based glenoid version and the humeral head version. This correlation suggests that the glenoid version is a guide in deciding the humeral head version, especially in shoulder arthroplasty due to trauma where the metaphysis cannot be evaluated. Further studies are needed to support this suggestion.

There are some limitations to this study. Firstly, it is not easy to make detailed evaluations on classical MRI slices. The 1.5 T MRI systems were used in this study. Secondly, the number of cases is not sufficient to make a statistically strong inference. Thirdly, we were unable to identify a glenoid-dependent criterion that could be used to determine the humeral head version. A reference point can be determined in the glenoid with further studies.

In conclusion, in cases in which the humeral metaphysis can be evaluated, metaversion is a good guide for the humeral head version. In cases in which the metaphysis cannot be evaluated, the glenoid version is a good option for determining the humeral head version. Further studies are needed to determine the humeral head version relative to the glenoid version.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Ankara Numune Training and Research Hospital (Date: August 9, 2018, Number: E-18-2174).

Informed Consent: Consent was obtained from the hospital management where patient data were collected.

Peer-review: Externally peer-reviewed.

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