Determining the Normal Glenoid Version in the Indian Population

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Abstract

Background Glenoid version refers to the angle subtended by the glenoid with the scapula. On average, it is 0 ± 10 degrees with a slight propensity toward retroversion. Numerous factors such the dominance(handedness), gender, ethnicity, and pathology are known to affect version. Version has important consequences on the biomechanics of the shoulder joint and is altered in those with arthritis and shoulder joint instability.

Aim Our study aimed to determine the normal range of glenoid version in the population. Further, we aim to assess the relationship between gender and version.

Settings and Design We conducted a retrospective observational study in a tertiary referral hospital with a target sample size of 200 shoulders.

Methods and Materials The computed tomography images were retrospectively reviewed to determine the scapular shape and the glenoid version angle.

Statistical Analysis Statistical analysis was done using SPSS v.22 software with *p*-value less than 0.05 considered as significant.

Results The mean age of the individuals in our study was 44 years. In our study, irrespective of gender, most individuals had some degree of anteversion and males had lower degree of anteversion. Previous studies have shown that most normal individuals usually have retroverted shoulder joints. The mean glenoid version was significantly lower in the right than in the left shoulder and males had significantly lower mean glenoid version than females in both shoulders. Most individuals in our study had a flat scapular spine.

Conclusion This study shows that the Indian population may have a slight propensity toward anteversion and this has an important bearing on shoulder arthroplasty. Further, this study shows that significantly lower degrees of version are found on the right side and that the degree of version is significantly lower in males. Understanding the role of glenoid version in shoulder biomechanics will go a long way in the early identification of pathology, the preoperative planning of shoulder arthroplasty, and the operative restoration of a functional shoulder joint.

Keywords
- shoulder
- glenoid
- version
- Indian

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Introduction

Glenoid version refers to the angle subtended by the glenoid with the scapula. It is the angle subtended by the mid-glenoid line and the perpendicular line to the scapular line. The mid-glenoid line refers to the line between the anterior and posterior ends of the glenoid, taken at approximately the center of the glenoid along the superoinferior axis. On average, it is close to 0 ± 10 degrees version on either side with a slightly higher propensity toward retroversion.[1] Numerous factors such the dominance(handedness), gender, ethnicity and pathology are known to affect version.[2,3] Version has important consequences on the biomechanics of the shoulder joint and is altered in those with arthritis and shoulder joint instability.[4–7]

Glenoid retroversion has also been associated with anterosuperior rotator cuff tears, while anteversion is associated with posterior rotator cuff tears. Glenoid version determination is also important in patients undergoing arthroplasty, as maintaining a normal degree of version helps reduce stress and wear on the glenoid component of the shoulder arthroplasty.[4,8] Glenohumeral arthritis is known to cause predominant wear at the 8 and 9 O'clock position of the glenoid with resultant progressive glenoid retroversion. Failure to correct this retroversion during arthroplasty can cause eccentric loading of the glenoid component, decreased glenohumeral contact, and eventually lead to implant loosening. The degree of version is higher in males, in the dominant shoulder as well as in arthritic shoulders.[4,8,9] Assessing the degree of version can help determine the severity of arthritis and the difficulty of shoulder joint replacement.[8] The glenoid version helps express complex three-dimensional data in a two-dimensional plane.[1]

Large-scale studies on the normal range of version in the Indian population are lacking. Establishing this range is essential to establish a normal value for our population and set deviations from the normal. Our study aims to determine the normal range of glenoid version in the population. Further, we aim to assess the relationship between gender and version.

Methodology

This is a retrospective observational study that was performed in a tertiary referral hospital with a target sample size of 200 shoulders. The scans of patients, that is, 200 shoulders who had undergone computed tomography (CT) for unrelated indications (such as CT cervicothoracic spine or CT neck) were retrospectively reviewed to determine the scapular shape and the glenoid version angle. Data such as age, gender, degree of version, and scapular shape were recorded. CT was done using a Philips Brilliance 64-slice CT. The glenoid version was measured in the axial plane with 0.9 mm thin cuts with three-dimensional multiplanar reconstruction.

The glenoid version was measured using the conventional method, that is, the Friedman method. The scapular line extends from the medial end of the scapular spine to the midpoint of the anterior and posterior ends of the glenoid (glenoid line). Next, a perpendicular line to the scapular line is drawn and the angle between the glenoid line and the perpendicular line to the scapular line is measured along the posterior aspect to determine the degree of version. Usually, the glenoid is tilted posteriorly resulting in a slight degree of retroversion. It is necessary to compensate for the coronal obliquity of the scapula, its medial to lateral anteversion, and its adduction or abduction as it follows the contour of the chest wall. ►**Fig. 1** demonstrates the normal technique of glenoid version measurement.

In practice, the angle is measured by orienting the axes as follows:

In the coronal plane, the reference line is oriented along the plane of the superior and inferior ends of the glenoid to correct for abduction. In the sagittal plane, the reference axis

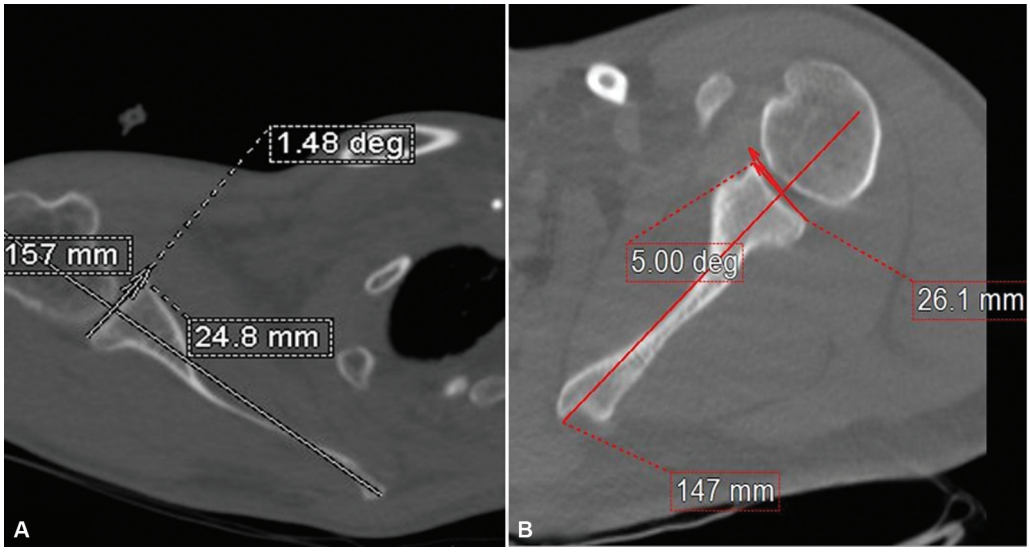

Fig. 1 (**A**, and **B**) The normal technique of glenoid version measurement in two sample images of the right and left shoulder with glenoid anteversion measuring 1.48 and 5 degrees, respectively.

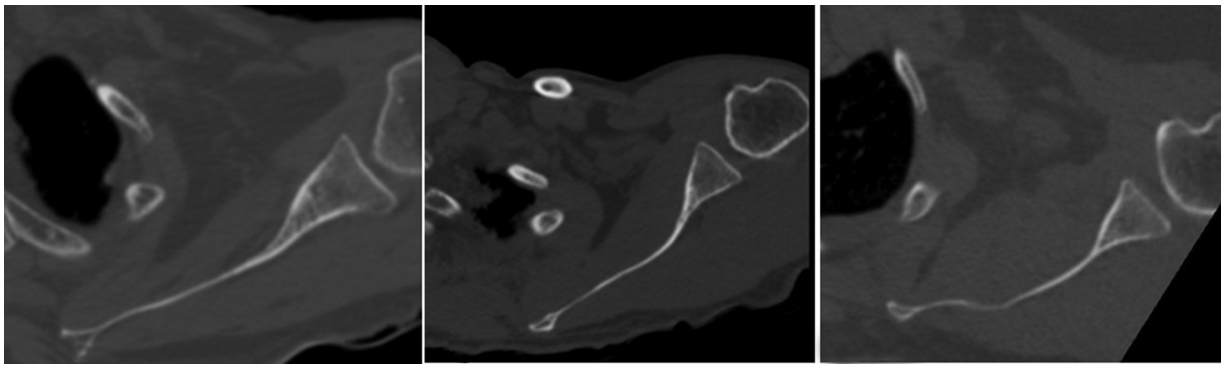

Fig. 2 Different patients with variations in scapular shape with the spine being flat, round, and wavy, respectively.

is oriented along the plane of the scapular body to correct for the coronal obliquity. Then, in the transverse plane, it is oriented along the scapular spine to correct for the medial to lateral anteversion of the scapular body. The angle of version is taken in the mid-glenoid plane after scrolling through a set of candidate slices where the entire scapular spine is visualized. ►**Fig. 2** shows the different scapular shapes seen in the normal population.

After orienting the axes as described above the angle is measured. First, a line is drawn between the anterior and posterior ends of the glenoid—the glenoid line. Next, a line is drawn from the medial end of the scapula to the mid-glenoid line—the scapular line. The angle subtended posteriorly by the perpendicular line to the scapular line with the glenoid line is the degree of version. A screenshot was taken at this level and these were then reviewed by two other radiologists for accuracy and discrepancies in technique. ►**Fig. 3** demonstrates the process of glenoid version measurement step by step.

Three observers assessed the study, two senior radiologists with over 25 years of experience, and 15 years of experience respectively and a junior radiologist with 3 years of experience. For interobserver variability, the first five patients were assessed together to ensure similar pattern of assessment as mentioned in the study protocol and the rest of the patients were assessed individually. For intraobserver variability, the assessment was repeated after a week with the same sample. Statistical measurements were performed using the Statistical Package for the Social Sciences (SPSS), from which it was determined that there was no statistically significant interobserver (p-value = 0.997) and intraobserver variation (p-value = 0.995).

Inclusion Criteria

- Absence of obvious pathology of the shoulder joint such as arthritis.
- Only studies in which the entire scapula including the medial end of the scapular spine are visualized were included.
- Only studies in which the elbow was extended and the forearm was supinated were included in the study as rotation in both the sagittal and coronal plane can alter the glenoid version by as much as 12 degrees.[1,2] In our particular hospital, all patients undergoing CT spine and CT neck are placed in such a position and only these studies were included.
- Only studies with the glenoid in the neutral position were included as it gives more accurate and reproducible measurements.[10]

Exclusion Criteria

Patients with symptoms and pathologies related to shoulder joint were excluded.

Data were analyzed using Microsoft Excel version. 2010 and SPSS v. 22. Statistical significance was set at p-value less than 0.05.

Ethics Statement

The project proposal was submitted to the institutional ethics committee and the study was conducted after obtaining a waiver for patient consent as it was a retrospective study. All patient data were anonymized before analysis and patient details will be kept confidential.

Results

Of the patients included in this study, 64 were male and 47 were female. The mean age of the patients included in the study was 44 years (range: 16–77 years). The mean version as determined by our study was 0.5 in the right shoulder and 0.85 in the left shoulder. The data were then tabulated to include the type of version (anteversion/retroversion) and the scapular shape as shown in ►**Table 1**. The same data were then analyzed separately by gender to study the effect; if any, that gender has on glenoid version and this was represented separately in ►**Tables 2** and **3**. Overall, most shoulders (123/200–58%) were anteverted, with the left shoulder generally showing a higher proportion of individuals with some degree of anteversion. When analyzed by gender, females generally had a higher proportion of individuals with some degree of anteversion. Males had a higher range of glenoid version on the right and the left. The normal range of glenoid version in our sample was −5.34 to 5.54. The left shoulder had a larger range of glenoid version than the right.

Overall, irrespective of gender, the right shoulder had lower degree of version as compared with the left (p-value

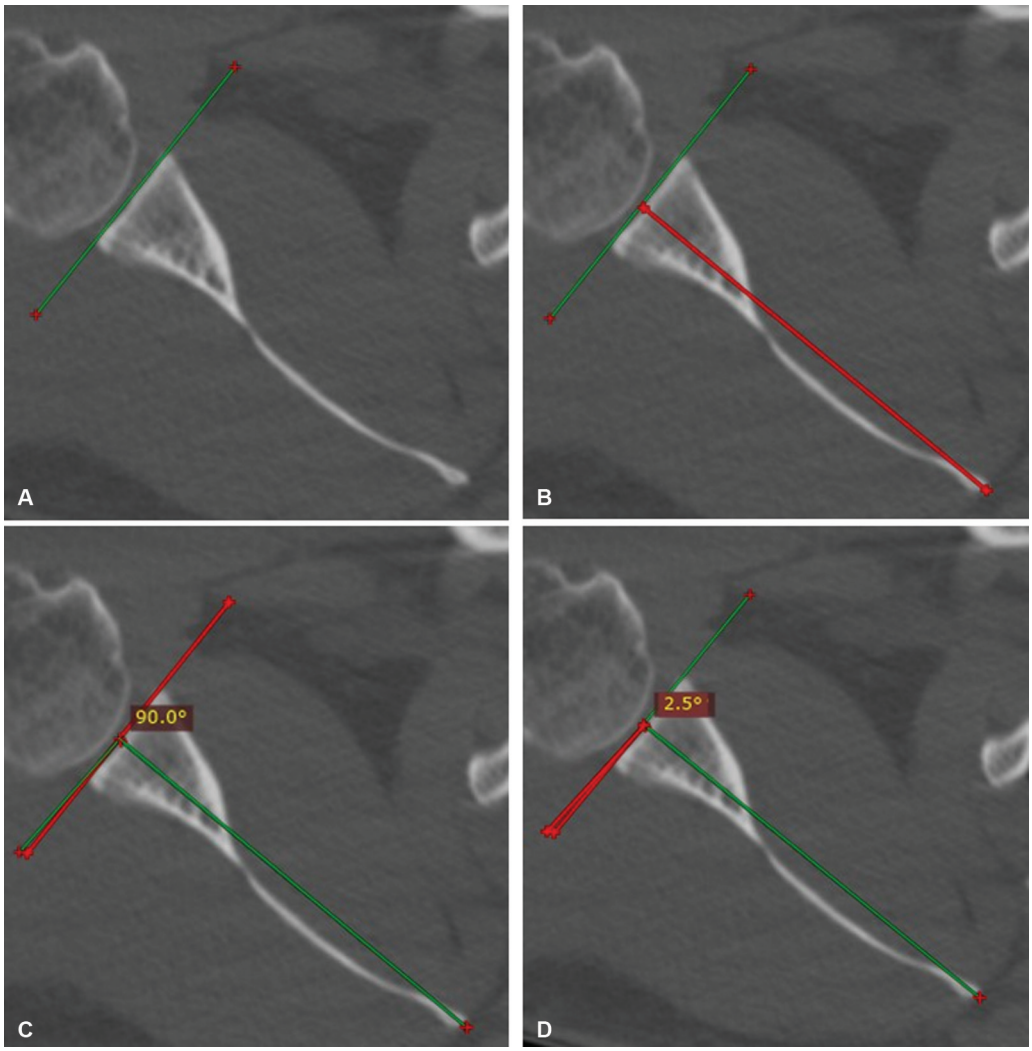

Fig. 3 The steps involved in measuring the glenoid version as per the conventional method. (**A**) First a line is drawn along the glenoid along its midpoint in the superior–inferior axis (glenoid line–in green). (**B**) Next, a line is drawn along the scapula, from the midpoint of the glenoid line to the medial end of the scapular spine (scapular line—in red). (**C**) A line is then drawn perpendicular to the scapular line. (**D**) The angle subtended by the perpendicular line to the scapular line with the glenoid line is measured that in this patient is 2.5 degrees of retroversion.

Table 1 Outline of the characteristics of patients included in this study with the respective *p*-value

Mean age: 44 years			
	Right shoulder	**Left shoulder**	***p*-Value**
Anteversion	58	65	0.309
Retroversion	42	35	0.309
Mean glenoid version	0.5	0.85	<0.001*
Range of version	−4.89 to 5.06	−5.34 to 5.54	–
Scapular shape			
– Flat	57	68	0.197
– Round	27	23	
– Wavy	16	9	

Note: *p*-Values that were significant have been marked with an asterisk i.e., I-Values <0.05.

Table 2 Outline of the characteristics of male patients included in this study

Male			
	Right shoulder	**Left shoulder**	***p*-Value**
Anteversion	32 (54%)	37 (64%)	0.293
Retroversion	27 (46%)	21 (36%)	0.293
Mean glenoid version	0.17	0.75	<0.001*
Range of version	−4.89 to 5.06	−5.34 to 5.54	–
Scapular shape			
– Flat	33 (56%)	41 (71%)	0.154
– Round	16 (27%)	13 (22%)	
– Wavy	10 (17%)	4 (7%)	

Note: *p*-Values that were significant have been marked with an asterisk i.e., I-Values <0.05.

Table 3 Outline of the characteristics of female patients included in this study

Female			
	Right shoulder	Left shoulder	*p*-Value
Anteversion	26 (63%)	28 (67%)	0.756
Retroversion	15 (37%)	14 (33%)	0.756
Mean glenoid version	0.97	1.00	0.874
Range of version	−4.21 to 4.98	−4.5 to 4.8	
Scapular shape			
– Flat	24 (58%)	27 (64%)	0.859
– Round	11 (27%)	10 (24%)	
– Wavy	6 (15%)	5 (12%)	

Table 4 Details of the measurement differences between males and females with respect to the right shoulder

Right shoulder			
	Female	Male	*p*-Value
Anteversion	26 (63%)	32 (54%)	0.360
Retroversion	15 (37%)	27 (46%)	0.360
Mean glenoid version (SD)	0.97	0.17	<0.001*
Range of version	−4.21 to 4.98	−4.89 to 5.06	–
Scapular Shape			
– Flat	24 (58%)	33 (56%)	0.795
– Round	11 (27%)	16 (27%)	0.974
– Wavy	6 (15%)	10 (17%)	0.756

Abbreviation: SD, standard deviation.
Note: *p*-Values that were significant have been marked with an asterisk i.e., I-Values <0.05.

<0.001), which tended toward neutral version with significant difference in the angle of glenoid version between shoulders in males (<0.001), but this difference failed to reach statistical significance in females. Also, when compared with females, males had significantly lower degree of version (closer to zero) in both the right ($p < 0.001$) and left (0.045) shoulders. ►**Tables 4** and **5** highlight version characteristics of the right and left shoulders, respectively, with a breakdown based on gender.

When the scapular shape was analyzed, a majority of individuals in the study had a flat scapular spine with gender not having any obvious correlation with the scapular shape. However, a higher proportion of individuals had a scapular spine that was flat on the left as compared with the right. These differences based on scapular shape did not reach statistical significance.

Table 5 Details of the measurement differences between males and females with respect to the left shoulder

Left shoulder			
	Female	Male	*p*-Value
Anteversion	28 (67%)	37 (64%)	0.766
Retroversion	14 (33%)	21 (36%)	0.766
Mean glenoid version (SD)	1.00	0.75	0.045*
Range of version	−4.5 to 4.8	−5.34 to 5.54	–
Scapular shape			
– Flat	27 (64%)	41 (71%)	0.498
– Round	10 (24%)	13 (22%)	0.870
– Wavy	5 (12%)	4 (7%)	0.387

Abbreviation: SD, standard deviation.
Note: *p*-Values that were significant have been marked with an asterisk i.e., I-Values <0.05.

Discussion

The glenoid version has an important bearing on shoulder dynamics and may increase the vulnerability to anterior/posterior shoulder dislocation as well as glenohumeral arthritis.[4–6] The degree of the glenoid version varies with ethnicity and is generally lower in Asians compared with those of African-American or Hispanic descent.[2]

The mean age of the individuals in our study was 44 years. As per the study by Piponov et al, males generally had a larger glenoid and exhibited a more retroverted glenoid.[2] In our study, a slightly higher percentage of males had a retroverted glenoid. Also, the mean glenoid version among males was 0.17 and 0.75 in the right and left shoulders, respectively. Compared with this, females had a slightly higher mean version with the mean glenoid version in females being 0.97 and 1 respectively. This difference was found to be significant in both the right and left shoulder. Differences in the nature of their work and engagement in sport activities during childhood may explain these gender specific differences.

However, irrespective of gender, most individuals in our study had some degree of anteversion rather than retroversion. Previous studies have shown that most normal individuals usually have retroverted shoulder joints. Larger multicentric studies are needed to confirm whether this tendency toward anteversion in our study reflects a change in the population glenoid version characteristics.

The mean glenoid version tended to be significantly lower in the right than in the left shoulder, with this difference being more pronounced in males. Other studies have shown that glenoid retroversion was greater on the dominant side than on the nondominant side in normal shoulders. Although data on handedness was unavailable, most individuals in the general population are right-handed and it is fair to assume that this tendency toward lower degrees of anteversion/retroversion is a result of altered glenoid version dynamics on the dominant

side.[3] The glenoid is thought to be retroverted in highly demanding situations. The differences between sides appear to occur in the glenoid vault and not in the scapular body.

Most individuals in our study had a flat scapular spine. None of the differences in scapular shape between genders or right/left shoulder reached statistical significance. The scapular shape has an important bearing on version as the conventional method utilizes the medial end of the scapular spine to determine the scapular line. To negate this effect, the vault version has been proposed to assess the glenoid version.[3] In individuals with a flat scapular spine, the version is more likely to be equal when determined by either of these methods.

Drakos et al conducted a study on the effective glenoid version in professional baseball players. They found significantly higher degrees of version in elite throwing athletes than nonthrowing athletes which they believe is an adaptive response during the development of the shoulder in overhead throwing athletes. Increased retroversion may be biomechanically necessary for throwing the baseball at high velocity that explains the increased osseous glenoid retroversion of the dominant shoulder in throwers. Their study also hinted that the morphological changes are likely related to the number of throws and years of throwing rather than velocity or intensity.[11] Pieper in a study of handball players found that those without humeral retroversion were more likely to present with chronic arm pain which suggests that this may be an adaptive response. Although our study did not investigate the angle of the glenoid version in overhead-throwing athletes, it remains an interesting avenue of research given the possible altered population characteristics.[12]

The drawbacks of this study are as follows: The glenoid version was assessed by the conventional method in our study, but the accuracy of this technique has been questioned as it is strongly influenced by the scapular shape with some referring to it as the scapular version rather than the glenoid version. However, most large-scale studies that were used as references in this study used the conventional method to assess the glenoid version, and hence the same was adopted.

The preoperative determination of the shoulder version is one of the most important factors affecting the placement of the glenoid component of the shoulder arthroplasty. This study shows that the Indian population may have a slight propensity toward anteversion and this has an important bearing on shoulder arthroplasty. Further, this study shows that lower degrees of version are generally found on the right side and that the degree of version is generally lower in males. Widespread understanding of the role that the glenoid version plays in shoulder biomechanics will go a long way in the early identification of pathology, the preoperative planning of shoulder arthroplasty, and the operative restoration of a functional shoulder joint.

Data Availability Statement
All data will be made available on request. Kindly email the corresponding author for the same.

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None.

Conflict of Interest
None declared.

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