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Original Research Article

A CT-Based Study of Glenoid Version in Patients with Frozen Shoulder

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Abstract

Background: Glenoid version is a key morphometric parameter influencing glenohumeral joint biomechanics, stability, and load distribution. Alterations in glenoid orientation, particularly increased retroversion, have been implicated in abnormal joint kinematics, posterior humeral head translation, and degenerative shoulder conditions. While glenoid version has been extensively studied in normal and arthritic shoulders, its role in frozen shoulder (adhesive capsulitis) remains inadequately explored, especially in relation to repetitive overhead activity. ***Aim:*** To evaluate glenoid version in patients with frozen shoulder using computed tomography (CT) and to analyze its association with dominance and overhead activity. ***Materials and Methods:*** This observational study included 40 patients clinically diagnosed with frozen shoulder. Glenoid version was measured on axial CT images using the Friedman method. Comparisons were made between dominant and non-dominant shoulders and between patients with and without a history of repetitive overhead activity. Statistical analysis was performed using SPSS, with results expressed as mean, standard deviation, and p-values. ***Results:*** The mean glenoid version was −10.9 ± 3.4°, indicating overall retroversion. Increased retroversion (>10°) was observed in 45% of patients. Glenoid retroversion was significantly greater in patients with overhead activity compared to those without ($p < 0.001$) and on the dominant side compared to the non-dominant side ($p = 0.002$). ***Conclusion:*** Increased glenoid retroversion is common in frozen shoulder patients, particularly in those with dominant-side involvement and repetitive overhead activity, suggesting a possible biomechanical contribution to disease pathology.

Keywords: Glenoid version, glenoid fossa, retroversion, observational study.

INTRODUCTION

The glenohumeral joint is the most mobile synovial joint in the human body and plays a central role in positioning the upper limb in space. This exceptional mobility is achieved through articulation between the large, spherical head of the humerus and the relatively shallow glenoid fossa of the scapula. The glenoid fossa is a variably shaped articular surface, commonly described as pear-shaped or oval, oriented laterally with a slight anterior or posterior tilt in the axial plane. Owing to its shallow depth, intrinsic bony stability of the shoulder joint is limited, making the precise morphology and orientation of the glenoid fossa critical for joint congruity, stability, and efficient load transmission during movement [1]

One of the most important morphologic parameters of the glenoid fossa is glenoid version, which refers to the angular orientation of the glenoid articular surface relative to the transverse axis of the scapula. Glenoid version is typically expressed as anteversion, neutral version, or retroversion. Although small degrees of retroversion are considered physiologic, excessive deviation from neutral alignment can substantially alter glenohumeral biomechanics [2]. Glenoid retroversion has been shown to promote posterior translation of the humeral head, increase eccentric joint loading, and predispose the shoulder to instability, degenerative changes, and altered capsuloligamentous stress patterns [3–5].

Accurate assessment of glenoid version has evolved significantly with the advent of advanced imaging techniques. Conventional radiographs, particularly axillary views, are limited by projectional errors, patient positioning, and scapular overlap, leading to inconsistent and often inaccurate measurements. Computed tomography (CT) has therefore become the imaging modality of choice for evaluating glenoid morphology and version. CT allows precise visualization

of the scapular anatomy in the axial plane and enables reproducible angular measurements independent of soft-tissue interference. Among the various measurement techniques described, the Friedman method remains the most widely used and validated approach for assessing glenoid version on axial CT images [1,2,6].

In the Friedman method, an axial CT slice at the mid-glenoid level—where the anterior and posterior rims of the glenoid are clearly visualized—is selected. A scapular axis line is drawn from the medial border of the scapula to the midpoint of the glenoid. A second line is drawn along the glenoid articular surface connecting the anterior and posterior margins. The angle between the glenoid line and a line perpendicular to the scapular axis defines the glenoid version. Angulation posterior to the perpendicular is considered retroversion, whereas anterior angulation indicates anteversion. This technique has demonstrated good inter- and intra-observer reliability and remains a reference standard in both clinical and research settings [6].

The orientation of the glenoid fossa has profound implications for shoulder joint biomechanics. During functional activities, particularly arm elevation, rotation, and overhead use, the glenohumeral joint is subjected to complex combinations of compressive, shear, and torsional forces. A near-neutral glenoid orientation facilitates centralization of the humeral head and uniform load distribution across the articular surface. In contrast, increased glenoid retroversion alters joint reaction forces, leading to posterior humeral head subluxation, increased stress on the posterior capsule, and compensatory changes in muscle activation. Over time, these biomechanical alterations may contribute to pain, stiffness, and progressive joint pathology [3,5].

Repetitive overhead activities, such as those performed by athletes, manual laborers, and individuals involved in sustained occupational shoulder use, further amplify these biomechanical stresses. Adaptive osseous changes in response to repetitive loading have been described, including alterations in glenoid and humeral head version [7]. Several studies have demonstrated increased glenoid retroversion and humeral head retroversion on the dominant side in overhead athletes, suggesting a long-term adaptive response to repetitive functional demands [3]. These adaptations, while potentially advantageous for performance, may predispose the joint to abnormal kinematics and capsuloligamentous strain [4].

A substantial body of literature has examined glenoid version in normal populations, cadaveric specimens, and pathological conditions such as shoulder instability and glenohumeral osteoarthritis. CT-based studies have reported considerable inter-individual variability in glenoid version, influenced by factors such as sex, handedness, ethnicity, and underlying pathology. Recent work in the Indian population has suggested a tendency toward neutral or mild anteversion, highlighting ethnic variations in glenoid orientation and underscoring the importance of population-specific normative data [4,6].

In osteoarthritic shoulders, progressive posterior glenoid wear and increasing retroversion have been strongly associated with posterior humeral head subluxation and poor outcomes following shoulder arthroplasty. Despite these advances, frozen shoulder (adhesive capsulitis) remains relatively underexplored from an osseous and morphometric perspective. Frozen shoulder is characterized clinically by pain, progressive restriction of active and passive movements, and functional disability [8]. Most imaging studies in frozen shoulder have focused on soft-tissue changes, including capsular thickening, rotator interval fibrosis, and synovial inflammation, predominantly using magnetic resonance imaging. The potential contribution of bony factors, particularly glenoid version, to altered shoulder biomechanics in frozen shoulder has received limited attention.[1]

This represents a significant gap in the existing literature. Altered glenoid version—especially retroversion—may influence joint kinematics, increase capsular tension during motion, and exacerbate stiffness in patients with frozen shoulder, particularly in those with a history of repetitive overhead activity. However, standardized CT-based evaluation of glenoid version using reproducible methods such as the Friedman technique has not been adequately studied in this patient population. Moreover, there is a paucity of data correlating glenoid version with the biomechanical and clinical features of frozen shoulder.

Aim: To study the glenoid version in patients with frozen shoulder by the computed tomography (CT) scan.

Objectives:

1. To measure the glenoid version in patients with frozen shoulder
2. To compare the glenoid version the dominate and non-dominant side of shoulder
3. To compare the glenoid version between overhead activity and non-overhead activity.

MATERIALS AND METHODS

Study Design: Observational study.

Study Setting: The study was conducted in the Department of Anatomy at Index medical college and research centre, Indore, Madhya Pradesh.

Sample Size: The present study included 40 patients diagnosed with frozen shoulder, selected by convenience sampling

Inclusion Criteria

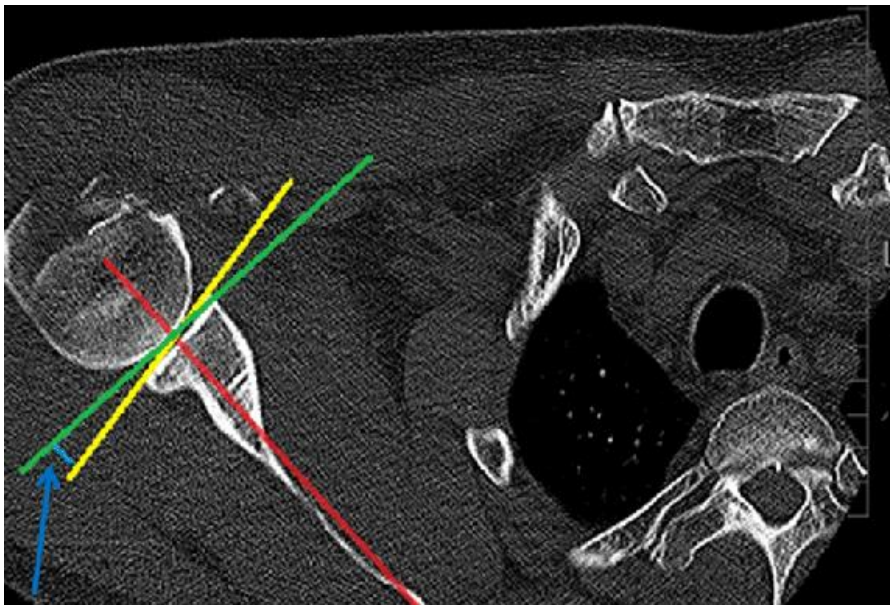
- Patients with the complain of shoulder pain
- Patients having limited range of motion in shoulder abduction
- Patients with overhead repeated activity

Exclusion Criteria

- Patients with acute injury
- Patients with congenital deformity

Method of Data Collection

The scan of 40 patients were taken who had undergone computed tomography (CT) for the complain of shoulder pain with limited range of shoulder abduction in coronal plane. Glenoid version was measured using the Friedman method from computed tomography (CT) scans in axial sections. Friedman method is a conventional method for measuring the glenoid version. The parameters studied included the glenoid version and the activity of the patient i.e. overhead activity. 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. Angles directed posteriorly were recorded as retroversion. Values exceeding 10° of retroversion were considered pathological. Measurements were performed and mean values were calculated



Statistical Analysis

Data was analyzed using SPSS software. Results were expressed as mean, percentage, and standard deviation.

RESULTS

Out of 40 samples the mean value of glenoid version angle was found to be -10.9± 3.4 where the negative sign shows retroversion. In our present study, 22 patient reported overhead activity and other where without overhead activity. The p value was statistically significant. In side wise comparison of glenoid version dominant side of the patient was more affected then the non-dominant side and also showing the result statistically significant for the side. In 18 patients the angle range was of more the 10 degree which contributes about 45% of the total sample. In 30% of sample i. e. 12 in number the range of glenoid version was in the normal range.

Table 1: Descriptive statistics of glenoid version angle

Variable	Mean ± SD (°)	Minimum (°)	Maximum (°)
Glenoid version angle	−10.9 ± 3.4	−5	−18

Table 2: Comparison of glenoid version between overhead and non-overhead activity groups

Activity Pattern	n	Mean Glenoid Version (°) ± SD	p-value
Overhead / repetitive activity	22	−13.2 ± 2.8	
No overhead activity	18	−7.8 ± 2.4	**<0.001***

Table 3: Side-wise comparison of glenoid version

Side	n	Mean Version (°) ± SD	p-value
Dominant side	24	−12.5 ± 3.0	
Non-dominant side	16	−8.6 ± 2.6	**0.002***

Table 4: Categorical distribution of glenoid version

Glenoid Version Category	Angle Range	Frequency	Percentage
Normal	−2° to −7°	12	30%
Mild retroversion	−8° to −10°	10	25%
Increased retroversion	> −10°	18	45%
Total		**40**	**100%**

DISCUSSION

We conducted study on 40 patient with the complain the shoulder pain and diagnose as frozen shoulder by the clinician. Study aim to measure glenoid version in patient with frozen shoulder by the computed tomography (CT). Objective of study was to measure and compare the glenoid version with respect to dominate side and overhead activity. The present study revealed that in 45% of the sample (i.e. 18 out of 40) there was increased retroversion. The mean version between dominate side and non-dominant side shows that there is statistically significance with the p value of .002. Also study shows that the retroversion was most in the overhead activity of shoulder with p value of <0.001. Overhead activity can damage the surface of glenoid fossa and shift the articulating surface in the posterior direction. There were 12 patients (30%) who were having normal range of value of glenoid version.

These findings are consistent with the studies conducted by Ashwini *et al.,* [6] saying the retroversion was found to be *0*±10 degrees. There was slight propensity toward retroversion. R. Sean *et al.,* [9] also says that overall glenoid version for the 172 group sample was found to be 1.23 degree of retroversion in an anatomical study. Both the above study was in the normal population that was not having pain in shoulder or frozen shoulder. Our study was focused for the pathology of frozen shoulder.

Version has important consequences on the biomechanics of the shoulder joint and is altered in those with arthritis and shoulder joint instability. The glenoid fossa is thought to be retroverted in highly demanding situations as in our study we have taken overhead and repetitive activity. The differences between sides appear to occur in the glenoid fossa and not in the scapular body. 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.

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[10]. Although our study did not investigate the angle of the glenoid version in normal population but focuses on overhead activity, it remains an interesting avenue of research given the possible altered population characteristics.[7] The present study shows that lower degrees of version are generally found patient of frozen shoulder and that too in the dominant hand which is used for the overhead activity. As there is increase retroversion in overhead activity the study will be beneficial for the clinician and surgeons for planning of the total shoulder arthroplasty like surgery's. The limitations of the study include small sample size and lack of radiological correlation.

CONCLUSION

This observational study was conducted at the department of anatomy and department of radiodiagnosis and imaging at Index medical college and research Centre, Indore, Madhya Pradesh. This study aimed to study the glenoid version in patients with frozen shoulder by the computed tomography. A total 40 patients undergone for the CT Scan radiography for the affected shoulder in the department of radiodiagnosis and imaging. Glenoid retroversion was measured and compared with the overhead activity and dominant side of the hand. Out of 40 patients, 24 patient was on the dominant side which was statistically significant. And also 22 patient was with the history of the overhead activity showing statistically significant value with comparison to the glenoid retroversion.

RECOMMENDATIONS

We recommend for the larger sample size including radiological correlation and clincical correlation, also the study should be more multicentric.

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