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ORIGINAL ARTICLE

THE RELATIONSHIP BETWEEN GLENOID OSTEOMETRY AND RECURRENT ANTERIOR GLENOHUMERAL INSTABILITY

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ABSTRACT

The most common joint to dislocate is the glenohumeral joint, resulting in chronic pain and limited function. The role of the capsuloligamentous structures and muscle balance in contributing to shoulder stability has been well documented in the literature but the case is not the same for the bony anatomy of the glenoid. There is limited data on the contribution of glenoid osteometry in increasing the risk of anterior shoulder dislocation. This study sought to find out the association between anterior glenohumeral instability and glenoid anteversion/inclination. A retrospective, case-control study was carried out. The study was carried out at the Departments of Radiology and Imaging at two university hospitals. Shoulder Magnetic Resonance Imaging (MRI) scans for 45 patients aged between 18 to 45 years with recurrent anterior shoulder instability were used in the study and compared with a control consisting of shoulder MRIs of 45 patients with other shoulder pathologies but having no incidences of dislocation. A structured data collection tool was used to collect the data. Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 26. The mean age for all the participants was 32.0 (SD 9.0) years. The mean age for the cases was 29.0 (SD 8.7) years, while for the controls was 34.6 (SD 8.5) years. The glenoid was anteverted in 40% and 35.6% of cases and controls respectively (p = 1.00) and retroverted in 60% and 64.4% of cases and controls respectively (p =0.666). Most of the glenoids were superiorly inclined (91.1% and 93.3% for cases and controls respectively. The differences in the glenoid version and inclination between the cases and controls were not statistically significant (p = 0.288 and p = 0.489 for the glenoid version and inclination respectively. Glenoid version and inclination are not significantly increased in patients with anterior shoulder instability compared to unmatched controls.

Keywords: **glenoid osteometry, recurrent anterior glenohumeral instability, anterior shoulder dislocation, risk factor, glenoid version, glenoid inclination.**

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INTRODUCTION

The glenohumeral joint is the most mobile of all joints mainly because of the little congruency of its bony articulating surfaces and studies have found it to be the most commonly dislocated joint (Chang, 2023). The very high prevalence of anterior glenohumeral dislocation of approximately 95% and shoulder redislocation rate of 25% following arthroscopic stabilization among patients raises critical questions, among them, whether glenoid anteversion has a role to play in glenohumeral instability (Baker et al.,1990; Grana et al.,1993; Kramer, Gajudo & Pandya,2019; Castagna et al.,2012). Recurrent shoulder dislocation has been associated with chronic pain, limited function, rotator cuff tears as well as early osteoarthritis (Beeson, 1999). There are no documented studies in Kenya on shoulder dislocation occurrence or its associated

instability. Grey et al. in South Africa and Ebong in Nigeria described several cases of anterior shoulder dislocations but had no follow-up or morphological studies (Grey, Ryan & Bhagwan; 2016 Ebong,1978). This study, therefore, sets out to find out whether there is any association between glenoid morphology (anteversion and inclination) and recurrent anterior glenohumeral dislocation.

MATERIALS AND METHODS

Study Design

This was a retrospective, case-control study. It involved evaluation of shoulder MRIs from patients being managed for recurrent anterior shoulder dislocations and measurements involving the glenoid version and inclination were done.

Study Location

The study was conducted at two university hospitals both located in Nairobi County. Both institutions are tertiary referral facilities with specialized radiologic and orthopaedic services and staff. The study was carried out in the Radiology departments of both hospitals where MRI Image repositories are found.

Study Population

The study used digital records of MRI images stored in the picture archiving and communication system (PACS). 45 images from the cases and 45 images from the control group were studied.

Case: A case was a shoulder MRI image of a patient who has had two or more anterior shoulder dislocations but those with multidirectional shoulder instability as a pre-imaging diagnosis were excluded.

Control: A control was a shoulder MRI image of a patient taken for shoulder pathologies like rotator cuff lesions, frozen shoulder, chronic shoulder pain, etc. but who had not had glenohumeral instability.

Patients above 45 years of age were excluded.

Sample Size

The sample size was calculated using Cochran's formula (Cochran,1977). The sample population was random thus the population standard deviation was estimated by the confidence interval. The z figure (standard normal deviation) is obtained from the z tables.

Cochran's formula: $n = \frac{z2p9}{e2}$

n = sample size

e = Desired level of precision (margin error)

p = estimated proportion of the population which has the attribute in question q = 1-p

CI=95%, z = 1.96,

P= the estimated population proportion to be reached during the research period is 86.5%, thus P = 0.865, q = 0.135. Therefore, n_0 was

n_0=1.96^2(0.865*0.135) =44.86.

As such, the minimum sample size would be 45 participants per arm.

Sampling Technique

Consecutive sampling of all shoulder MRI images of patients who met the inclusion criteria was done until the sample size was achieved.

Data Collection Procedures

A structured data collection tool was used to collect the data. Demographic information was obtained from the patient's medical records. The shoulder MRI images were obtained from the PACS system, printed MRI images or any other storage forms including DVD copies. At ABC, the MRI images are taken with a 1.5 T GE or a 3T Philips MR scanner. At XYZ, the MRI images are taken with a 3T MR. A third of the images were obtained from XYZ and the rest from the ABC repository. The shoulder MRI images were reviewed by the primary investigator and the

consultant radiologist and the necessary measurements were done as shown below.
Measuring Glenoid Version utilized the Friedman method where two lines drawn on an axial MRI image of the shoulder were used for this technique. The first line a, connects the anterior glenoid to the posterior margin. The second line b, connects the midpoint of the glenoid fossa to the medial end of the image of the scapula. The glenoid version angle is the angle between the first line and the line perpendicular to the second line obtained by subtracting 90 degrees from the angle measured. A negative angle denotes retroversion, and a positive angle denotes anteversion (Friedman, Hawthorne & Genez,1992).

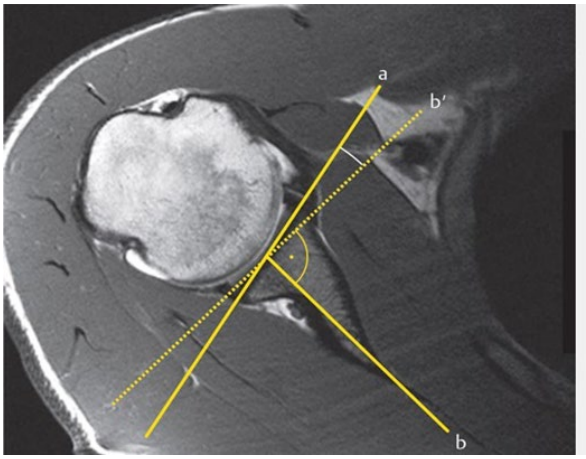

Figure 1: An axial shoulder MRI image showing the measurement of glenoid version (Hohmann & Tetsworth, 2015).

Measuring Glenoid Inclination involved the use of the method by Maurer et al. where the coronal image which displays the supraspinatus fossa at its deepest point is displayed, and the scapula body line (SBL) is drawn along this point. The glenoid fossa line (GFL) is drawn connecting the most superior and most inferior points on the glenoid. The angle of inclination is obtained by subtracting 90 from the angle formed at the intersection of GFL and SBL. An inferior inclination is denoted by a positive angle and a superior inclination by a negative angle (Hohmann & Tetsworth, 2015).

Figure 2: A coronal shoulder MRI image showing measurement of glenoid inclination (Hohmann & Tetsworth, 2015).

The data was analyzed using of the Statistical Package for Social Sciences version 26. Demographic and clinical characteristics of the patients are presented as frequencies and percentages for categorical data, and as means with standard deviations for continuous data or as median with interquartile range. The range of the glenoid version was analyzed and presented as mean with standard deviation, minimum and maximum values. The range of glenoid inclination will also be reported as a mean with standard deviation as well as minimum and maximum values. The relationship between glenoid anteversion and inclination and anterior glenohumeral instability was analyzed with the use of the students t test. All statistical tests were considered significant if $p < 0.05$.

Ethical Considerations

The study was conducted after approval by the ABC and XYZ IERC Reference number P52/02/2022. Patients were identified by MRI number only to safeguard confidentiality.

RESULTS

Ninety shoulder MRI scans were studied, fifty percent of them were cases and the rest were controls. For the cases, 9 were females and 36 males while the controls had 14 females and 31 males.

Demographic characteristics

The mean age of the participants was 32.0 (SD 9.0) years, where the youngest was 15.0 years and the oldest 45.0 years. The median age was 32.0 (IQR 24.5 – 40.0) years. The mean age for the cases was 29.0 (SD 8.7) years, where the youngest patient was 17.0 years and the oldest 45.0 years. The mean age for the controls was 34.6 (SD 8.5) years, with the youngest being 15.0 years and the oldest 45.0 years.

Majority of the cases (91.1%) had a superior glenoid inclination while controls had (93.3%). The glenoid was anteverted in 40% and 35.6% of cases and controls respectively (p = 1.00) and retroverted in 60% and 64.4% of cases and controls respectively (p =0.666). These differences were not statistically significant.

The mean superior inclination was 11.8 o and 11.7 o for cases and controls respectively. The mean inferior inclination was 2.5 o and 1.8 o for the cases and controls respectively (See Table 1).

		n	Mean (SD)		Min	Max	Median (IQR)
Cases	Superior	41	11.8 ° (6.5)		1.0 °	29.7 °	11.5 (6.7 – 15.5)
	Inferior	4	2.5 ° (1.6)		0.9 °	4.6 °	2.2 (1.4 – 3.6)
Control	Superior	42	11.7 ° (6.0)		1.3 °	29.3 °	12.2 (7.5 – 15.9)
	Inferior	3	1.8 ° (0.7)		1.2 °	2.6 °	1.7 (1.5 – 2.2)

Table 1: Means for glenoid inclination (superior and inferior)

The mean retroversion and anteversion in the cases were 4.3 o and 3.8 o respectively while the controls had a mean retroversion and anteversion of 5.2 o and 3.0 o respectively. The highest value for retroversion noted amongst the cases was 16.3 o while 21.5o was the highest for the controls (Table 2).

		n	Mean (SD)	Min	Max	Median (IQR)
Cases	Retroversion	27	4.3 ° (3.4)	0.4 °	16.3 °	3.8 (1.8 – 5.7)
	Anteversion	18	3.8 ° (3.2)	0.3 °	9.7 °	2.3 (1.1 – 7.1)
Control	Retroversion	29	5.2 ° (4.6)	0.1 °	21.5 °	4.1 (2.4 – 6.2)
	Anteversion	16	3.0 ° (2.5)	0.1 °	8.5 °	2.7 (0.8 – 4.9)

Table 2: Glenoid version

The distinction between male and female was made and from the analysis in the table below, no statistically significant differences were noted between the cases and controls for both males and females (Table 3).

	Cases	Controls	p-value
Inclination			
Superior			
Male	11.9±6.9	11.9±6.5	0.957
Female	11.2±6.9	11.4±6.5	0.919
Inferior			
Male	2.5±1.6	1.8±0.7	0.562
Female*	-	-	-
Version			

Retroversion			
Male	4.1±3.5	5.4±3.6	0.260
Female	4.9±3.3	4.8±6.6	0.946
Anteversion			
Male	3.6±2.9	3.3±2.7	0.749
Female	5.4±6.1	2.4±2.1	0.335

Table 3: Table showing Means for males and females

Relationship between glenoid anteversion and inclination and anterior glenohumeral instability.An independent samples t-test was used to determine if there were statistical differences in the means for inclination and also for version between the cases and the controls. For inclination, the means for superior as well as those for inferior between the cases and controls were found not to be statistically significant. As for version, the means for retroversion as well as those for anteversion between the cases and controls were also found not to be statistically significant. The results are as shown on Table 4. The data was analysed further and means were calculated for both version and inclination for cases and controls. The cases had a mean version of 1.04 o while the controls mean glenoid version was 2.26 o. For glenoid inclination, the means were 10.5 o and 10.8 o for cases and controls respectively.

	Cases	**Controls**	**p-value**
Inclination			
Superior	11.8±6.5	11.7±6.0	0.956
Inferior	2.5±1.6	1.8±0.7	0.562
Version			
Retroversion	4.3±3.4	5.2±4.6	0.425
Anteversion	3.8±3.2	3.0±2.5	0.416

Table 4: Inclination and version of the cases and controls

DISCUSSION

This study revealed that most of the cases were of a younger demographic while the controls were mostly in their fourth and fifth decades. There were generally more males than females among the cases and controls. This finding mirrors that noted by Hohmann et al. in their case-control study where the mean age was 24.5 years and 30.9 years for the cases and controls respectively (Hohmann & Tetsworth 2015). Glenoid morphology did not vary significantly between the cases and the controls with version and inclination parameters being almost similar between the two groups. These findings compare with that of Friedman et al. who studied Shoulder CT scans of 63 patients with no shoulder pathology and found a version range of 14 ° anteversion to 12 ° retroversion (Friedman, Hawthorne & Genez,1992). This study's mean glenoid version finding was consistent with several studies. A study by Das et al. on 50 dry scapula showed that 30 of them had retroverted glenoids ranging from 2 ° to 12 ° while 20 had anteverted glenoids ranging from 2 ° to 10 ° (Das & Ray,1966). Another study by Churchill et al. also found a mean version of 1.23 which is also consistent with this study's finding (Churchill, Brems & Kotschi, 2001). Hohmann et al. in their MRI-based study (case control) found mean a version of 1.7 ° (retroversion) for cases and 5.8 ° (retroversion) for controls and the difference was statistically significant (Hohmann & Tetsworth 2015). A CT scan-based study by Matsumura et al. on 410 3D reformatted shoulder CT scans of healthy individuals found a mean glenoid

retroversion of 1 ± 3 ° ranging from 9 ° anteversion to 13 ° retroversion (Matsumura et al.,2014). The study by Welsch et al. using reconstructed 12 3D scapula models had different findings on the mean glenoid version. They found no difference between the left and right sides or male and female. On the left, the mean version was 9.02 ± 3.89 ° (retroversion) while on the right it was 8.26 ± 3.7 degrees(retroversion). No measurements for inclination were made (Welsch et al.,2003). Another study by Cyprien et al. which was X-ray based studied 50 healthy patients. The average glenoid was determined to be retroverted approximately 7° to 8°. The study went further to compare this value with that obtained for 15 shoulders in patients with a history of recurrent anterior dislocation and no statistical difference between the groups was found which is consistent with this study's findings (Cyprien et al., 1983). Randelli et al. published their CT evaluation of 50 patients without a history of glenohumeral arthritis or instability. Although no mean values were given for the group, the "preponderance of cases" measured 5°, 2°, and 7° of retroversion for the upper, middle, and lower glenoid locations, respectively. They too found no difference in the glenoid version between healthy patients and those with a history of recurrent anterior dislocation (Randelli & Gambrioli, 1986).The mean glenoid inclination for this study was 10.5° (superior) and 10.8° (superior) for cases and controls respectively. This finding differs from that in the study by Hohmann et al. who also did a case/control study and found glenoid inclination means of 1.6 ° (inferior) and 4.0 ° (superior) for case and controls respectively (Hohmann & Tetsworth 2015). Two cadaveric studies were found in the literature which had studied both glenoid inclination and version. The first by Mathews et al. was CT scan based and found a mean glenoid inclination (male and female) of 13.0° ± 7° and a mean glenoid version of 1.0° ± 4° (retroverted) (Mathews et al, 2017). The other study by Sandra W.L et al. involving a hundred and fifty scapula from the osteological collection at the National Museums of Kenya, found a mean glenoid inclination of 6° (interquartile range 6° to 7°). The study further noted that the average glenoid version was retroverted 3.5° and 3.0° for male and female respectively (Kimani, 2020). This study therefore adds weight to studies by Cyprien et al. and Randelli et al. which found no difference between glenoid inclination and version between patients with recurrent anterior shoulder dislocation and a group of controls (Cyprien et al.,1983:Randelli & Gambrioli, 1986). The findings, however, are in contrast to that of Hohmann et al. who found between-group (cases vs controls) differences that were significant for version (P =0.00001) and inclination (P = 0.00001) (Hohmann & Tetsworth 2015). The study had several limitations. No bilateral shoulder MRI were available to compare glenoid morphology bilaterally. The age distribution was skewed towards the young for the cases while the controls were from an older age group and this may have impacted on the results for lack of absolute case and control matching. Cases and controls were not randomized and this could be a confounder in the analysis. However, this is the only study to our knowledge done in Africa to highlight the association between anterior glenohumeral instability and glenoid anteversion/inclination.

CONCLUSION

The results of this study revealed that glenoid version and inclination in patients with established anterior shoulder instability do not differ significantly compared with a control group of patients with no history of anterior glenohumeral instability. Therefore, glenoid alignment does not seem to be a significant risk factor for anterior shoulder dislocation in this population. A follow-up study involving history taking on the cause of the dislocation and mechanism of injury and clinical examination of both cases and

controls is recommended to shed more light on the subject.

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