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A STUDY OF MORPHOLOGICAL PATTERNS OF GLENOID CAVITY OF SCAPULA IN A NIGERIAN POPULATION

Ugwa, Okezie Chinedu [1], Oladipo Gabriel Sunday[2], Igbemi Mathias Akama[3], Ekeneokot, Utoon Ekeneokot[4]

[1,2,3,4]Department of Anatomy University of Port Harcourt Rivers State Nigeria.

***Corresponding Author: Dr. Okezie Chinedu Ugwa**

Department of Anatomy University of Port Harcourt Rivers state Nigeria.

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ABSTRACT

Background: An understanding of variations in normal anatomy of the glenoid cavity is a prerequisites for better understanding of the mechanics of shoulder joint and shoulder joint arthroplasty. **Aim:** The aim of this study is to determine the morphology and morphometry of the glenoid cavity in adult dry human scapulae in South-South Nigeria. **Materials and Methods:** A total of 103 adult dry undamaged scapulae (49 left side, 54 right side) were selected from the osteology museum of the Departments of Anatomy University of Port Harcourt Rivers state, Niger Delta University and Madonna University. The shapes of the glenoid were evaluated. All the linear measurements were taken by using digital Vernier caliper. Parametric variables were expressed in terms of mean and standard deviation while non-parametric variables were expressed in terms of percentage. Paired t test was used to compare the observations of right and left sided glenoid cavity. The data was analysed using the SPSS Software (2018 version). P values <0.05 was considered significant. **Results:** The present study showed the inverted comma shaped glenoid cavity was the most common type. This study showed the mean superior inferior diameter on the right to be 40.55±2.61mm and that on the left to be 40.43±2.46mm. The mean anterior posterior diameter -1 on the right was 26.68±2.52mm and that on the left was 26.49±2.45mm.The right mean antero-posterior diameter-2 on the right glenoid was 18.93 ± 2.20mm and that of the left glenoid was 18.52 ± 1.73mm. **Discussion:** There was no statistical difference between the left and right scapulae. The AP-2 diameter and the glenoid cavity index (GCI) of the glenoid cavity is significantly affected by the shape. **Conclusion** The sound knowledge of various parameters of glenoid cavity is important for the anatomists, anthropologists, orthopaedist and prosthetists.

KEYWORDS: Scapular, Glenoid, Arthroplasty.

INTRODUCTION

The glenohumeral joint, primarily referred to as the shoulder joint, is formed by the articulation of the larger humeral head with the shallow glenoid fossa of the scapula (Faiz & Moffat, 2002). The shoulder joint is subject to many pathologic conditions. These include severe proximal humeral fractures, primary glenohumeral osteoarthritis, post-traumatic arthritis, rotator cuff tear arthropathy, shoulder girdle tumours and osteonecrosis (Schrumpf et al., 2011). These disease conditions may necessitate arthroplasty. Arthroplasty is a surgical technique designed to reshape, reconstruct, or replace a pathologic joint (Venes & Taber, 2013). Anatomical parameters like shape, height, width, articular surface area and inclination of the glenoid cavity are relevant to design the prosthesis (Gosavi et al., 2011). This will help in performance of arthroplasty and avoidance of revision surgeries. The measurements of glenoid cavity parameters vary in different races and locality (Tiwar et al., 2018). Thus it is important to have anatomical parameters of the glenoid cavity specific for each population. The aim is to study the morphology and morphometry of the glenoid cavity in adult dry human scapulae in South-South Nigeria.

MATERIALS AND METHODS

This study was performed at the Departments of Anatomy University of Port Harcourt Rivers state, Niger Delta University Wilberforce Island, Amassoma Bayelsa state and Madonna University Elele Rivers state. 103 unpaired dry scapular specimens from the departmental collection of skeletons were examined irrespective of whether the age and sex is known. All the scapular bones were separated into right and left. The bones were isolated and inspected macroscopically. Metric parameters and non-metric parameters were taken from the glenoid cavity.

The following metric parameters were studied in the glenoid cavity of the dry scapulae; the Superior-Inferior glenoid diameter (SI), Anterior-Posterior glenoid diameter-1 (AP-1) and Anterior-Posterior glenoid diameter-2 (AP-2). Measurements were taken in millimeters using sliding Vernier caliper calibrated to 0.01mm. The same sliding Vernier caliper was used for all measurements for standardization.

Metric parameters

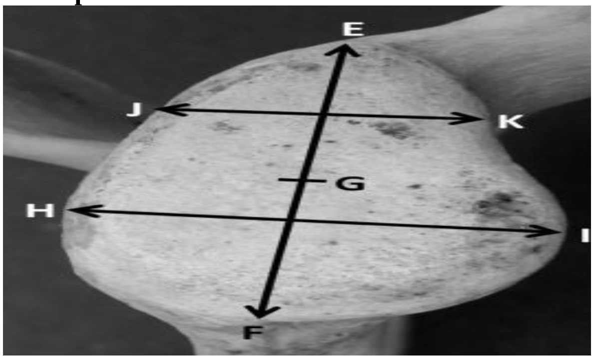

Fig. 3.1: Morphometric parameters of the glenoid cavity (Culled from Akhtar et al., 2016).

Key: E to F=Superior-inferior glenoid diameter.
H to I =Antero posterior glenoid diameter 1 (AP-1)
J to K =Antero posterior glenoid diameter 2 (AP-2)
Point G= the mid point of supero inferior glenoid diameter. F;

Superior-Inferior glenoid diameter (SI)
This was measured as the maximum distance from the inferior point on the glenoid margin to the most prominent point of supraglenoid tubercle (Rajput et al., 2012; Sinha et al., 2016).

Anterior-Posterior glenoid diameter-1 (AP-1)
This is the maximum breadth of articular margin of the glenoid cavity perpendicular to glenoid cavity height (Sarwar et al., 2015; Dhinda & Singh 2014).

Anterior-Posterior glenoid diameter-2 (AP-2) E-F
This is the anterior-posterior diameter (breadth) of the top half of the glenoid cavity at the mid-point between the superior rim and the mid equator (Akhtar et al., 2016).

Glenoid cavity index (GCI)
From the measurements above, Glenoid cavity index (GCI) was calculated with the help of following formula.
GCI = Anterior-Posterior Glenoid Diameter- 1 x 100
(Aigbogun et al., 2017)

Superior-Inferior Glenoid Diameter
Nonmetric parameters
Shape of the glenoid cavity
The tracing of the shape of the glenoid cavity was taken on a white paper with the help of a lead pencil. Three types of glenoid tracings were observed: (a) Pear shape (b) Inverted comma shape and (c) Oval shape.

Inclusion criteria
Only fully ossified, dried, macerated and thoroughly cleaned scapulae that are complete in all respects in order to give the correct observations were included in the study.

Exclusion criteria
Scapulae that are damaged and those having any deformity or pathology like healed fractures at and around the glenoid cavity were excluded from the study.

Ethical considerations Ethical approval was obtained from the ethical committee department of the College of Graduate Studies University of Port Harcourt before commencement of the research.

Method of data analysis: Parametric variables were expressed in terms of mean and standard deviation while non-parametric variables were expressed in terms of percentage. Paired t test was used to compare the observations of right and left sided glenoid cavity. The data was analysed using the SPSS Software (2018 version). P values <0.05 was considered significant.

RESULTS AND DISCUSSIONS
103 dry scapulae, 54 belonging to the right side and 120 to the left side were seen in this study.

Table 1: Percentage distribution of incidence of different shapes of glenoid cavity.

Shapes	Right glenoid	Left glenoid	% of Total
Inverted comma	50.00%(n=27)	36.73%(n=18)	43.69%(n=45)
pear	28.57%(n=14)	42.86%(n=21)	33.98%(n=35)
oval	26.53%(n=13)	20.41%(n=10)	22.33%(n=23)
Total	100%(n=54)	100%(n=49)	100%(n=103)

This study noted the various shapes of glenoid cavity and recorded their percentage of incidence depending on the presence or absence of a notch on the glenoid rim. In this study, 43.69% of the scapulae are inverted comma shaped, 33.98% are pear shaped and 22.33% are oval. Thus, the commonest shape in our population is inverted comma.

However Rajput et al. (2012), Kavita et al. (2013) and Mamatha et al. (2009) in India showed pear to be the commonest shape. This was agreed by the study of Coskun et al. (2006) in Tukey and Preschner et al. (1997) in Germany. However, El-Din et al. (2015) in Egypt and Shortt et al. (2009) in USA showed oval shape as the commonest. The difference seen between the values of present study and that of other workers could be explained on the basis of ethnic and racial variations. The explanations given for the presence of the glenoid notch is still speculative but Hommem et al. (2018) suggests it may be influenced by handedness. The knowledge of the shapes of the glenoid cavity is important in designing and fitting of glenoid components during total shoulder arthroplasty.

Morphometry and side differences

Table. 2: Mean (Standard deviation) and test of mean difference of the right and left side of the glenoid cavity for the general population.

VARABLE	SIDE	N	Mean±S.D	T-test of mean difference	
				t-value	P-value
SI	Right	54	40.55±2.61	0.229	0.819
	Left	49	40.43±2.46		
AP1	Right	54	26.68±2.52	0.394	0.694
	Left	49	26.49±2.45		
AP2	Right	54	18.93±2.20	1.058	0.2393
	Left	49	18.52±1.73		
GCI (%)	Right	54	65.83±4.94	0.274	0.785
	Left	49	65.57±4.61		

The mean of the SI, AP1 and AP2 of the right and left are as stated in the table above. This study shows the mean superior inferior diameter on the right to be 40.55±2.61 and that on the left to be 40.43±2.46. Though the right glenoid value was slightly more than the left, it was not statistically significant. Similarly, Reddy et al. (2016) Rajput et al.(2012) and Tiwari et al. (2018) found no statistical difference in the dimensions of the mean superior inferior diameter on the right and on the left. Patil et al. (2014) and Kohli et al. (2018) however found the right scapulae mean superior inferior diameter to be statistically higher than that of the left.

The combined mean SI diameter in this study is however 40.50±2.53. Von Schroeder et al. (2001), Coskun et al. (2006) and Karelse et al. (2007) reported lower combined mean SI diameter to be 36 ± 4mm, 36.3 ± 3 mm and 35.9 ± 3.6 mm respectively. Mamatha et al. (2009), Rajput et al. (2012) and Kavita et al. (2013), measured the SI diameter of right and left side separately and got lower values compared to that from this study. Similarly, Frutos (2002) and Ozer et al. (2006) measured the SI diameter of the male and female glenoid separately. The average SI diameters of male and female glenoid measured by these three authors were significantly lower than our study. As the sex of scapulae was not known to us, we could not measure male and female scapulae separately.

The mean AP1 on the right was 26.68±2.52 and that on the left was 26.49±2.45. The general population mean for the AP1 is 26.59±2.39**.** Though the right glenoid value is slightly broader than the left, it was not statistically significant. Kohli et al. (2018) however found the higher difference of the right to be statistically significant. Conversely El-Din and Ali (2015) in Egypt however found the left AP1 mean to be higher than that of the right.

The AP1 value of 29.00± 3.00mm noted by von Schroeder et al. (2001) in Canada and 27.20± 3.00mm Karelse et al (2007) in Belgium were higher than those noted in this study. The value observed in this study was very close to the values seen by Churchill et al. (2001) in United States of America (26.04±1.55mm). Lower values were seen in India by Mamatha et al. (2009) and Rajput et al (2012).

The average anterior-posterior diameter (AP-2) of the right glenoid was 18.93 ± 2.20mm and that of the left glenoid was 18.52 ± 1.73mm in the current study. This suggested that the right glenoid cavity was slightly broader than the left glenoid cavity though this was not statistically significant. The combined mean for both sides was 18.73±1.97. Rajput et al. (2012) and Sarwar et al. (2015) showed the AP2 to be higher on the right. However El-Din and Ali (2015) showed the AP2 to be higher on the left. The combined mean from this study was lower than that seen by El-Din et al. (2015) and Iannoti et al. (1992) Other studies from Rajput et al. (2012), Tiwari et al. (2018), and Sarwar et al. (2015) showed much lower AP2 diameter.

The glenoid cavity index (GCI) in this study was 65.83% on the right and 65.57% on the left. Ankushrao et al. 2017 had similar values of 65.13±7.67% on the right side and 65.73±8.47% on the left side with a mean of 65.40±8.14%. Higher values were seen by Dhindsa et al. (2014). Since the GCI shows the proportionate relationship between the glenoid height and glenoid width, it is key to understanding the morphometric role of glenoid cavity in shoulder joint stability (Tiwari et al., 2018). Aigbogun et al. (2017) deduced that very low GCI of 50% and below implies a lower AP1 to SI ratio and the balance arc of glenoid cavity would be distorted and may not properly accommodate the humeral head. Conversely, a very high GCI of 80% and above suggests a more rounded glenoid which may alter the upper margin of the cavity which give room for attachment of the long head of the bicep tendon and thus creating susceptibility to upward luxation (Aigbogun jr et al., 2017; Merrill et al., 2009). The mean GCI from this study is within limits of the expected normal function.

This study compared the shape of the glenoid cavity with the dimensions. We checked if the dimensions of the glenoid cavity were statistically influenced by the shape. The observations were that the SI values were greatest in oval shapes, followed by inverted comma and then pear. This was however not statistically significant. The AP1 values were greatest in oval shapes, followed by pear and then inverted comma. This was however not statistically significant. This suggests that the shape of the glenoid cavity does not influence its maximum width (AP1). The AP2 values are greatest in oval shapes, followed by pear and then inverted comma. The higher dimensions in pear compared to inverted comma is however statistically significant. This suggests that the upper half of the glenoid cavity is influenced by the shape of the glenoid cavity. The glenoid cavity index (GCI) values are greatest in pear shapes, followed by inverted comma and then oval. However, it is only the higher dimensions in pear compared to inverted comma that is statistically significant. This study shows that the GCI is influenced by the shape of the glenoid cavity. The table is showed below;

Table. 3: Mean (Standard deviation) and test of mean difference of the right and left side of the glenoid cavity with inverted comma morphology.

Inverted Comma Shape					
Varable	**Side**	**N**	**Mean±S.D**	**T-test of mean difference**	
				t-value	**P-value**
SI	**Right**	27	40.45±2.86	-0.255	0.800
	Left	18	40.66±2.37		
AP1	**Right**	27	26.03±1.79	-0.911	0.367
	Left	18	26.67±2.97		
AP2	**Right**	27	18.07±1.04	0.437	0.664
	Left	18	17.89±1.78		
GCI	**Right**	27	0.64±0.04	-0.731	0.469
	Left	18	0.66±0.06		

Table. 3: Mean (Standard deviation) and test of mean difference of the right and left side of the glenoid cavity with oval morphology.

Oval Shape					
Varable	**Side**	**N**	**Mean±S.D**	**T-test of mean difference**	
				t-value	**P-value**
SI	**Right**	13	41.39±2.60	1.03	0.32
	Left	10	40.19±3.00		
AP1	**Right**	13	27.44±3.95	1.32	0.20
	Left	10	25.64±1.99		
AP2	**Right**	13	20.66±3.66	1.28	0.21
	Left	10	19.10±1.33		
GCI	**Right**	13	0.62±0.19	-0.37	0.72
	Left	10	0.64±0.03		

Table. 5: Mean (Standard deviation) and test of mean difference of the right and left side of the glenoid cavity with pear morphology.

Pear Shape					
Varable	**Side**	**N**	**Mean±S.D**	**T-test of mean difference**	
				t-value	**P-value**
SI	**Right**	14	39.97±2.06	-0.508	0.615
	Left	21	40.36±2.38		
AP1	**Right**	14	27.24±1.82	0.851	0.401
	Left	21	26.75±1.55		
AP2	**Right**	14	19.00±0.84	0.477	0.637
	Left	21	18.78±1.76		
GCI	**Right**	14	0.68±0.04	1.233	0.226
	Left	21	0.66±0.04		

Morphometric difference among the shapes

Table. 6: Brown-Forsythe robust test of equality of mean among the right glenoid cavity morphology; inverted comma, oval and pear.

Variables	df1	df2	F-value	p-value
SI	2	42.415	1.142	0.329
AP1	2	20.653	1.469	0.253
AP2	2	14.582	**5.256**	**0.019**
GCI	2	13.881	0.965	0.405

Table. 7: Post-Hoc multiple comparison test using DunnetteT3 for the right glenoid cavity morphology.

Variable	Morphology		Mean Difference	Std. Error	p-value
	I	J	(I-J)		
SI	**Inverted Comma**	**Pear**	0.485	0.778	0.897
		Oval	-0.935	0.907	0.666
	Pear	**Oval**	-1.420	0.908	0.337
AP1	**Inverted Comma**	**Pear**	-1.215	0.597	0.145
		Oval	-1.411	1.149	0.542
	Pear	**Oval**	-0.196	1.200	0.998
AP2	**Inverted Comma**	**Pear**	-0.926	0.300	**0.012**
		Oval	-2.590	1.034	0.074
	Pear	**Oval**	-1.664	1.039	0.333
GCI	**Inverted Comma**	**Pear**	-0.038	0.014	**0.038**
		Oval	0.029	0.055	0.935
	Pear	**Oval**	0.066	0.055	0.564

Table. 8: Brown-Forsythe robust test of equality of mean among the left glenoid cavity morphology; inverted comma, oval and pear.

	df1	df2	F-value	p-value
SI	2	27.933	0.117	0.890
AP1	2	33.709	0.930	0.404
AP2	2	43.826	2.319	0.110
GCI	2	38.256	1.181	0.318

Table. 9: Post-Hoc multiple comparison test using DunnetteT3 for the left glenoid cavity morphology.

Variable	Morphology		Mean Difference	Std. Error	p-value
	I	J	(I-J)		
SI	**Inverted Comma**	**Pear**	0.297	0.764	0.972
		Oval	0.473	1.103	0.962
	Pear	**Oval**	0.176	1.083	0.998
AP1	**Inverted Comma**	**Pear**	-0.081	0.777	0.999
		Oval	1.038	0.940	0.617
	Pear	**Oval**	1.119	0.714	0.347
AP2	**Inverted Comma**	**Pear**	-0.898	0.570	0.322
		Oval	-1.211	0.594	0.147
	Pear	**Oval**	-0.314	0.569	0.926
GCI	**Inverted Comma**	**Pear**	-0.009	0.016	0.929
		Oval	0.016	0.016	0.669
	Pear	**Oval**	0.025	0.012	0.133

Table 9: Comparison of mean(S.D) values of this study and other published values from different populations *=P<0.05, **=P<0.01; Blue=other sample's mean > study mean

Researches on glenoid cavity parameters		Right (Mean±S.D measured in mm)			Left (Mean±S.D measured in mm)			Undisclosed (Mean±S.D measured in mm)		
Author	Year	N	SI	AP 1	N	SI	AP 1	N	SI	AP 1
This study	2019	54	40.55±2.62	26.68±2.52	49	40.44±2.47	26.50±2.25	103	40.50±2.53	26.59±2.39
Ianotti et al. (PHILADEPHIA USA)	1992							140	39.00±3.50**	29.00±3.20**
Churchill et al. (USA)	2001							344	35.45±2.02**	26.04±1.55**
von Schroeder (CANADIAN)	2001							30	36.00±4.00**	29.00±3.00**
Frutos (GUATEMALA)	2002							103	34.27±1.85**	24.83±1.43**
Taser and Basaloglu	2003							52	34.85±2.90**	25.40±2.46**
Ozer et al (TURKEY)	2006							186	36.28±2.86**	25.05±2.04**
Coskun et al (TURKEY)	2006							90	36.30±3.00**	24.60±2.50**
Karelse et al (BELGIUM)	2007							40	35.90±3.60**	27.20±3.00
Mamatha et al. (SOUTHERN INDIA)	2009	98	33.67±2.82**	23.35±2.04**	104	33.92±2.87**	23.02 ± 2.30**			
Rajput et al. (GUJARAT, INDIA)	2012	43	34.76±3.00**	23.31±3.00**	57	34.43±3.21**	22.92±2.80**			
Kavita et al. (INDIA)	2013	67	35.20±3.00**	25.00±2.70**	62	34.7±2.80**	24.9±2.40**			

CONCLUSION

In this study the inverted comma shaped glenoid cavity was most common type followed by pear shaped and then oval glenoid cavity. This is different from other studies and may be due to racial variations. This study suggests that there are statistically non-significant differences between the dimensions of the glenoid cavity of right and left side. However, the AP2 diameter of the glenoid cavity is significantly affected by the shape and is greatest with the oval shape. The glenoid cavity index (GCI) values are significantly affected by the shape of the glenoid cavity been greatest in pear shapes, followed by inverted comma and then oval.

This study has provided a baseline data on morphological and osteometric details of human scapular in the South South population of Nigeria. One important highlight in the current study is the correlation between various glenoid shapes and the osteometric parameters. High statistical significance observed in correlation between some osteometric parameters supports their suitability for application in predicting the dimensions of implants for shoulder arthroplasty.

Recommendations

This study recommends that companies making prosthesis for the population of South South Nigeria put into cognisance the variation of this population with that of others. Parameters of glenoid cavity are vital in planning prosthetic sizing, positioning and design for total shoulder arthroplasty. Thus, this knowledge is important for prosthetist and orthopaedist for successful shoulder arthroplasty in order to avoid loosening of the joint which may require revision. These results are also expected to be of use in medicolegal investigation and probably for scapular reconstruction as in addition to the morphometric and morphology studied, further studies to measure glenoid cavity depth and labrum morphology will help in achieving better shoulder arthroplasty.

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