Morphometric analysis of cavitas glenoidalis with multidedector CT

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SUMMARY

The glenoid cavity is a sliced egg-shaped joint surface located on the lateral margin of the scapula to form the shoulder joint. Recognition of variations in shape and dimensions of the glenoid cavity is important for a better comprehension of joint-associated diseases, especially in total shoulder arthroplasty procedures. The aim of this study was to perform morphometric measurements on the glenoid cavity. Glenoid cavities of 391 individuals (197 males [50.4%], 194 females [49.6%]) were reviewed by using Multi-detector Computed Tomography. The maximum length and maximum width of glenoid cavities, as well as the width, depth and circumference at the notch level were measured, and the index value was calculated. The glenoid cavity shapes were typed as pear, inverted comma and oval type. Furthermore, the metric values that provide the best differentiation between genders were identified through ROC analysis.

The pear glenoid cavity type was detected in 53.2%, inverted comma type was detected in 28.4%, and oval type was detected in 18.4% of cases. In all of our morphometric measurements, male values were higher than female values, and there was significant difference between them. Results of ROC analysis revealed significant measurements for the maximum length and maximum width measurements of the glenoid for gender determination. Morphometric information of the glenoid cavity can be useful in order to increase clinical success in case of Bankart lesion, rotator cuff disease, and osteochondral defect. Recognition of different shapes and dimensions of the glenoid cavity is essential for the design of the glenoid component, especially for total shoulder arthroplasty procedure. We believe that the data obtained in our study would be useful for prosthesis designers and orthopaedic surgeons.

Key words: Glenoid cavity – Morphometric – Computed tomography – Gender – Index – Variations

ABBREVIATIONS

GC: Glenoid cavity
MDCT: Multi-detector Computed Tomography
SI: Glenoid cavity length
AP1: Glenoid cavity width (Anterior-Posterior glenoid diameter-1)
AP2: Glenoid cavity width at notch level (Anterior-Posterior glenoid diameter-2)

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DGC: Glenoid cavity depth
PGC: Glenoid cavity circumference
GCI: Glenoid cavity index
$R_{n:}$ Number of right side
$L_{n:}$ Number of left side
$M_{n:}$ Number of male
$F_{n:}$ Number of female

INTRODUCTION

The glenoid cavity (GC) is located on the concave surface of the shoulder joint on the lateral angle of the scapula (Halder et al., 2001). The joint surface is surrounded by a structure called the glenoid labrum without restriction of movement (Pagnani and Warren 1994; Halder et al., 2001). The glenoid labrum contributes to the stability of the glenohumeral joint, and increases the concavity of the GC (Lippitt et al., 1993).

Prescher and Klümpen (1997) stated that if the notch in the antero-superior part of the GC is prominent, the glenoid labrum is not fixed to the notch region and may predispose to the Bankart lesion. However, the presence of the glenoid notch may not always predispose to having anatomical variants in the labrum. Thomson et al. (2015) reported that the presence of the glenoid notch is not a useful tool to predict a normal variant of the anterior and superior labrum. Research suggests that individuals with a GC notch have a greater rate of recurrent shoulder dislocation, with a reported 61% occurrence rate (Lo et al., 2004). The shoulder joint is more stable since the glenoid labrum is attached along GC margins when the glenoid notch is absent (Coskun et al., 2006; Khan et al., 2020).

The shoulder joint is the most common dislocating joint. Glenoid fractures are common along with dislocations due to trauma. Prostheses and arthroplasty are needed several times for solution. The morphometry and variation of the GC is actually important in order to decide adequate size of the glenoid component in shoulder arthroplasty for traumatic or pathological conditions associated with shoulder area (Mamatha et al., 2011; Rajput et al., 2012; Singh et al., 2019).

Mamatha et al. (2011) stated that recognition of variation in normal anatomy of the GC is essential for evaluation of pathological conditions such as Bankart lesion and osteochondral defects.

Hassanein (2015) conducted a study to detect morphological types and diameters of the GC in scapula samples of adult Egyptians, and expressed that variations in the form and size of the GC should be well-known in order to understand the shoulder joint arthroplasty, and to minimize the failure rates that affect the glenoid component. There are other studies that analyse the morphometric parameters of the glenoid cavity on the dry scapula (Khan et al., 2020), cadaver (Mathews et al., 2017), or CT (Jia et al., 2020).

The aim of this study was to collect morphological data of GC, to reveal important measurements that are important for gender determination through the data obtained, and to evaluate these in comparison to the literature. Therefore, we believe that this study would provide anatomic parameters that would guide anatomists, orthopaedic surgeons, prosthesis designers, and anthropologists.

MATERIAL AND METHODS

In the present study, the scapulae of individuals were measured through Multi-detector Computed Tomography (MDCT) in the Radiology Department of Meram Faculty of Medicine within Necmettin Erbakan University. MDCT (Sensation 64, Siemens, Erlangen, Germany) parameters are as follows; KV: 120, Effective MaS: 50-170, MAS: 86, Pitch 1,4, Rotation speed: 0,5 sec, Detector area: 1,2 mm, Slice thickness: 1,5 mm. 3D and inspace programs (Leonardo, Siemens, Germany) were used in measuring parameters and GC typing.

In this study, all patients (443) whose scapulae were visible on comparative thoracic MDCT images between the 1st of January 2014 and the 30th of April 2016 were examined. A total of 52 individuals with fractures, defects, osteoporotic appearance, and pathological conditions in the measurement area were not included in the study. The measurements were carried out on a total of 391 (197 males and 194 females) individuals without any history of trauma or pathology of the shoulder joint. The age average of males was 60.28 ± 15.43 years with an age range of 9 to 94 years; the age average of females was 58.82 ± 16.38 years with an age range of 10 to 92 years. Approval of the local ethics committee was obtained by decision number of 2016/574 within Necmettin Erbakan University. Measurements were made once by a researcher who has been working in the field of radiology for 11 years.

The measurements analysed in the present study are as follows:

GC length (SI): Maximum length between lowest point of the GC and the most prominent point of supraglenoid tubercle (Fig. 1).

GC width (AP1): Maximum width of the joint space (Fig. 1).

GC width at notch level (AP2): The width of the joint space at the glenoid notch level (Fig. 1).

GC depth (DGC): The length of the line drawn between the top and lowest points on axial images, and the length of the line drawn 90 degrees vertically from the deepest point of the GC to this line (Fig. 1).

GC circumference (PGC): The GC measurement including all margins from supraglenoid tubercle, and ending in the start point (Fig. 1).

GC index (GCI): It was calculated as (AP1 ÷ SI) × 100 [12].

SI, AP1, AP2, DGC and PGC parameters were measured in mm and GCI was calculated in %.

There is a notch on the anterosuperior part of the GC. When the notch is present, the shape of the glenoid cavity can be described as pear-shaped or as inverted comma-shaped (when the notch is distinct, it is an inverted comma; when the notch is slight, it is pear-shaped). When it is absent, the cavity is oval-shaped (Prescher and Klümpen, 1997). In this study, GC was typed in three groups as pear (Fig. 2A), inverted comma (Fig. 2B), and oval shape (Fig. 2C).

Statistical analysis of the measurements was performed through IBM SPSS Statistics 21.0 program. The Paired-Samples T test was used in order to compare the measurements on the right and left sides. All measurements were also evaluated

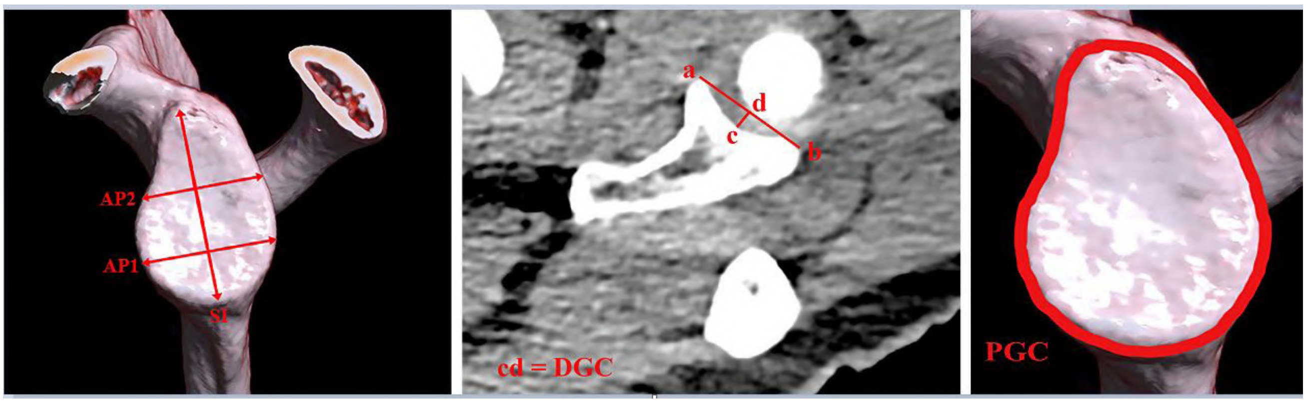

Fig. 1.- SI: Superior-inferior glenoid diamater, **AP1**: Anterior-Posterior glenoid diameter-1, **AP2**: Anterior-Posterior glenoid diameter-2, **DGC**: Depth of glenoid cavity (**ab length:** The length of the line drawn between the top and lowest points on axial images.**cd length:** The length of the line drawn 90 degrees vertically from the deepest point of the GC to this line, **PGC**: Perimeter of glenoid cavity.

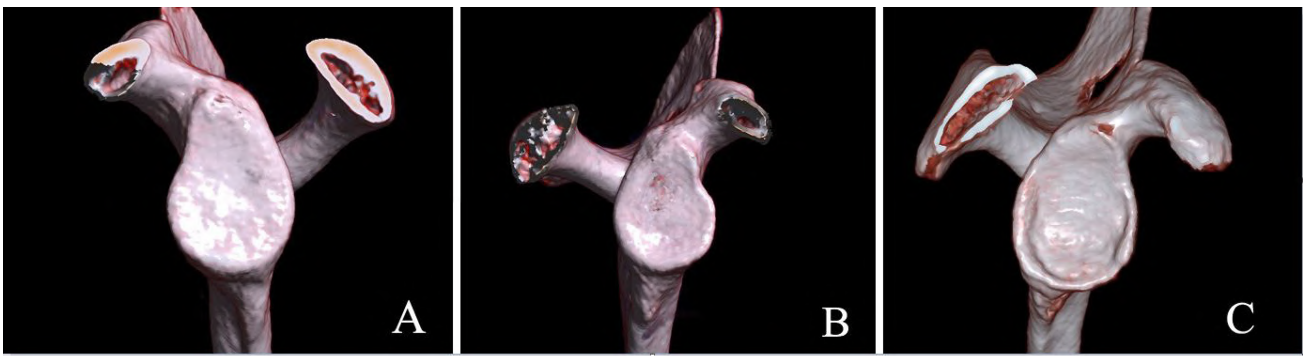

Fig. 2.- Different shapes of the glenoid cavity. **A:** Pear shape, **B:** Inverted comma shaped, **C:** Oval shaped.

according to genders through Independent-Samples T test. Furthermore, the cut-off point, sensitivity, specificity and the area under the curve were found for metric values that provide the best differentiation between genders by ROC analysis.

RESULTS

There was not any significant difference between right and left GC values in SI, AP1, PGC, and GCI parameters; however, a significant difference was detected between right and left GC values for AP2 and DGC. Furthermore, a significant difference was detected in all measurements between males and females; morphometric values of male GC measurements were detected greater (Table 1) ($p < 0.05$).

In the present study, 13.1% of the right-side samples appeared without notch (Fig. 3A), 81.3% of right-side samples appeared with a single notch (Fig. 3B) and 5.6% appeared with double notches (Fig. 3C); as far as the left-side samples are concerned, 12.5% appeared without notch, 83.1% appeared with a single notch, and 4.4% appeared with double notches. Moreover, 11% of males had no notch; 84% and 5% of males presented single and double notch, respectively; and 15% of females had no notch, whereas 80% and 5% of them had single and double notch, respectively. The ratio of the single notch is higher on both sides and in both genders. While the ratio of the notch was statistically significant between the right and left sides, the difference between the sexes was not significant (Table 2).

GC shape was found to have pear shape in genders. The pear GC type was detected in 53.2%, inverted comma type was detected in 28.4%, and oval type was detected in 18.4% of cases. The difference between the genders according to GC shape was not statistically significant ($p>0.05$) (Table 3).

According to the data obtained as a result of ROC analysis in our study, AP1, SI, PGC and AP2 parameters give the highest rate in estimation of gender, respectively. In addition, it was observed that left-sided parameters gave a higher rate in estimating gender than right-sided parameters (Table 4, Fig. 4).

Table 1. Glenoid cavity morphometry

n		Glenoid cavity morphometry					
		SI	**AP1**	***AP2**	**DGC**	**PGC**	**GCI**
Laterality	**Rn = 391** **Ln = 391**	39.20 ± 3.80 38.80 ± 3.70	26.60 ± 3.10 26.40 ± 2.90	19.20 ± 2.20 18.80 ± 2.10	4.20 ± 1.10 4.0 ± 1.10	112.9 ± 10.9 111.9 ± 11.6	67.91 ± 5.08 68.13 ± 5.56
	P-value	0.170	0.367	**0.022**	**0.012**	0.227	0.564
Gender	**Mn = 394**	41.60 ± 3.00	28.60 ± 2.30	20.20 ± 1.80	4.50 ± 1.20	119.3 ± 9.90	68.82 ± 5.77
	Fn = 388	36.40 ± 2.40	24.40 ± 2.0	17.80 ± 1.70	3.80 ± 0.90	105.5 ± 7.70	67.20 ± 4.70
	P- value	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***

SI: Superior-inferior glenoid diamater, **AP1**: Anterior-Posterior glenoid diameter-1, **AP2**: Anterior-Posterior glenoid diameter-2, **DGC**: Depth of glenoid cavity, **PGC**: Perimeter of glenoid cavity. **R_n:** Right, **L_n:** Left, **M_n:** Male, **F_n:** Female.
(* For **AP2** Rn: 340, Ln: 340; Mn: 350, Fn: 330) (mm) (Mean ± SD) (SD: Standard deviation)

Table 2. Glenoid cavity notch numbers

n		Glenoid cavity notch numbers						
		Bilateral without glenoid notch		**One-sided glenoid notch**		**Bilateral glenoid notch**		**p**
		N	**%**	**N**	**%**	**N**	**%**	
Laterality	**R_n = 391**	51	13.1	318	81.3	22	5.6	**0.000***
	L_n = 391	49	12.5	325	83.1	17	4.4	**0.000***
Total	**n_T = 782**	100	12.8	643	82.2	39	5	
Gender	**M_n = 394**	43	11	331	84	20	5	0.498
	F_n = 388	57	15	312	80	19	5	0.505

N: Number, **R_n:** Right, **L_n:** Left, **M_n:** Male, **F_n:** Female, **n_T:** Total, * $p<0.05$

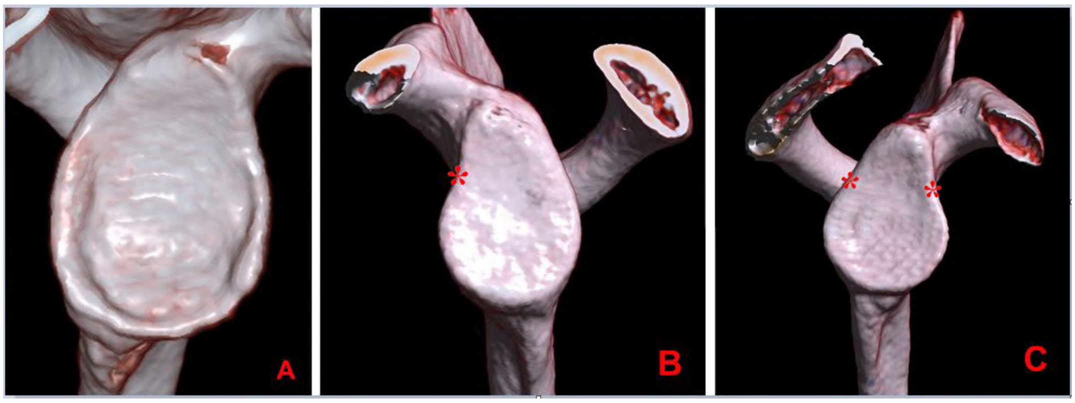

Fig. 3.- Glenoid cavity notch numbers. **A:** Bilateral without glenoid notch**, B:** One-sided glenoid notch**, C:** Bilateral glenoid notch, *****:** shows the glenoid notch.

Table 3. Different shapes of the glenoid cavity

Glenoid Shape	Incidence (%)			p
	Total	Male	Female	
Pear shape	53.2	52.2	54.1	0.724
Inverted comma shaped	28.4	28	28.9	
Oval shaped	18.4	19.8	17	
Total	100	100	100	

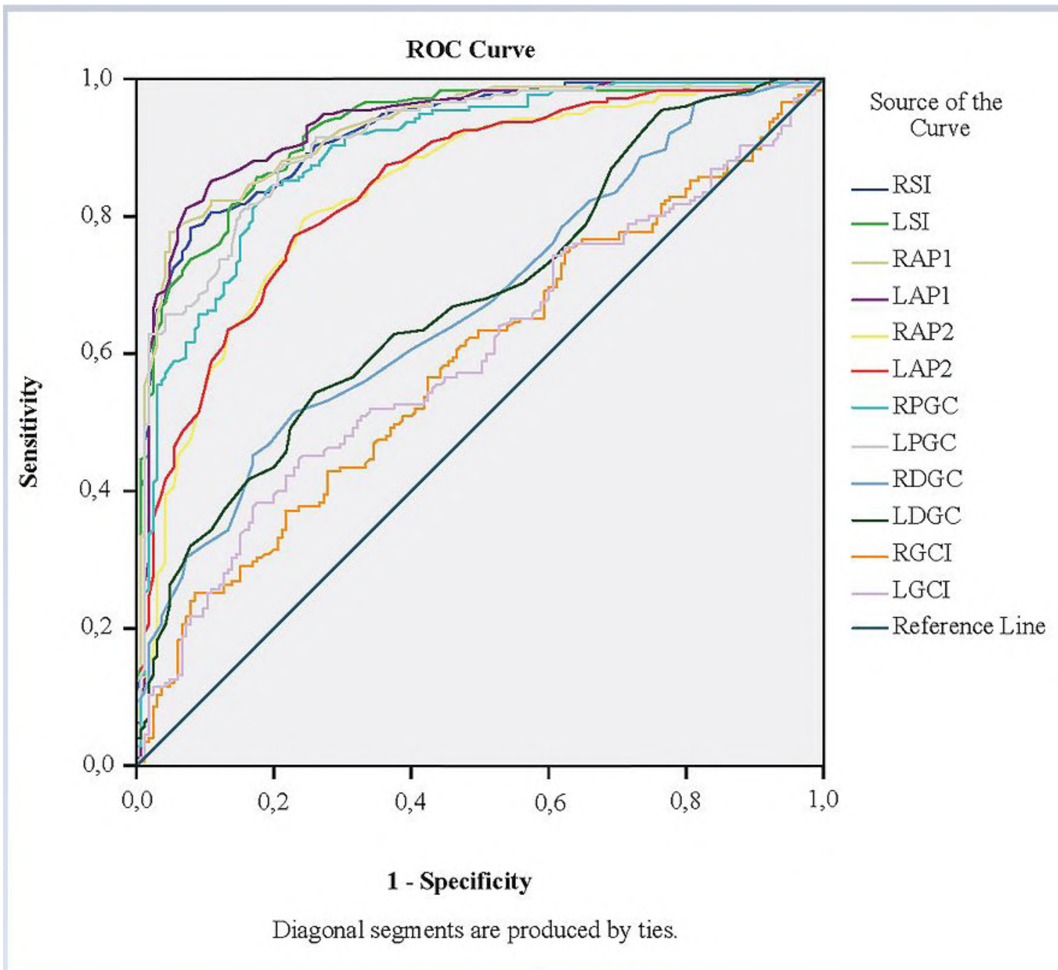

Fig. 4.- Roc curve.

Table 4. ROC's analysis

Parameters	AREA	p	Cutt off (mm)	Sensitivity (%)	Specifity (%)
RSI	0.921	0.000	39	83.4	82.4
LSI	0.922	0.000	38.6	83.4	83.6
RAP1	0.926	0.000	26.2	83.4	84.2
LAP1	0.931	0.000	26.1	86.9	84.8
RAP2	0.837	0.000	19.3	76	77
LAP2	0.843	0.000	18.7	77.1	77
RPGC	0.892	0.000	112.2	81.7	82.4
LPGC	0.908	0.000	112.4	81.7	82.4
RDGC	0.671	0.000	4.1	60.6	0.6
LDGC	0.678	0.000	3.9	62.9	62.4
RGCI	0.585	0.007	67.67	56.6	56.4
LGCI	0.595	0.002	67.54	56.6	55.2

GC: Glenoid cavity, **RSI:** Right-GC length, **LSI:** Left-GC length, **RAP1:** Right- GC width, **LAP1:** Left- GC width, **RAP2:** Right-GC width at notch level, **LAP2:** Left- GC width at notch level, **RPGC:** Right- GC circumference, **LPGC:** Left- GC circumference, **RDGC:** Right- GC depth, **LDGC:** Left- GC depth, RGCI: Right-GC index, **LGCI:** Left- GC index

DISCUSSION

Evaluation of the morphometry of the glenoid cavity plays a key role in different pathological conditions such as Bankart lesion, rotator cuff disease, osteochondral defect. Various researchers have performed the morphometric analysis of the glenoid cavity in different populations (Coskun et al., 2006; Mamatha et al., 2011; Hassanein, 2015; Akhtar, 2016; Singh et al., 2019; Khan et al., 2020). This study is a radiological study, and measurements were performed through multidetector CT. The data obtained was compared with the literature findings. We believe that our study may provide a great contribution to the literature since there are right and left side findings as well as gender data.

SI appears to be greater on the right side than left side; however, this finding does not have any statistical significance. Although our data are similar to results obtained by El-din and Ali (2015) Chhabra et al. (2015) and Vaishnani et al. (2018), these data are longer than results of other researchers. Furthermore, SI was greater in males when compared with females in our study. We believe that the possible cause is greater bone mass quantity of male individuals. Gender-dependent SI data is greater than the data obtained by all previous researchers. SI values on females detected in our study are similar to those obtained on female individuals by Polguj et al. (2013)

In this study, AP1 was found greater on the right side than on the left. The AP1 values on the right obtained by Merill et al. (2009) and Shi et al. (2013), and the left obtained by Aigbogun et al. (2017) were similar to our data; however, data obtained by El-din and Ali (2015) was greater than our data. AP1 values were detected 28.60 ± 2.30 mm in males, and 24.40 ± 2.0 mm in females in our study. Merill et al. (2009) detected similar AP1 values to our study in males. Von Schroeder et al. (2001) Mathews et al. (2017) and Jia et al. (2020) detected greater values whereas results of other researchers are lower (Table 5).

AP2 value measurements were found greater on the right side than the left side. Findings of Chhabra et al. (2015) are close to our results; however, findings of El-din and Ali (2015) are greater. The AP2 value (17.40 ± 2.60 mm) in women reported by Khan et al (2020) and the AP2 value (17.80 ± 1.70 mm) in women in our study were similar. Merill et al. (2009) and Shewales et al. (2017) detected lower gender-based findings than our data (Table 5).

Merill et al. (2009) reported DGC 4.54 ± 0.06 mm in males, and 3.78 ± 0.07 mm in females. In our study, it was found 4.50 ± 1.20 mm in males, and 3.80 ± 0.90 mm in females. Our results are consistent with results obtained by Merill et al. (2009). The difference between male and female DGC may be important for prosthesis designers. Furthermore, DGC was detected 4.20 ± 1.10 mm on the right, and 4.0 ± 1.10 mm on the left on all scapulae; believe that these data would contribute to further studies (Table 5).

Macaluso et al. (2011) measured PGC values as 103.04 ± 5.38 mm in men and 91.13 ± 4.73 mm in women in South Africa Shi et al. (2013) found it to be 97.31 ± 8.43 mm on the right and 97.12 ± 8.83 mm on the left in their study in China. In our study, PGC was found as 112.9 ± 10.9 mm in the right, 111.9 ± 11.6 mm in the left, 119.3 ± 9.90 mm in men and 105.5 ± 7.70 mm in women. Our data were found longer than Macaluso et al. (2011) and Shi et al. (2013) (Table 5). We think this is due to racial difference.

Table 5. Comparison of GC parameters with different researchers

Observers	Method	n	SI (MEAN ± SD)	AP1 (MEAN ± SD)	AP2 (MEAN ± SD)	DGC (MEAN ±SD)	PGC (MEAN ± SD)	GCI (MEAN ± SD)
Von Schroeder et al.(2001)	C	(Mn/Fn) (14/12)	38.0±3.30/33.60±1.70	30.90±3.10/25.80±0.90	-	-	-	-
		(Rn/Ln)	-	-	-	-	-	-
Ozer et al. (2006)	DS	(Mn/Fn) (94/92)	38.71±2.71/33.79±3.08	27.33±2.40/22.72±1.72	-	-	-	-
		(Rn/Ln)	-	-	-	-	-	-
Merrill et al. (2019)	DS	(Mn/Fn) (184/184)	37.01±0.18/33.83±0.18	28.56±0.17/23.67±0.17	17.58±0.16/15.85±0.17	4.54±0.06/3.78±0.07	-	-
		(Rn/Ln) (184/184)	35.21±0.12/35.63±0.12	25.94±0.11/26.29±0.11	-	-	-	-
Mamatha et al. (2011)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (98/104)	33.67±2.82/33.92±2.87	23.35±2.04/23.05±2.30	-	-	-	-
Macaluso (2011)	DS	(Mn/Fn) (60/60)	38.21±1.90/33.87±1.92	27.02±1.82/23.59±1.45	-	-	103.04±5.38/91.13±4.73	-
		(Rn/Ln)	-	-	-	-	-	-
Rajput et al. (2012)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (43/57)	34.76±3.0/34.43±3.21	23.30±3.0/22.92±2.80	15.10±2.54/13.83±2.45	-	-	-
Kavita and Singh (2013)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (67/62)	35.20±3.0/34.70±2.80	25.07±2.70/24.90±2.0	16.80±1.8/16.30±2.0	-	-	-
Shi et al. (2013)	CT	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (60/60)	34.74±3.21/34.90±3.26	27.08±2.65/26.97±2.58	-	-	97.31±8.43/97.12±8.83	-
Polguj et al. (2013)	DS	(Mn/Fn) (41/33)	40.04±2.97/36.09±2.20	29.14±2.14/25.65±1.98	-	-	-	71.88±5.77/72.98±5.34
		(Rn/Ln)	-	-	-	-	-	-
Dhindsa and Singh (2014)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (41/39)	34.13±3.16/34.11±2.57	24.05± 2.86/23.36±2.22	-	-	-	70.37 ± 4.08/68.59 ± 4.36
Patil et al. (2014)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (104/120)	33.68±4.32/32.09±4.11	23.29±2.34/24.90±2.95	-	-	-	-
El-Din and Ali (2015)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (80/80)	38.88±2.63/39.01±2.49	28.31±2.38/27.99±2.55	21.33±2.49/21.69±2.06		-	-
Hassanein (2015)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (38/30)	33.10±3.90/28.70±4.10	24.40±4.40/22.10±4.40	-	-	-	73.67±9.08/76.71±8.37

Gupta et al. (2015)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (30/30)	34.90±4.40/33.0±3.30	23.10±3.10/20.60±3.0	-	-	-	-
Chhabra et al. [14]	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (55/71)	38.46±2.81/39.03±3.18	25.04±2.69/24.85±2.46	18.70±2.22/18.6± 2.07	-	-	65.11±5.11/63.67±3.76
Akhtar et al. (2016)	DS	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (126/102)	36.03±3.15/35.52±3.12	23.67±2.53/23.59±2.47	16.30±2.16/16.0±2.34	-	-	66.13±8.67/66.73±7.47
Aigbogun et al. (2017)	DS	Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (96/104)	37.71±4.24/36.22±3.58	26.20±3.30/24.35±3.64	-	-	-	69.59±5.529/67.11±6.031
Shewela et al. (2017)	DS	(Mn/Fn) (102/40)	35.95±2.30/31.0±2.50	24.60±1.96/20.30±2.25	17.46±2.52/14.8±1.91	-	-	-
		(Rn/Ln)	-	-	-	-	-	-
Mathews et al. (2017)	C	(Mn/Fn) (7/11)	39.50±3.50/34.80±2.20	30.30±3.30/26.20±1.60	-	-	-	-
		(Rn/Ln)	-	-	-	-	-	-
Pai et al. (2018)	DS	Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (74/62)	34.81±2.46/33.37±2.96	24.07±2.58/22.75±2.45	15.27±1.92/15.19±2.31	-	-	-
Vaishnani et al. (2018)	DS	Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (36/38)	38.49±3.17/38.06±3.34	24.76±2.49/24.23±2.14	18.83±2.19/17.97±2.08	-	-	-
Singh et al. (2019)	DS	Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (56/44)	34.84±3.46/33.48±2.88	24.25±2.55/25.52±2.78	13.69±1.54/12.01±1.77	-	-	69.87±1.54/70.44±7.59
Jia et al. (2020)	CT	(Mn/Fn) (55/29)	-	29.09±2.27/25.52±1.72	-	-	-	-
		(Rn/Ln)	-	-	-	-	-	-
Khan et al. (2020)	DS	(Mn/Fn) (68/96)	35.30±3.10/34.60±2.80	24.20±2.70/23.70±2.80	18.20±3.30/17.40±2.60	-	-	-
		(Rn/Ln) (80/84)	35.20±3.10/34.90±3.0	24.50±2.90/23.60±20.60	18.40±3.30/17.50±2.90	-	-	-
Gnanasundaram et al. (2022)	DS (Acrylic mould)	(Mn/Fn)	-	-	-	-	-	-
		(Rn/Ln) (52/54)	31.65±2.32/31.78±2.56	22.91±2.86/22.99±2.48	16.10±2.11/15.69±1.62	-	-	-
Present study	CT	(Mn/Fn) (394/388)	41.60±3.00/36.40±2.40	28.60±2.30/24.40±2.0	20.20±1.80/17.80±1.70	4.50±1.20/3.80±0.90	119.3±9.90/105.5±7.70	68.82±5.77/67.20±4.70
		(Rn/Ln) (391/391)	39.20±3.80/38.80±3.70	26.60±3.10/26.40±2.90	19.20±2.20/18.80±2.10	4.20±1.10/4.0±1.10	112.9±10.9/111.9±11.6	67.91±5.08/68.13±5.56

C: Cadaver, **DS**: Dry Scapula, **CT**: Computer Tomography, **SD**: Standard deviation, (mm). **R_n:** Right, **L_n:** Left, **M_n:** Male, **F_n:** Female.

Table 6. Comparison of notch and non-notch GC values with different researchers

Observers	Population	n	Notch (%)	Non-notch (%)
Prescher ve Klümpen (1997)	Germany	n_T: 236	55	45
Mamatha et al. (2011)	India	Rn: 98	80	20
		Ln: 104	76	24
Rajput et al. (2012)	India	Rn: 43	84	16
		Ln: 57	85	15
Patil et al. (2014)	India	Rn: 104	81.74	18.27
		Ln: 120	77.5	22.5
Hassanein (2015)	Egypt	Rn: 38	76.32	23.68
		Ln: 30	76.67	23.33
Present study	Turkey	Rn: 391	87	13
		Ln: 391	87.5	12.5

R_n: Right, **L_n:** Left, **n_T:** Total.

Polguj et al. (2013) detected male and female GCI values (71.88 ± 5.77 and 72.98 ± 5.34, respectively) higher than our data. Right and left GCI values detected in our study are greater than Chhabra et al. (2015) and Akhtar et al. (2016) and lower than values found by Dhindsa and Singh (2014), Hassanein (2015) and Singh et al. (2019) (Table 5).

Since GC has a variable morphology, anatomy is important for surgeons and prosthesis designers. The notch on antero-superior part of the GC affects the morphology of the glenoid labrum. Anatomic variations of the GC is also important for different pathologies including the shoulder joint (Yang et al., 2018). Previous studies on the notch of the GC in the literature, and data obtained were provided in Table 6. In the study, notch was detected on the right side by 87%, no notch was detected on the right side by 13%; and notch was detected on the left side by 87.5%, and no notch was detected on the left side by 12.5%. We believe that higher values of our study than all other researches may be associated with race differences. The closest values to our findings are obtained by Rajput et al. (2012). Prescher and Klümpen (1997) stated about the cause of such difference as loose attachment of the glenoid labrum onto the GC at notch area. In the absence of the glenoid notch, the glenoid labrum is attached along GC margins; therefore, the shoulder joint is more stable (Coskun et al., 2006; Khan et al., 2020). We reviewed GCs with notch according to the notch count. We detected that GC had no notch by 12.8%, one notch by 82.2%, and two notches by 5% (Table 6). Number of the notches was also reviewed by Prescher and Klümpen (1997); rates of GC with no notch (35%) and two notches (30%) were higher than our findings; however, the rate of GC with one notch (35%) was lower.

The pear GC type was detected by 53.2%, inverted comma type was detected by 28.4%, and oval type was detected by 18.4%. Prescher and Klümpen (1997) detected the most common types as pear (55%) and inverted comma types in German population. Similar to our study, the most common GC type was found as the pear type by Kavita and Singh (2013) by 58%, by Akhtar et al. (2016) by 50.44%, by Singh et al. (2019) in Indian population, by Hassanein (2015) by 45.59% in Egyptian population. Among all studies conducted on this topic, El-Din and Ali (2015) found the most common type as the oval type (50.63%) in Egyptian population (Table 7).

The present study has some limitations. The first limitation is that interobserver variability was not used in the study. Measurements were performed by a single researcher. This disadvantage can be overcome by repeating the measurements by more than one investigator. Secondly, 391 samples could be included in the study because the study was conducted on a limited geography. Although we think that it is sufficient for this study, this number can be increased in future studies and it can be planned in a wider geography. Third,

Table 7. Comparison of glenoid cavity typing with different researchers

Observers	Populations	Method	Pear Shaped (%)	Inverted Comma Shaped (%)	Oval Shaped (%)
Prescher and Klümpen (1997)	Germany	DS	55		45
Kavita et al. (2013)	India	DS	58	11	30
El-Din and Ali (2015)	Egypt	DS	31.25	18.12	50.63
Gupta et al. (2015)	India	DS	42	38	20
Hassanein (2015)	Egypt	DS	45.59	30.88	23.53
Akhtar et al. (2016)	India	DS	50.44	35.96	13.60
Pai et al. (2018)	India	DS	62.5	15.4	22.1
Singh et al. (2019)	India	DS	44	22	34
Das et al. (2020)	India	DS	43.46	33.96	22.64
Presents study	Turkey	CT	53.2	28.4	18.4

DS: Dry Scapula, **CT**: Computer Tomography.

because the study was planned retrospectively, a specific age group could not be established among the obtained data. Prospective studies to be carried out may eliminate this limitation.

When metric values obtained are compared to the data obtained by other researchers, different results were obtained in studies conducted in different countries and populations. Results obtained in our study would be useful for prosthesis designers in glenoid component designing, and for orthopaedic surgeons for shoulder pathologies and shoulder arthroplasty. In conclusion, we think that taking these values into account can help design glenoid components for the Turkish population.

Handicaps like the gender uncertainty in dried bone studies, or the limited number of the cases in cadaver studies were not experienced in our study. Different from other studies, AP1 and SI values were detected as important measurements for gender determination (Table 4). Therefore, data obtained would contribute to the literature for gender and number. Since the method used in our study ensured reliable data evaluation visually, cases with abnormal anatomic structures that show osteophytes and surface roughness were easily detected and excluded from the study. However, such deformations constitute a limitation in studies conducted on dried bones; this was minimized in our study. Therefore, the data obtained would ensure reliable measurements for healthy individuals.

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