Original Article

Morphology and Morphometry of the Glenoid Cavity of Adult Dry Human Scapula

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Abstract

Background: The glenoid cavity of scapula is regarded as the scapular head. Variations in the glenoid cavity's morphology and morphometry can be observed. It showed different types of shapes such as pear, oval and inverted comma shape. **Objectives:** Objectives of this study was to determine the morphology and morphometry of the glenoid cavity of adult dry human scapula. **Methods:** The study was a cross-sectional type of descriptive study which was conducted for a period of 1 year from January 2023 to December 2023 in the Department of Anatomy, Rajshahi Medical College, Rajshahi. This study was performed on 365 dry adult human scapulae which were taken from the Museum and medical students at different Medical Colleges of Bangladesh. The Purposive sampling technique was adopted and data were collected by semi-structured questionnaire. Data were analyzed via SPSS software (version 26.0). P value < 0.05 was considered statistically significant for all tests. **Results:** Out of 365 dry adult human scapulae, 273 (74.80%) of the glenoid cavity were pear shaped, 53 (14.50%) oval shaped and 39 (10.70%) inverted comma shaped. The mean SI –D was 39.49±4.89 mm, AP -D1 was 26.51±3.21 mm and AP-D2 was 20.28±3.22 mm. Glenoid cavity index was 67.44±6.92%. SI, AP -D1 and AP -D2 of glenoid cavity were significantly increased in male than female ($p < 0.001$ for each). But there were no statistically significant difference of shape of glenoid cavity and glenoid cavity index between male and female. There was also no statistically significant difference of shape of glenoid cavity, SI -D, AP -D1, AP -D2 of glenoid cavity and glenoid cavity index between the right and left scapula. **Conclusion:** Morphologic and morphometric variation of glenoid cavity of adult dry human scapula was observed between male and female..

Key words: *Morphology, Morphometry, Glenoid cavity, Human scapula,Superior-inferior diameter(SI-D), Anterior-posterior diameter 1 (AP-D1), Anterior-posterior diameter 2 (AP-D2).*

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Introduction

Scapula is a bone that forms the shoulder girdle in association with the clavicle. Its lateral angle becomes truncated and broadened that bears the glenoid cavity which articulates with the head of the humerus in the shoulder joint.[1] The glenoid cavity also known as the head of the scapula is a shallow, concave, oval fossa and form glenohumeral joint with humeral head. It is a ball and socket type of synovial joint. It has wide range of movement but short range of stability. Shoulder joint is frequently dislocated postero-inferiorly due to having less support in that region of the joint. During trauma, dislocation with fracture of glenoid is also common.[2] When the arm is swing by the side of the body, the glenoid cavity is directed slightly upwards, forwards and laterally and when the arm is raised above the head level, it is directed almost straight upwards.[3] Variations in the superior transverse scapular ligament and the suprascapular notch are the most recognized possible predisposing factors for suprascapular notch (SSN) entrapment.[4] The disproportionate sizes of the head of the humerus and the small, shallow glenoid cavity combined with a lax articular capsule give this joint a wide range of movements but make the joint inherently unstable.[5] Dislocation occurs commonly in shoulder joint. Alignment of the humeral head and the glenoid articular surfaces are the predisposing factors for glenohumeral joint instability which is one of the important causes for rotator cuff pathology.[6] Dislocation may also be associated

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with fracture of the glenoid cavity. For the management of this condition prostheses and arthroplasty are required. The knowledge of variations in shape and size of the glenoid fossa are required for better understanding of shoulder joint arthroplasty.[7] The variations in the morphology of glenoid fossa are influenced by genetic and environmental factors. The shoulder joint is the third most common joint that requires reconstruction following knee and hip. Therefore, it is mandatory to understand its complex anatomy which in turn facilitates prompt fabrication of glenoid implants and screws. Knowledge on the morphology and morphometry of the glenoid fossa is essential for understanding and management of demographic diseases pertaining to shoulder joint such as glenohumeral arthritis, rotator cuff disorders, shoulder dislocations and fractures.[8] The information about the shape and dimensions of the glenoid cavity are also important in designing and fitting of glenoid component for total shoulder arthroplasty. So precise knowledge about the variations in normal anatomy of glenoid cavity is essential for dealing with its clinical correlation. This study was carried out to determine the morphology and morphometry of the glenoid cavity of adult dry human scapula.

Methods

The study was cross sectional type of descriptive study which was conducted in the Department of Anatomy, Rajshahi medical college ,Rajshahi for a period of 1 year from January 2023 to December 2023. Data on Glenoid cavity of dry adult human scapula were collected from the Museum of Anatomy and medical students of different medical Colleges (Rajshahi Medical College, Pabna Medical College, Islami Bank Medical College Rajshahi, Barind Medical College Rajshahi and Khwaja Yunus Ali Medical College, Sirajganj). Damaged glenoid fossa due to fracture, trauma, other pathological reason (osteoarthritic changes), deformities or congenital anomalies were excluded from the study.

A total of 365 specimens were included in the study. The sample size was estimated using the single-proportion method. According to the findings of Shubhangi et al., the expected prevalence of the pear-shaped glenoid cavity was 51.22%. At a 5% level of significance, the minimum sample size was calculated using the formula:

$$n = \frac{Z^2 \text{ X } p \text{ X } q}{d^2}$$

Here

n=The desired sample size

Z=Standard normal deviation for Z distribution which corresponds to 95% confidence interval in normal distribution = 1.96

p=Anticipated prevalence of pear shaped Glenoid cavity = 51.22% = 0.51.

q=1-0.51=0.49

d=Degree of accuracy=10% of the anticipated 'p'=0.051

Therefore, the desired sample size

$$n = \frac{(1.96)^2 \text{ X } 0.51 \text{ X } 0.49}{(0.051)^2}$$

$$= \frac{3.8 \text{ X } 0.25}{0.0026}$$

$$= \frac{0.91}{0.0026}$$

$$= 365.38 \text{ (approximately)} = 365$$

Data collection process: Each scapula was carefully examined for the shape of the glenoid cavity, its anterior and posterior margins and notches. The presence of notches were noted whether it was present or not. If present number of notches were noted in term of single or more. The shape of the glenoid cavity was observed and recorded as follows: Oval shape-the anterior margin of glenoid cavity without notch. Pear shape-the anterior margin of glenoid cavity shows indistinct notch. Inverted coma shape-the anterior margin of the glenoid cavity shows distinct notch. The total length and breadth of the scapulae were measured in mm using digital sliding vernier calipers to detect sex. Then the measurements of vertical diameter/length and transverse diameter/breadth of glenoid cavity were taken with the help of digital sliding vernier calipers. The maximum vertical diameter was measured from supraglenoid tubercle to inferior glenoid margin. Antero-posterior glenoid diameter was the transverse diameter/breadth of articular margin of glenoid cavity. Then the calculation was done.

Figure: Different shapes of Glenoid cavity

Figure: Morphometric parameters of Glenoid cavity measured by Digital Vernier calipers.

Supero-inferior diameter (SI-D): It is the maximum distance between the most prominent point of the supraglenoid tubercle and the inferior point of the glenoid border and was measured (from point A to B as shown in Fig).

Antero-posterior diameter 1 (AP-D1): It is the maximum breadth of the articular margin of the glenoid cavity perpendicular to the glenoid cavity height and was measured (from point C to D as shown in Fig).

Antero-posterior diameter 2 (AP-D2): It is the anterior-posterior diameter of the superior half of the glenoid cavity at its mid-point and was measured (from point E to F as shown in Fig).

Glenoid Cavity Index (GCI) was calculated by the following formula,

$$\text{Glenoid cavity index} = \frac{\text{AP–D1}}{\text{Superoinferior diameter}} \text{X100}$$

Statistical analysis: All data were recorded and analyzed. Categorical variables were summarized by using numbers and percentages while continuous variables were summarized by means ± standard deviation (SD). Relationship of morphometry of the glenoid cavity with side and gender were assessed by unpaired t-Test and shape of glenoid cavity with side and gender were determined by Chi-square (χ^2) Test. Data were analyzed by SPSS software, version-26 and a p value < 0.05 was considered statistically significant for all tests.

Ethical approval: At first permission was taken from the Ethical Review Committee (ERC) of Rajshahi Medical College, Rajshahi. Keeping compliance with Helsinki Declaration for Medical Research Involving Human Subjects 1964, revised and last amended in 2013, all the bone's owner and respective authority was informed verbally about the study design.

Results

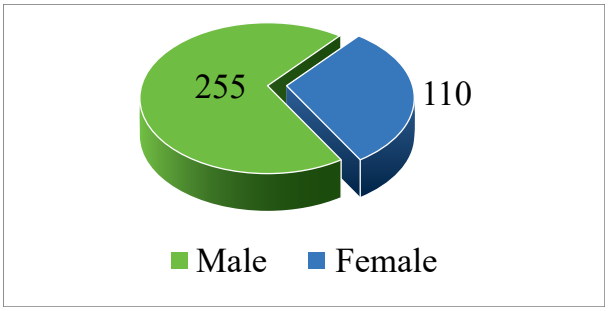

Figure I: Distribution of the glenoid cavity of scapula by gender (n=365).

It revealed that 255 (69.90%) of the scapula were male and 110 (30.10%) were female.

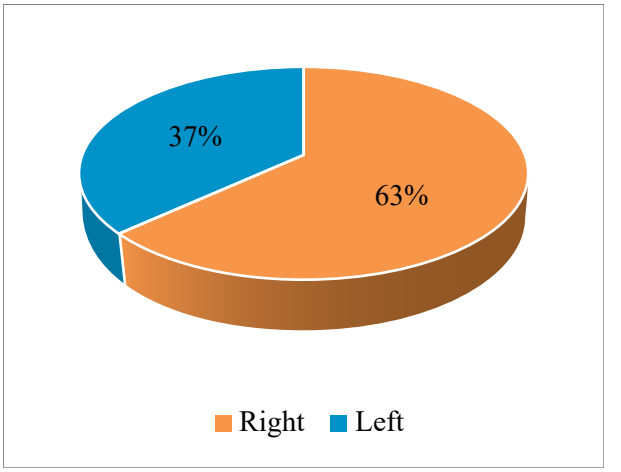

Figure II: Distribution of the glenoid cavity of scapula by side (n=365).

It revealed that 230 (63%) of the scapula were right sided and 135 (37%) were left sided.

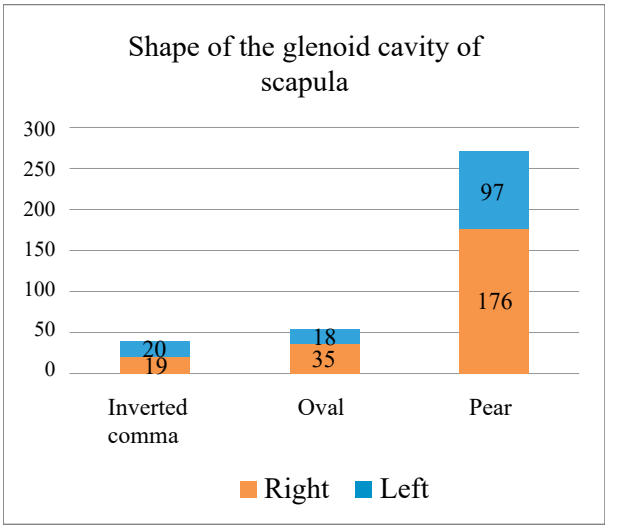

Figure III: Distribution of the glenoid cavity of scapula by shape (n=365).

It revealed that 273 (74.80%) of the glenoid cavity were pear shaped, 53 (14.50%) were oval shaped and 39 (10.70%) were inverted comma shaped.

Table 1: Relationship of the shape of glenoid cavity between the male and female adult human scapula (n=365).

Shape of glenoid cavity	Gender of human scapula		Total Frequency (%)
	Male Frequency (%)	Female Frequency (%)	
Inverted comma shaped	23 (59.00%)	16 (41.00%)	39 (10.70%)
Oval shaped	38 (71.70%)	15 (28.30%)	53 (14.50%)
Pear shaped	194 (71.10%)	79 (28.90%)	273 (74.80%)
Total	255 (69.90%)	110 (30.10%)	365 (100.00%)

So, the relationship of the shape of glenoid cavity between the male and female adult human scapula was found statistically nonsignificant (p > 0.05)

Table 2: Values of different diameters of the glenoid cavity of scapula (n=365).

Parameter	Mean ± SD	Minimum (mm)	Maximum (mm)
Supero-inferior diameter (SI-D)	39.49±4.89	25.00	98.12
antero-posterior diameter 1 (AP-D1)	26.51±3.21	20.21	36.50
Antero-posterior diameter 2 (AP-D2)	20.28±3.22	12.16	32.90
Glenoid cavity index (GCI)	67.44±6.92	22.52	95.55

Table 3: Comparison of different diameters of the glenoid cavity between right and left sided scapula (n=365).

Parameter	Right sided Mean ± SD	Left sided Mean ± SD	p-value
Supero-inferior diameter (SI-D)	39.40±5.60	39.51±3.73	> 0.05
antero-posterior diameter 1 (AP-D1)	26.46±3.14	26.59±3.33	> 0.05
Antero-posterior diameter 2 (AP-D2)	20.29±3.12	20.26±3.39	> 0.05
Glenoid cavity index (GCI)	67.50±7.37	67.34±6.12	> 0.05

So, there was statistically nonsignificant difference between the right and left sided adult human scapula (p > 0.05).

Table 4: Comparison of different diameters of the glenoid cavity between male and female (n=365).

Parameter	Male Mean ± SD	Female Mean ± SD	p-value
Supero-inferior diameter (SI-D)	41.28±4.57	35.18±2.82	< 0.001
antero-posterior diameter 1 (AP-D1)	27.87±2.64	23.36±1.95	< 0.001
Antero-posterior diameter 2 (AP-D2)	21.31±3.09	17.89±2.02	< 0.001
Glenoid cavity index (GCI)	67.90±6.80	66.39±7.12	> 0.05

So, there was statistically significant difference between the male and female adult human scapula (p > 0.05).

Discussion

Though glenoid cavities showed highly variable morphological features, the clinicians should be well versed with the normal appearance and anatomical variants of glenoid cavities so that they can interpret its morphology on radiographs and MRI scans. It will be also very helpful especially for the orthopedic surgeons for the diagnosis and treatment modalities of shoulder dislocations and fracture. In this study, total 365 scapula were included for the morphological analysis of glenoid cavity. Out of this total 365 scapula, 69.90% were from male and 30.10% were from female. After side determination it was found that about two-third of the scapula (63%) were right sided. Other study compsrism-

Present study revealed that, 273 (74.80%) of the glenoid cavity were pear shape, 53 (14.50%) were oval shape and 39 (10.70%) were inverted comma shape. Similar findings were found with other studies done by different researchers.[10-14] In contrast to this study Azhagiri et al.[15] stated that among the 100 glenoid cavities, 54(54%) were inverted comma shaped, 30(30%) were pear shaped and 16(16%) were oval shaped which findings were different from the study. Dissimilar findings were also found with the study done by Shubhangi et al.[9] The glenoid fossa is largely pear-shaped because the upper transverse diameter is less than the lower transverse diameter. These differences might be due to nationality and race variations.

The relationship of the shape of glenoid cavity between the right and left sided adult human scapula was found statistically nonsignificant (p > 0.05). S and N, 2020 found no statistically significant relationship of the shape of glenoid cavity between the right and left side (p > 0.05) which findings were similar with the study.

In the present study, the mean±SD of supero-inferior diameter was 39.49±4.89 mm but for only right sided it was 39.48±5.46 mm and for left sided it was 39.51±3.73 mm. Similar findings were found in another study where mean supero-inferior diameter of glenoid cavity was 39 ± 3.5 mm.[16] In another study done by Gunasekaran[13] the mean supero-inferior diameter of the glenoid cavity of scapula was 38.44±2.53 mm on the right side and 36.61±2.92 mm on the left side. Nearly similar findings were also found in other studies.[8,17-19] Azhagiri et al. found that the mean supero-inferior diameter (SI-D) of glenoid cavity was 35.17±2.62 mm in right side and 34.73±2.42 mm in the left side which findings were lower from the study.[15] These findings differ with some other studies.[20-23] These differences might be due to factors that affect bone morphology such as genetic constitution, diet, nutrition status, environment, physical activity and geographical distribution.

In this study, the mean±SD of AP -D1 was 26.51±3.21 mm but 26.46±3.14 mm on right side and 26.59±3.33 mm on left side. In a study the mean AP-D1 was 25.11±1.84 mm on the right side and 24.47±2.02 mm on the left side, that is similar with this study.[13] Azhagiri et al. showed that the mean AP-D1 was 24.12±1.99 mm in right side and 23.73±1.64 mm in the left side which findings were near about to the study.[15] Nearly similar findings were also found with other studies.[17,21,22,24] Different findings were found with the study done by other researchers where mean AP-D1 was greater on right side.[14,25]

This study revealed that the mean±SD of AP-D2 was 20.28±3.22 mm but 20.29±3.12 mm on right side and 20.26±3.39 mm on left side. Similar findings were found with the study done by Vaishnani et al.[17] where mean AP-D2 was 18.83±2.19 mm in right side and 17.97±2.08 mm in left side. Azhagiri et al. reported that the mean AP-D2 was 17.92±2.57 mm in right side and 17.21±2.56 in left side which findings were lower from this study.[15] Dissimilar findings were also found with the studies done in other researchers.[24-26]

In our study, the mean±SD of glenoid cavity index was 67.44±6.92% but 67.50±7.37% on right side and 67.34±6.12% on left side. Nearly similar findings were found in a study where the mean GCI was 68.18±5.93% with minimum and maximum value were 54% and 87%, respectively.[27] Nearly similar findings were also found in other studies.[8,11] Shubhangi et al.[9] showed that the mean glenoid cavity index on right side was 63.62±6.73% and 65.19±6.44% on the left side which was different from the study. They are not similar with some other studies.[28,29]

The relationship of the shape of glenoid cavity between the right and left sided adult human scapula was found statistically nonsignificant ($p > 0.05$). In research they found no statistically significant relationship of the shape of glenoid cavity between the right and left side ($p > 0.05$) which findings were similar with the study.[30] The incidence of both pear and inverted comma shape in right side was greater than in left whereas the incidence of oval shape in left side was greater than right side that were also similar with a study.[31] Gunasekaran[13] stated that oval shaped glenoid fossa was seen in 13 (12.03%) of right scapula and 12 (11.11%) of left scapula while pear-shaped glenoid fossa was seen in 35 (32.40%) of right scapula and 35 (32.40%) of left scapula and notch type glenoid fossa was observed in 6 (5.55%) of right scapula and 7 (6.48%) of left scapula which findings were not similar with the study.

The relationship of the shape of glenoid cavity between the male and female adult human scapula was found statistically nonsignificant ($p > 0.05$) in the study. No sex difference was found in the prevalence of the shape of glenoid cavity in a study which was similar with the study.[32]

Statistically nonsignificant difference of supero-inferior diameter (SI-D) of glenoid cavity between the right and left sided adult human scapula ($p > 0.05$) was observed in this study. Similar findings were showed in some studies.[15,26] But findings were not similar with the study done by Raaj et al.[31] where the SI diameter of right glenoid is greater than the left which is statistically significant.

In recent study, there was statistically significant difference of mean supero-inferior diameter (SI-D) of glenoid cavity between male and female ($p < 0.001$). Similar findings were found with a study where there was statistically significant difference of supero-inferior diameter (SI-D) of glenoid cavity between the male and female.[33] But different findings were also found with other studies where there were statistically nonsignificant difference of mean supero-inferior diameter (SI-D) of glenoid cavity between male and female ($p > 0.05$).[24,34]

In the present study, there was statistically nonsignificant difference of (AP-D1) of glenoid cavity between the right and left sided adult human scapula ($p > 0.05$). Similar findings were also found with other studies.[26,31,33] But in one study, statistically significant difference of mean antero-posterior diameter 1 (AP-D1) of glenoid cavity was found between the right and left side ($p=0.0005$).[29]

Mean antero-posterior diameter 1 (AP-D1) of glenoid cavity was significantly different between the male and female adult human scapula ($p < 0.001$). Similar findings were observed in other studies.[3,34,35]

In the current study, there was statistically nonsignificant difference (AP-D2) of glenoid cavity between the right and left sided adult human scapula ($p > 0.05$). Similar findings were found with the study where the antero-posterior diameter 2 of right glenoid is greater than the left but not statistically significant ($p > 0.05$).[26,31] But K et al.[29] found statistically significant difference of mean antero-posterior diameter 2 (AP-D1) of glenoid cavity between the right and left side ($p=0.0001$).

Mean antero-posterior diameter 2 (AP-D2) of glenoid cavity was significantly different between the male and female adult human scapula ($p < 0.001$). Similar findings were found in another study.[36]

In the present study, there was statistically nonsignificant difference of glenoid cavity index (GCI) between the right and left sided adult human scapula ($p > 0.05$). Similar findings were found with a study where there was no statistically significant difference of glenoid cavity index (GCI) between the right and left side ($p > 0.05$).[9] Similar findings were also found with other studies.[8,28] The difference in mean GCI between the right and left side was found to be very statistically significant ($p= 0.0023$) in a study which was not similar with the study.[29]

Size and shape of the glenoid cavity are directly related to the dislocation of shoulder joint and may affect the results of total shoulder arthroplasty and rotator cuff surgeries. The present study analyzed the morphological types and diameters of the glenoid cavity in adult human scapulae to minimize the failure rates of shoulder arthroplasty.

Conclusion

In this study, majority of the glenoid cavity (74.8%) were pear shaped followed by oval and inverted comma shape. Supero-inferior diameter, antero-posterior diameter 1 and antero-posterior diameter 2 of glenoid cavity were significantly greater in male than female ($p < 0.001$ for each). There was no significant difference in glenoid cavity index between male and female.

Limitations:

1. Purposive sampling technique was selected.
2. Modern technology for the measurement of the length of glenoid cavity was not possible to use and only traditional method was used for measurement and calculation.
3. Only adult dry scapulae were taken.

Conflict of interest:

There is no conflict of interest.

References

1. Standring, S. Gray's anatomy e-book: the anatomical basis of clinical practice. 42nd ed. London, 2021.776-862.
2. Sushma, K.K. & Sm Ms, Morphological and Morphometric Study of Glenoid Cavity and It's Clinical Application in Western Rajasthan Population. Scholars International Journal of Anatomy and Physiolog, 2023. 6 (1): 1-6.
3. Churchill, R.S., Brems, J.J., Kotschi, H. Glenoid size, inclination, and version: an anatomic study. Journal of Shoulder and Elbow Surgery. 2001. 10 (4): 327–332.
4. Bayramoğlu, A., Demiryürek, D., Tüccar, E., Erbil, M., Aldur, M.M., Tetik, O., et al. Variations in anatomy at the suprascapular notch possibly causing suprascapular nerve entrapment: an anatomical study. Knee Surgery, Sports Traumatology, Arthroscopy, 2003. 11 (6): 393–398.
5. Hassanein, G.H.E. Morphometry of glenoid fossa in adult Egyptian scapulae. International Journal of Anatomy and Research, 2015. 3 (2): 1138-42.
6. Ülki r, M., Salman, N., Farimaz, M. Morphologic Evaluation of the Glenoid Cavity on Dry Scapula. Duzce Medical Journal, 2022. 24 (2): 182-186.
7. El-Din, W.A.N., Ali, M.H.M. A morphometric study of the patterns and variations of the acromion and glenoid cavity of the scapulae in egyptian population. Journal of clinical and diagnostic research: JCDR, 2015. 9 (8): AC08–11.
8. Akhtar, M., Kumar, B., Fatima, N., Kumar, V. Morphometric analysis of glenoid cavity of dry scapulae and its role in shoulder prosthesis. International Journal of Research in Medical Sciences, 2016. 4 (7): 2770-2776.
9. Shubhangi, B.G., Kailash, B. W., Amrut, A. M. Morphometric study of glenoid cavity of human scapula. Indian Journal of Anatomy. 2018. 7(3):233-236.
10. Singh, R. Surgical anatomy of the glenoid cavity and its use in shoulder arthroplasty among the north indian population. Cureus, 2020. 12 (12): e11940.
11. Ankushrao, In our morphological study the pear-shaped glenoid cavity was most common type followed by inverted comma shaped. Indian Journal of Clinical Anatomy and Physiology, 2017. 4 (3): 298-303.
12. Singh, A., Singh, A., Agarwal, P., Gupta, R. A morphological and morphometric study of glenoid fossa of scapula and its implication in shoulder arthroplasty. International Journal of Anatomy, Radiology and Surgery, 2019. 8 (3): AO06-AO09.
13. Gunasekaran. Morphology and Morphometric Analysis of Glenoid Cavity of Scapula and Its Clinical Significance. IOSR Journal of Dental and Medical Sciences, 2020. 19 (9): 1-5.
14. Rajput, H.B. A Study of Morphological Patterns of Glenoid Cavity of Scapula. National Journal of Medical Research, 2022. 2 (4): 504-507.
15. Azhagiri, R., Anitha, M., Hemapriya, J., Murugaperumal, G., Sumathi, G. Morphology and morphometric study of dry scapula, with emphasis on the glenoid fossa and acromion process in Chennai city, South India. Asian Journal of Medical Sciences, 2022. 13 (1): 158–165.
16. Iannotti, J.P., Jun, B.J., Teplensky, J., Ricchetti, E. Humeral head shape in native and prosthetic joint replacement. Journal of Shoulder and Elbow Arthroplasty, 2019. 3 (2): 1- 5.
17. Vaishnani, H., Jethva, K., Rathwa, A., Sharma, P. Morphometry and morphology of glenoid cavity of scapula. International Journal of Academic Research, 2018. 6 (1.1): 4798–4802.
18. Chaturvedi, D. Glenoid Cavity of Dry Scapula in Central India. Journal of Pharmaceutical Negative Results, 2022. 13 (10): 3753-3760.
19. Mahto, A.K., Omar, S. Dimensions of glenoid fossa of scapula: implications in the biomechanics of an implant design. International Journal of Scientific Study, 2015. 3 (4): 146-148.
20. Von Schroeder, H.P., Kuiper, S.D., Botte, M.J.. Osseous anatomy of the scapula. Clinical Orthopaedics Related Research, 2001. 9 (3): 131–139.
21. Coskun, N., Karaali, K., Cevikol, C., Demirel, B.M., Sindel, M. Anatomical basics and variations of the scapula in Turkish adults. Saudi Medical Journal, 2006. 27 (9): 1320–1325.
22. Karelse, A., Kegels, L., De Wilde, L. The pillars of the scapula. Clinical Anatomy, 2007. 20(4):392–399.

23. Dhindsa, G.S., Singh, Z. A study of morphology of the glenoid cavity. Journal of Evolution of Medical and Dental Sciences, 2014. 3(25):7036–7046.

24. Mamatha, T., Pai, S.R., Murlimanju, B.V. Morphometry of glenoid cavity. Online Journal of Health and Allied Sciences, 2011. 10 (3): 1-4.

25. Patil, G.V. Morphometrical study of scapular glenoid cavities. Journal of the Anatomical Society of India, 2015. 14 (2): 4-10.

26. Joshi, M., Pakhale, S.V. Morphological study of glenoid cavity of scapula. Ind. Indian Journal of Clinical Anatomy and Physiology, 2023. 10(1):46–51.

27. Aigbogun, E.O., Oladipo, G.S., Oyakhiree, M.O., Ibeachu, C.P. Morphometry of the glenoid cavity and its correlation with selected geometric measurements of the scapula. Bangladesh Journal of Medical Science, 2017. 16(4):572.

28. Chhabra, N., Prakash, S., Mishra, B.K. An anatomical study of glenoid cavity: its importance in shoulder prosthesis. International Journal of Academic Research, 2015. 3(3):1419–1424.

29. K, K.S., Manu, S., Kalpana, G., Samata, G. Morphological and morphometric study of glenoid cavity and it's clinical application in western rajasthan population. Scholars International Journal of Anatomy and Physiology, 2023. 6(1):1–6.

30. S, S., N, V. Morphological Variations of Glenoid Cavity of Human Scapulae: An Anatomical Study with Clinical Relevance. International Journal of Anatomy and Research, 2020. 8(1.2):7288-7293.

31. Raaj, M.S., Felicia, C., S., S., A., A.K. Morphologic and morphometric analysis of glenoid cavity of human scapula. International Journal of Research in Medical Sciences, 2018. 7 (1): 52.

32. Prescher, A., Klümpen, T. The glenoid notch and its relation to the shape of the glenoid cavity of the scapula. Journal of Anatomy, 1997. 190 (3): 457–460.

33. Phad, V.V., Joshi, R.A. Determination of sex from morphometric analysis of scapula. MedPulse – International Journal of Anatomy, 2019. 11 (2): 44-46.

34. Ozer, I., Katayama, K., Sağir, M., Güleç, E. Sex determination using the scapula in medieval skeletons from East Anatolia. Collegium Antropologicum, 2006. 30(2):415–419.

35. Ríos Frutos, L. Metric determination of sex from the humerus in a Guatemalan forensic sample. Forensic Science International, 2005. 147 (2-3): 153–157.

36. Merrill, A., Guzman, K., Miller, S.L. Gender differences in glenoid anatomy: an anatomic study. Surgical and radiologic anatomy: SRA, 2009. 31 (3): 183–189..