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Original Research Article

Morphological Analysis of Glenoid Cavity of Scapula in Bihar Population

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Abstract:

Background: The glenoid cavity of the scapula forms the socket component of the shoulder joint and is a critical anatomical structure for maintaining shoulder stability and function. Variations in its shape, size, and orientation are of immense clinical importance, particularly in shoulder dislocation, arthroplasty, and rotator cuff injuries. Precise morphometric data on the glenoid cavity can assist orthopedic surgeons and anatomists in better understanding joint biomechanics and designing prosthetic components. However, population-based variations are known to exist, and limited data is available for the Bihar region.

Objectives:

- To determine the shape of the glenoid cavity in dry human scapulae from Bihar.
- To record morphometric parameters such as superoinferior diameter, anteroposterior diameters (at upper and lower halves), and glenoid cavity index.
- To classify the shapes based on standard anatomical classification and correlate findings with similar Indian and international studies.

Materials and Methods: This cross-sectional osteological study was conducted in the Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya, Bihar. A total of 100 adult human dry scapulae (50 right and 50 left) were included. Damaged or deformed specimens were excluded. Parameters measured included superoinferior diameter (SI), anteroposterior diameter at upper and lower halves (AP1 and AP2), and glenoid cavity index (GCI). The shape of the glenoid cavity was classified into pear-shaped, oval, or inverted comma-shaped based on anatomical landmarks. Data were statistically analyzed for side-wise comparison and variation patterns.

Results: The most common shape observed was the pear shape (45%), followed by oval (33%) and inverted comma (22%). The mean superoinferior diameter was 36.8 mm on the right and 37.2 mm on the left. The mean AP diameters were 24.6 mm (upper) and 26.8 mm (lower). The mean glenoid cavity index was 67.1% on the right and 68.5% on the left. No statistically significant difference was found between the sides.

Conclusion: This study confirms that glenoid cavity morphology in the Bihar population is predominantly pear-shaped, with measurements aligning closely with other Indian populations. The data provide a valuable reference for orthopedic and reconstructive shoulder surgeries and emphasize the need for population-specific anatomical databases to guide clinical decision-making.

Keywords: Glenoid Cavity, Scapula, Morphometry, Shoulder Joint, Glenoid Index, Pear-Shaped Glenoid, Bihar Population.

Introduction

The shoulder joint is the most mobile joint in the human body and owes much of its functionality to the anatomical configuration of the scapula and its articulation with the humerus. The glenoid cavity, a shallow, concave articular surface located on the lateral angle of the scapula, serves as the socket of the glenohumeral joint and plays a critical role in shoulder stability and range of motion. Its size, shape, and orientation influence joint congruence, susceptibility to dislocation, and the outcome of both conservative and surgical interventions [1,2].

From a developmental perspective, the glenoid cavity undergoes morphological changes during growth and maturation, influenced by both genetic and biomechanical factors. Clinically, its variations are associated with conditions such as recurrent shoulder dislocations, rotator cuff pathologies, and degenerative joint diseases [3]. In orthopedic procedures like total shoulder arthroplasty, precise anatomical knowledge of the glenoid cavity is essential for optimal prosthetic fit and alignment. Inaccurate interpretation of glenoid shape and size can result in implant failure, glenoid loosening, or restricted shoulder mechanics post-surgery [4].

Anatomical classification of the glenoid cavity has primarily been based on its shape, with the most commonly observed configurations being pear-shaped, oval, and inverted comma-shaped. The glenoid cavity index, calculated as the ratio of anteroposterior to superoinferior diameter, further helps quantify the variability in cavity dimensions. Such indices are useful in comparative anatomy, implant design, and preoperative planning for shoulder surgeries [5].

While several studies from different regions of India and abroad have documented glenoid morphology, there remains a paucity of data specific to the Bihar population. Anatomical parameters are known to vary across ethnic and regional groups, influenced by skeletal build, lifestyle, and genetic diversity. Establishing normative glenoid cavity data for the Bihar region will assist both anatomists and clinicians in enhancing the anatomical curriculum and improving surgical precision, especially in shoulder reconstructive procedures [6].

Therefore, this study was undertaken to perform a detailed morphometric and morphological analysis of the glenoid cavity in dry adult human scapulae sourced from the Bihar population. The findings aim to serve as a regional reference for anatomical teaching, clinical diagnostics, and orthopedic applications involving the shoulder joint.

Objectives: This study was designed to analyze the morphological variations and dimensional characteristics of the glenoid cavity in adult human scapulae from the Bihar population.

Primary objectives:

1. To determine the predominant shape of the glenoid cavity (pear-shaped, oval, or inverted comma) in dry human scapulae.
2. To measure key morphometric parameters of the glenoid cavity including:
   - Superoinferior diameter (SI)
   - Anteroposterior diameter at upper half (AP1)
   - Anteroposterior diameter at lower half (AP2)

Secondary objectives:

1. To calculate the Glenoid Cavity Index (GCI) and assess side-wise variations (right vs. left scapulae).
2. To compare the observed findings with published data from other regional and international populations.
3. To provide baseline morphometric data for the Bihar region to assist in clinical and surgical applications related to the shoulder joint.

Materials and Methods

Study design and setting: This cross-sectional osteological study was conducted in the Department of Anatomy, at Anugrah Narayan Magadh Medical College, Gaya, Bihar, India from Jan 2020 to December 2020

Study Material: A total of 100 dry adult human scapulae were examined, comprising 50 right and 50 left-sided bones. All scapulae were sourced from the osteology collection of the department.

Inclusion criteria:

- Fully ossified, adult human scapulae.
- Bones without gross deformity or pathological damage.
- Clearly identifiable anatomical landmarks including the glenoid cavity and its margins.

Exclusion criteria:

- Damaged, broken, or eroded scapulae.
- Bones with congenital anomalies or post-mortem alterations affecting glenoid shape or dimensions.

Parameters recorded:

The following morphometric parameters were measured using digital Vernier calipers to the nearest 0.1 mm:

1. **Superoinferior diameter (SI):** Maximum vertical height of the glenoid cavity.
2. **Anteroposterior diameter at upper half (AP1):** Maximum breadth in the upper half.
3. **Anteroposterior diameter at lower half (AP2):** Maximum breadth in the lower half.
4. **Glenoid Cavity Index (GCI):** Calculated using the formula:

GCI = (AP1 / SI) × 100

Shape classification:

Based on the anatomical contour of the glenoid cavity and presence of the glenoid notch, the cavity was categorized into:

- **Pear-shaped** (prominent inferior projection)
- **Oval-shaped** (uniformly curved margins)
- **Inverted comma-shaped** (distinct glenoid notch)

Measurement tools and method: Measurements were taken by two independent observers using digital calipers. Each parameter was measured three times, and the average value was recorded to minimize observer bias.

Data Analysis: The data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Descriptive statistics including mean, standard deviation, and frequency percentages were calculated. Side-wise comparisons were assessed using independent t-tests, and shape distribution was presented as frequencies and proportions. A p-value <0.05 was considered statistically significant.

Results

The present descriptive osteological study was conducted on a total of 100 dry, adult human scapulae obtained from the Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya, Bihar. The sample consisted of 50 right-sided and 50 left-sided scapulae, ensuring an equal representation of both sides to allow for comparative analysis. Each scapula was free from gross deformity, erosion, or pathological alteration and was subjected to detailed morphometric evaluation using standard osteometric procedures.

The primary aim was to assess the morphology of the glenoid cavity, a crucial anatomical feature forming the socket of the glenohumeral joint. The glenoid cavity of each scapula was examined visually to determine its morphological shape categorized as pear-shaped, oval-shaped, or inverted comma-shaped—based on the presence or absence of a glenoid notch and contour symmetry.

In addition to morphological classification, three key linear dimensions of the glenoid cavity were measured using digital Vernier calipers: (1) superoinferior diameter (maximum vertical length), (2) anteroposterior diameter at the upper half (AP1), and (3) anteroposterior diameter at the lower half (AP2). These dimensions were used to calculate the Glenoid Cavity Index (GCI), which reflects the proportional breadth of the glenoid cavity in relation to its height. Each measurement was taken thrice and averaged to minimize observer error.

The data collected were systematically categorized based on side (right or left) and shape classification, and were subjected to statistical analysis to evaluate side-wise variation, predominant morphological trends, and population-specific anatomical patterns relevant to clinical practice. The findings are presented in the tables below with detailed interpretations.

Table 1: Distribution of scapulae studied by laterality

Side	Number of scapulae	Percentage (%)
Right	50	50.0
Left	50	50.0

Table 2: Shape classification of glenoid cavity

Shape	Frequency	Percentage (%)
Pear-shaped	45	45.0
Oval-shaped	33	33.0
Inverted comma-shape	22	22.0

Table 3: Shape distribution by side

Shape	Right side	Left side
Pear-shaped	21	24
Oval-shaped	16	17
Inverted comma-shape	13	9

Table 4: Superoinferior diameter (SI) of glenoid cavity

Side	Mean SI diameter (mm)	Standard deviation
Right	36.8	2.5
Left	37.2	2.7

Table 5: Anteroposterior diameter at upper half (AP1)

Side	Mean AP1 (mm)	Standard deviation
Right	24.6	2.1
Left	25.2	2.4

Table 6: Anteroposterior diameter at lower half (AP2)

Side	Mean AP2 (mm)	Standard deviation
Right	26.8	2.3
Left	27.1	2.5

Table 7: Glenoid Cavity Index (GCI)

Side	Mean GCI (%)	Standard deviation
Right	67.1	3.5
Left	68.5	3.8

Table 8: Comparison of mean SI diameter by glenoid shape

Shape	Mean SI diameter (mm)
Pear-shaped	36.5
Oval-shaped	38.2
Inverted comma-shape	35.4

Table 9: Side-wise comparison of SI diameter (t-test)

Variable	t-value	p-value
SI Diameter (mm)	0.714	0.477

Table 10: Comparative analysis with other regional studies

Study location	Mean SI (mm)	Most common shape
Present (Bihar)	37.0	Pear-shaped
South India	36.2	Oval-shaped
West Bengal	37.4	Pear-shaped
Maharashtra	35.8	Inverted comma-shaped

Table 1 confirms that the study included equal numbers of right and left scapulae, ensuring symmetrical analysis. Table 2 establishes the pear-shaped glenoid cavity as the most prevalent in the Bihar population, accounting for 45% of the total sample. Table 3 shows that this trend was more common on the left side, while oval and inverted comma-shaped cavities were nearly evenly distributed between both sides. Table 4, Table 5, and Table 6 display the morphometric dimensions of the glenoid cavity, indicating slightly larger average measurements on the left side, particularly in the anteroposterior planes. Table 7 shows that the Glenoid Cavity Index was comparable between sides, with no statistically significant lateral variation. Table 8 reveals that oval-shaped glenoids tend to have larger superoinferior diameters, while inverted comma shapes have relatively smaller cavities. Table 9 presents statistical analysis confirming that there is no significant side dominance in glenoid dimensions. Table 10 situates the current findings within the broader context of Indian literature, reaffirming that pear-shaped cavities predominate in the eastern region, whereas some southern and western states report differing dominant forms.

Discussion

The glenoid cavity of the scapula, forming the socket component of the shoulder joint, plays a vital role in facilitating upper limb mobility and stability. Its morphology has direct implications in the biomechanics of the glenohumeral articulation and influences the prevalence of shoulder dislocation, rotator cuff pathology, and outcomes of shoulder arthroplasty. Understanding the shape, size, and variation of this articular surface is thus indispensable for both anatomical knowledge and clinical applications [7,8].

The current study, conducted on 100 adult dry scapulae from the Bihar population, revealed that the pear-shaped glenoid cavity was the most predominant morphological type, followed by oval and inverted comma-shaped configurations. These findings align with previous Indian studies from West Bengal and northern regions, suggesting that the pear shape may represent a common morphological pattern in eastern Indian populations. In contrast, some studies from southern and western India reported oval or inverted comma shapes as dominant, reflecting possible regional and ethnic skeletal variations [9,10].

Morphometric analysis demonstrated that the superoinferior and anteroposterior diameters were comparable between the right and left scapulae, with slightly larger values observed on the left side. However, statistical analysis did not reveal any significant side-wise differences, indicating morphological symmetry of the glenoid cavity in the present sample. This finding is consistent with several published reports, reinforcing that laterality has limited impact on glenoid dimensions in dry bone analysis [11,12].

The Glenoid Cavity Index (GCI), calculated to assess proportional breadth of the cavity, showed mean values close to 67–68% across both sides, indicating that the breadth of the glenoid cavity is typically two-thirds of its height. This proportion is crucial for prosthetic design in total shoulder replacement and provides a guideline for surgical planning during glenoid component fixation [13].

The variation in shape, particularly the presence of the glenoid notch as seen in inverted comma-shaped cavities, may predispose individuals to anterior shoulder dislocation. These cavities often have reduced articular surface contact with the humeral head and may compromise joint stability, especially in high-mobility individuals. Knowledge of such morphological types can assist surgeons in risk stratification and customizing surgical techniques [14].

The findings of this study are in concordance with previous Indian literature, with minor differences likely attributed to sample size, demographic diversity, and measurement techniques. By providing region-specific anatomical data, this study contributes valuable insights for orthopedic surgeons, radiologists, and anatomists working with the Bihar population.

Conclusion

The present study demonstrates that the glenoid cavity of the scapula in the Bihar population exhibits predominantly pear-shaped morphology, followed by oval and inverted comma-shaped configurations. The morphometric parameters—including superoinferior and anteroposterior diameters—were found to be consistent across right and left sides, indicating anatomical symmetry. The calculated Glenoid Cavity Index values support the established proportional relationships essential for joint congruity and prosthetic alignment. These findings reinforce the importance of regional anatomical data in enhancing the precision of orthopedic interventions, particularly in procedures such as shoulder arthroplasty, arthroscopic repair, and rotator cuff reconstruction. The results also provide a valuable anatomical reference for educators, clinicians, and researchers working with shoulder joint anatomy in eastern Indian populations.

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