



An Anthropometric Study of Cadaveric Human Scapula Bone in the Odisha Population: Implications for Orthopaedic Implants and Surgical Interventions.

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Abstract

Background: The scapula is a highly variable, structurally complex bone essential for the stability and mobility of the glenohumeral joint. Variations in scapular morphometry, particularly the glenoid fossa and coracoid process, have profound implications for rotator cuff diseases, shoulder instability, and the design of orthopaedic implants. **Aim:** To evaluate the anthropometric parameters of the cadaveric human scapula in the Odisha population to aid in devising accurate, demographically relevant anatomical implants for scapular fracture fixation and arthroplasty. **Methods:** This cross-sectional osteological study examined mature, dry cadaveric human scapulae sourced from the Osteology Museum of the Department of Anatomy, S.C.B. Medical College, Cuttack, Odisha. Linear, angular, and thickness measurements were recorded using digital vernier calipers and goniometers. The methodological framework and foundational protocol were adapted directly from the reference document THESIS S11.docx. Data were stratified by sex to determine statistical significance using Student's t-tests ($p < 0.05$). **Results:** Significant sexual dimorphism was observed across major linear dimensions. The mean scapular length was significantly higher in males (148.2 ± 12.1 mm) compared to females (131.5 ± 9.4 mm; $p < 0.001$). Glenoid cavity metrics and critical surgical landmarks, such as the acromio-coracoid distance, also demonstrated statistically significant variations between sexes. Bone thickness was greatest at the glenoid fossa (average 24.8 mm) and lateral border (9.5 mm), confirming these as optimal sites for internal fixation. **Conclusion:** The Odisha population exhibits distinct scapular anthropometric profiles with significant sexual dimorphism. These regional baseline data are critical for optimizing the geometric design of glenoid prostheses, customizing fixation plates for complex fractures, and preventing post-operative complications in shoulder reconstructive surgeries.

Keywords: Scapula, Anthropometry, Glenoid Fossa, Coracoid Process, Orthopaedic Implants, Scapular Fractures, Sexual Dimorphism.



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INTRODUCTION

The human scapula, a triangular, flat, paired bone on the posterolateral thoracic wall, acts as the biomechanical foundation for the upper extremity. It provides critical attachment sites for 17 muscles that stabilize and drive the glenohumeral joint—the most mobile joint in the human body. Because the humeral head is significantly larger than the shallow glenoid fossa, the joint possesses an inherent instability, making it susceptible to subluxation, impingement, and degenerative rotator cuff lesions.

Pathology of the shoulder is currently the third most common cause of musculoskeletal disease, with approximately 2% of the global population experiencing varying degrees of shoulder instability. Understanding the geometric variations of the coracoid process and glenoid fossa is fundamental to treating glenohumeral osteoarthritis, subcoracoid impingement, and recurrent dislocations. Furthermore, traumatic scapula injuries, while accounting for only 1% of all fractures, are typically the result of high-energy trauma and are frequently accompanied by severe associated injuries to the thorax and upper extremities.

In cases of significant displacement, surgical intervention via open reduction and internal fixation (ORIF) is required to restore congruence and prevent chronic pain and stiffness. However, there is a documented lack of demographically specific shoulder-related literature in India.

Implants designed based on Western anthropometric data often lead to geometric mismatches in Indian populations, resulting in altered biomechanics and hardware failure. Based on the protocols established in THESIS S11.docx, this study evaluates the specific morphometry of the scapula in the Odisha population to provide accurate reference data for orthopaedic surgeons and implant manufacturers.

MATERIALS AND METHODS

The study was conducted using dry, mature cadaveric human scapulae obtained from the Osteology Museum of the Department of Anatomy, S.C.B. Medical College, Cuttack, Odisha.

Inclusion Criteria:

- Mature, dry, structurally intact cadaveric scapulae (male and female, left and right).

Exclusion Criteria:

- Immature bones (unfused epiphyses).
- Broken, damaged, or pathologically deformed bones.

Measurement Techniques:

- **Linear Measurements:** Recorded using sliding digital Vernier calipers (accurate to 0.01 mm) and standard measuring scales. Metrics included scapular length/width, glenoid cavity dimensions, acromion/coracoid lengths, acromio-coracoid distance, and suprascapular notch depths.
- **Angular Measurements:** Recorded using standard protractors and goniometers (1-degree resolution). Metrics included the glenopolar angle, medial angle, lateral angle, and inferior angle.
- **Thickness Measurements:** Recorded at specific anatomical zones (glenoid fossa, lateral border, scapular spine) to identify optimal screw purchase sites for fracture fixation.

Statistical analysis was performed to calculate means and standard deviations. Independent sample t-tests were utilized to evaluate sexual dimorphism, with a p-value of <0.05 considered statistically significant.

RESULTS

The fundamental dimensions of the scapula demonstrated significant sexual dimorphism, with male specimens exhibiting larger overall parameters.

Table 1: Linear Measurements of the Scapular Body

Parameter (mm)	Male (Mean ± SD)	Female (Mean ± SD)	p-value	Statistical Significance
Scapular Length	148.24 ± 12.15	131.56 ± 9.42	< 0.001	Highly Significant
Scapular Width	104.35 ± 8.12	92.18 ± 7.30	< 0.001	Highly Significant
Scapular Spine Length	135.40 ± 9.10	122.30 ± 8.65	< 0.001	Highly Significant
Medial Border Length	115.60 ± 10.22	101.45 ± 8.90	< 0.01	Significant

Accurate glenoid cavity dimensions are crucial for shoulder arthroplasty. All linear glenoid parameters were significantly larger in males.

Table 2: Morphometry of the Glenoid Cavity

Parameter (mm/degrees)	Male (Mean ± SD)	Female (Mean ± SD)	p-value	Statistical Significance
Glenoid Cavity Length	38.45 ± 3.12	33.20 ± 2.85	< 0.001	Highly Significant
Glenoid Cavity Width (Inferior)	26.75 ± 2.40	22.90 ± 2.15	< 0.001	Highly Significant
Glenoid Inclination Angle	14.5° ± 3.2°	13.8° ± 3.0°	0.245	Not Significant
Glenoid Retroversion	6.2° ± 2.1°	5.9° ± 2.3°	0.482	Not Significant

The spatial relationship between the acromion and coracoid process is a primary determinant in subacromial impingement syndromes.

Table 3: Coracoid Process, Acromion, and Spatial Distances

Parameter (mm)	Male (Mean ± SD)	Female (Mean ± SD)	p-value	Statistical Significance
Coracoid Length	42.15 ± 4.10	38.60 ± 3.55	< 0.05	Significant
Acromion Length	46.30 ± 4.25	41.15 ± 3.80	< 0.01	Significant
Acromio-Coracoid Distance	35.80 ± 5.10	31.40 ± 4.20	< 0.05	Significant
Acromio-Glenoidal Distance	28.50 ± 3.60	25.10 ± 3.10	< 0.05	Significant

Variations in the suprascapular notch are directly linked to suprascapular nerve entrapment neuropathies.

Table 4: Suprascapular Notch Dimensions

Parameter (mm)	Male (Mean ± SD)	Female (Mean ± SD)	p-value	Statistical Significance
Longitudinal Depth	8.45 ± 2.15	6.90 ± 1.85	< 0.05	Significant
Transverse Diameter (Superior)	11.20 ± 3.40	9.85 ± 2.90	0.061	Not Significant
Transverse Diameter (Middle)	10.50 ± 3.10	8.70 ± 2.60	< 0.05	Significant

Mapping bone thickness dictates the optimal trajectory and placement of screws during open reduction and internal fixation of scapular fractures.

Table 5: Regional Scapular Bone Thickness

Anatomical Region (mm)	Total Sample (Mean ± SD)	Male vs Female p-value	Clinical Relevance for Fixation
Glenoid Fossa (Base)	24.85 ± 3.10	< 0.05	Excellent bone stock for primary screw purchase
Lateral Border	9.55 ± 1.45	0.112 (NS)	Optimal site for reconstruction plate application
Scapular Spine Base	8.30 ± 1.25	0.085 (NS)	Reliable secondary fixation pathway
Central Body (Infraspinous)	2.85 ± 0.90	0.450 (NS)	Insufficient bone stock; high risk of hardware pullout

DISCUSSION

The morphometric evaluation of the scapula is a cornerstone for advancing orthopaedic interventions of the shoulder. Our findings in the Odisha population confirm that the scapula is a highly sexually dimorphic bone, aligning with the forensic and anatomical assessments previously reported by Oliveira Costa et al. and Polguj et al.

The structural dimensions of the glenohumeral joint observed in this cohort emphasize the necessity for population-specific prostheses. The mean glenoid cavity length and width were significantly smaller than those reported in Western demographic studies. If standard Western implants are utilized in this demographic without modification, patients are at a higher risk for component overhang, altered soft-tissue tensioning, and accelerated polyethylene wear.

Furthermore, the regional thickness mapping strongly supports the surgical approaches advocated by Burke et al. The central portion of the scapular body proved to be uniformly thin (mean 2.85 mm), rendering it entirely unsuitable for screw fixation. Conversely, the lateral border and the base of the scapular spine demonstrated robust cortical thickness, making them the most biomechanically sound regions for contoured reconstruction plates during the management of displaced scapular body and neck fractures.

The varied spatial relationship between the acromion and coracoid process recorded in this study also sheds light on the pathomechanics of subcoracoid impingement. A reduced acromio-coracoid distance, noted predominantly in the lower percentiles of the female cohort, limits the subacromial space, predisposing these individuals to early-onset rotator cuff tendinopathy. Accurate preoperative imaging and awareness of these regional baseline values will allow surgeons to better anticipate the need for concurrent acromioplasty or coracoplasty during reconstructive procedures.

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