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Original Research Article

MORPHOMETRIC ANALYSIS AND SURGICAL ANATOMY OF PROXIMAL HUMERUS

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ABSTRACT

Introduction: It is know that Asian shoulders are small and require attention while planning replacement surgeries. The prostheses currently available are based on western database and only few sizes fit into the Asian shoulders. The native database will also help us to calculate humerus bone loss and prostheses designing.

Materials and Methods: Sixty seven paired humeri (Left-33, Right-34) were included in study. Adult wet humeri were retrieved from embalmed human cadavers fixed in formalin. The humeral head dimensions and version were measured with fixed protocol.

Results: The mean humerus head height, antero-posterior and medio-lateral diameter of both sides was 18.57 ±2.82 mm, 39.65 ±2.97 mm and 43.11 ±3.73 mm respectively. The mean humerus head version on both sides was 37.30 ±7.85 degrees.

Conclusion: The smaller dimensions of the proximal humerus in the Asian population need to be contemplated while designing and fitting prosthesis in total shoulder arthroplasty and for assessing bone loss while establishing criteria for anatomic restoration, post surgery.

KEY WORDS: Humerus head, Morphometry, Cadaver, Arthroplasty, Humerus version.

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INTRODUCTION

The Gleno-humeral joint is a multiaxial ball-and-socket synovial joint, however humeral head curve do not match the Glenoid curve. The head of the humerus is larger than the glenoid fossa, so only part of the humeral head articulates with the glenoid fossa in any position of the joint. The dimensions of head of Humerus are important for evaluating percentage bone loss in presence of Hillsach's lesion and for Shoulder replacements. Moreover it has been observed, only the lower sizes of the available prosthesis fit in for the Asian population and sometimes leads to overstuffing, discomfort and restricted movements of joint. Restoration of normal anatomy is important to maintain optimal lever arm of Deltoid and cuff muscle in

all axis. Any drift from normal anatomy will cause abnormal kinematics and early failure of Surgery [1,2,3].

As a general method for all proximal humerus fractures or replacement surgery, we use the contra-lateral humerus as the template for correction. But there is enough literature evidence that high inter-specimen and side specific variability exists [4,5,6]. Variations in humeral version and dimensions should be considered at the time of actual replacement surgery. Most of the shoulder surgeons accept 25 degree to 35 degree of humeral head retroversion as a practical reference figure[7] Various biomechanical studies have shown that even a small variation in prosthetic geometry deviates from the normal anatomy, there will be suboptimal functional outcome [4,8].

The current study was aimed to obtain morphometric data of proximal Humerus in the Indian population.

MATERIALS AND METHODS

Data Source: Adult wet Humeri were harvested from embalmed human cadavers, Asian in origin fixed in formalin from the department of Anatomy, B J Medical College, Pune.

Ethical considerations: Prior written consent was obtained and legal documentation was completed by the body donors, expressing self willingness to donate their body for medical education and research purpose. Institute Ethics committee approval was obtained for current study.

Sample size: Sixty seven paired Humeri (Left-thirty three, Right-thirty four)

Inclusion Criteria: Adult wet Humeri of both sexes were included. Age varied from sixty to eighty years.

Exclusion Criteria: The bones showing any apparent pathology, features of osteoarthritis and fractures were discarded from the study.

Study Design: Cross Sectional Descriptive type.

Protocol of the procedure: The periarticular muscles and the soft tissue were stripped off to expose the glenohumeral joint, and disarticulated. The dimensions of proximal humerus were measured manually with the vernier caliper accurate to 0.1mm and goniometer. Observations were taken by two people to rule out any inter observer variation. The Humerus head axis was marked, which is the longitudinal axis joining the superior and inferior most points on articular margin of anatomical neck. Antero-posterior diameter (HAP), Medio-lateral diameter (HML) and Head height (HH) were measured using vernier caliper.

HH is the maximum measurement of humerus head from anatomic neck to dome of head (Figure1)

HAP is the maximum anterior- posterior measurement of humerus head (Figure 2)

HML is the maximum medio-lateral measurement of humerus head (Figure 3)

Humerus version (HV) is Angle formed by humerus epicondyle axis and head axis (Figure 4) the measurement of humeral head retroversion followed the identical technique as described by Edelson [5]. Firstly a line from Superior to Inferior aspect of humeral head was drawn by 3 dot technique described by Edelson. The humerus was placed flush against wall as a vertical structure - so that the shaft of humerus was touching the wall. The Goniometer was applied against the wall surface in the axial plane. The line that was drawn bisecting the head of humerus was matched to the nearest reading on the Goniometer to achieve the actual retroversion of the head of humerus. This method was illustrated by previous authors [9].

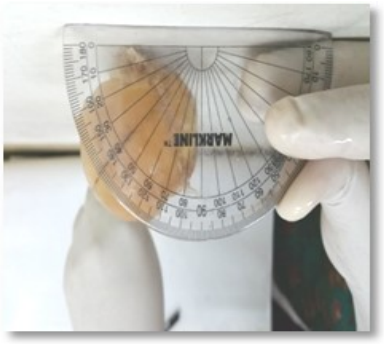
Statistical analysis: Data analysis was done by using SPSS (Statistical package for social science version 20:0) The Quantitative data variables expressed by using descriptive statistics viz Range, Mean, Standard deviation, 95% confidence interval etc. Two independent sample t-test was used to compare Head height (HH), Antero-posterior diameter (HAP), Medio-lateral diameter (HML) and Humerus version (HV) with respect to left and right side. The p-value <0.05 was considered as significant.

Fig. 1: Measurement of Head height (HH).

Fig. 2: Measurement of Antero-posterior diameter (HAP).

Fig. 3: Measurement of Medio-lateral diameter (HML).

Fig. 4: Measurement of Humerus version (HV).



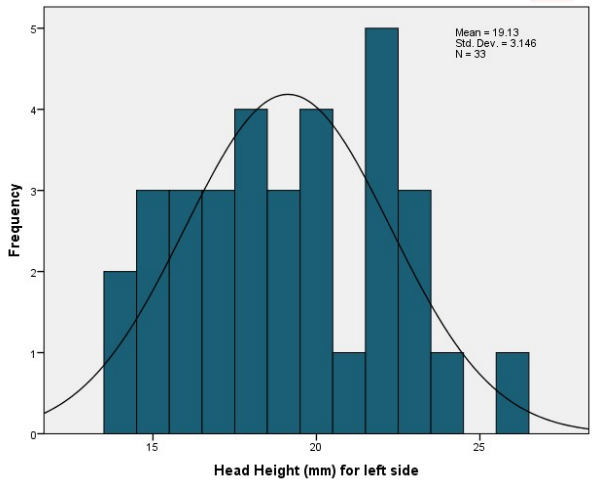
RESULTS

This study included sixty seven humeri (Left-33, Right-34).The summary of the morphometric parameters measured is listed in Table 1

Table 1: Showing the Mean, Sd and Range for various parameters.

Parameter	N	Mean ± Sd	Range
Humerus head height (mm)			
Both	67	18.58±2.82	13.00 to 26.00
Left	33	19.13±3.15	14.00 to 26.00
Right	34	18.04±2.39	13.00 to 24.00
Humerus head Antero-Posterior diameter (mm)			
Both	67	39.65±2.97	33.20 to 46.00
Left	33	39.75±2.76	33.50 to 46.00
Right	34	39.55±3.20	33.20 to 45.70
Humerus head medio-lateral diameter ML(mm)			
Both	67	43.11±3.73	34.50 to 51.00
Left	33	42.73±3.55	34.50 to 50.80
Right	34	43.47±3.92	36.10 to 51.00
Humerus Version(degrees)			
Both	67	37.30±7.85	20 to 55
Left	33	36.82±8.08	23 to 55
Right	34	37.76±7.70	20 to 50

Fig. 5: HH - Left: histogram n=33, (mean±sd) 19.13 ±3.15 mm, (range)14.00 to 26.00 mm.



Humerus head height (HH): The mean head height of humerus on both sides was 18.57 ±2.82 mm. The mean head height on left side was 19.13 ±3.15 mm, and 18.04 ±2.39 mm on right side. Left side measurements were higher than right side but p-value is 0.118 (>0.05) not significant. On left side, was 18.05 mm to 20.21 mm and of the right, was 17.22 mm to 18.87 mm. (Figures 5, 6, 7)

Fig. 6: HH - Right: histogram n=34,(mean±sd) 18.04±2.39 mm, (range)13.00 to 24.00 mm.

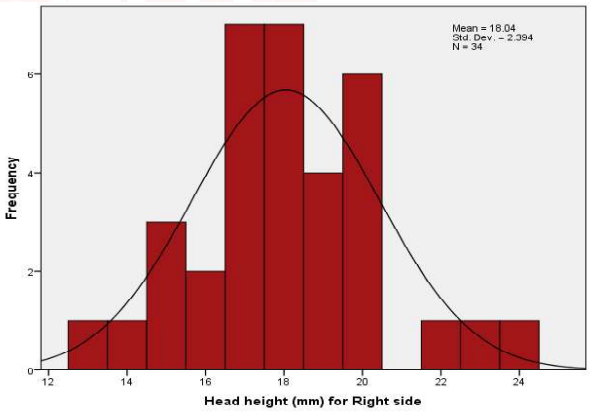
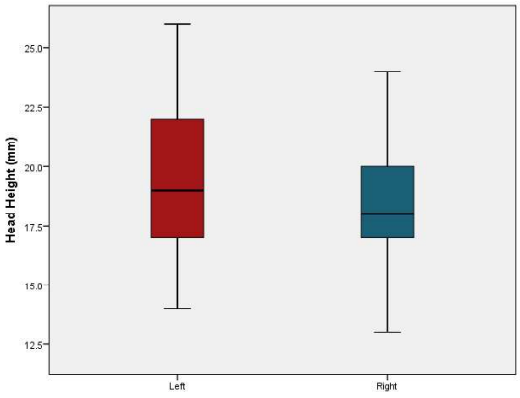


Fig. 7: HH - Comparison Left and Right sides.



Humerus head Antero-posterior diameter (HAP): The mean HAP on both sides was 39.65 ±2.97 mm. The mean HAP on left side was 39.75 ±2.76 mm, and 39.55 ±3.20 mm on right side. The mean HAP of both sides was comparable as p-value was 0.783 (> 0.05) Not significant.

On left side, 95% confidence interval was 38.81 mm to 40.70 mm. On right side, 95% confidence interval was 38.46 mm to 40.65 mm. (Figure 8, 9,10)

Fig. 8: Diameter HAP- Left: histogram n=33, (mean±sd) 39.75±2.76 mm, (range) 33.50 to 46.00mm

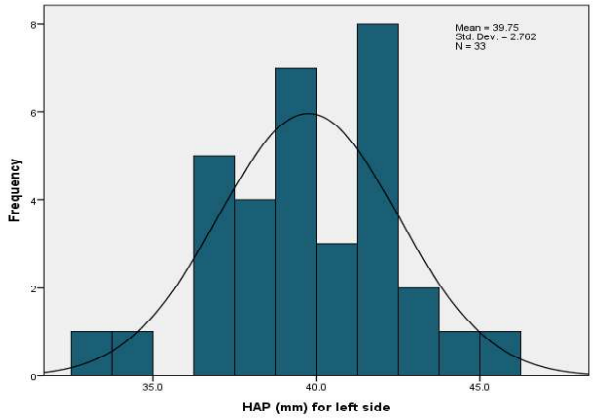


Fig. 9: Diameter HAP- Right: histogram n=34, (mean±sd) 39.55±3.20 mm, (range) 33.20 to 45.7 mm

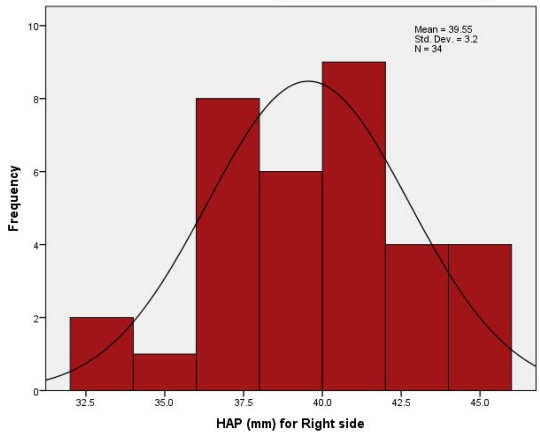
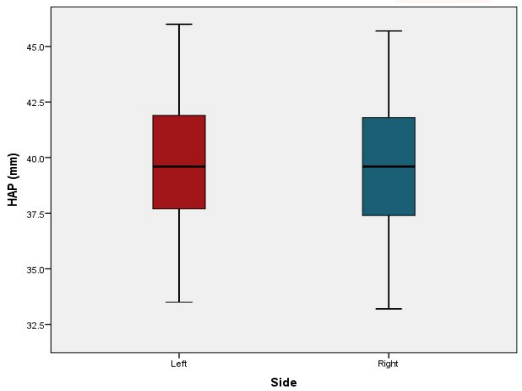


Fig. 10: Diameter HAP comparison of Left and Right sides.



Humerus head Medio-lateral diameter (HML): The mean HML on both sides was 43.11 ±3.73 mm. The mean HML on left side was 42.73 ±3.55 mm, which was 43.47 ±3.92 mm on right side. The mean HML of both sides was comparable as p-value was 0.420 (> 0.05) not significant. On left side, 95% confidence interval was 41.52 mm to 43.95 mm. On right side, 95% confidence interval was 42.13 mm to 44.82 mm (Figures 11, 12, 13)

Fig. 11: Diameter HML- Left: histogram n=33, (mean±sd) 42.73 ±3.55 mm, (range)34.50 to 50.8 mm.

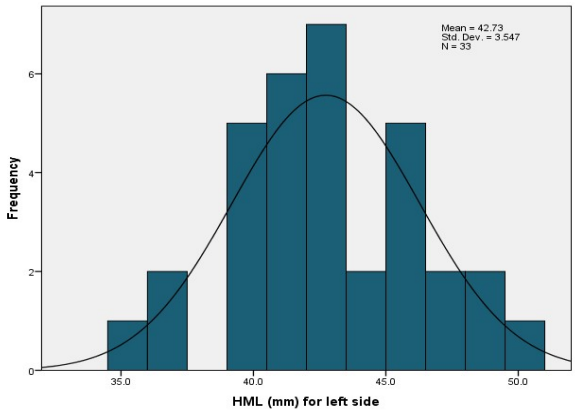


Fig. 12: Diameter HML- Right: histogram n=34, (mean±sd) 43.47±3.92 mm, (range) 36.1 to 51.0 mm.

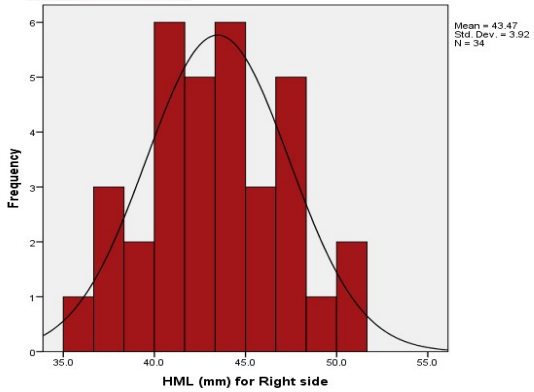
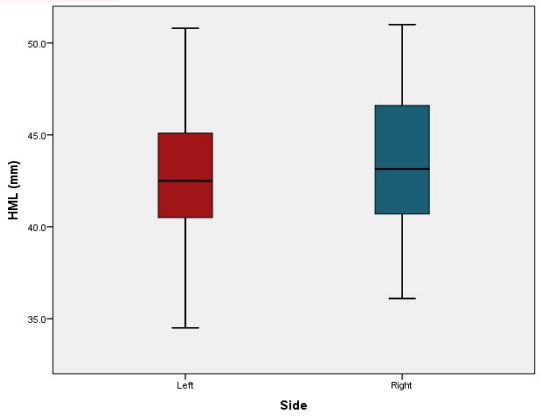


Fig. 13: Diameter HML –comparison Left and Right sides.



Humerus Version (HV): The mean HV on both sides was 37.30 ±7.85 degree. The mean HV on left side was 36.82 ±8.09 degree, which was 37.76 ±7.70 degree on right side. The mean HV of both sides was comparable as p-value was 0.626 (>0.05) not significant. On left side, 95% confidence interval was 34.04 degrees to 39.59 degrees. On right side, 95% confidence interval was 35.12 degree to 40.41 degree (Figures 14, 15, 16)

Fig. 14: HV– Left: histogram n=33, (mean ± sd) 36.82±8.08 degree, (range) 23 to 55 degree.

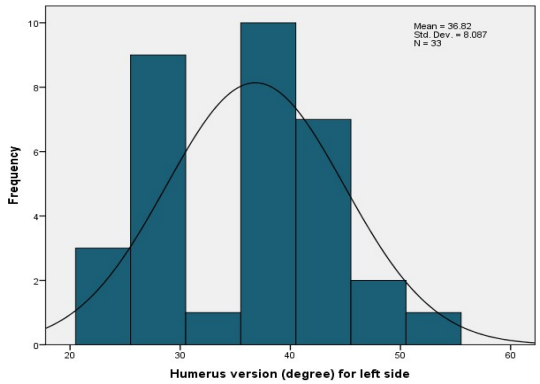


Fig. 15: HV – Right: histogram n=34, (mean±sd) 37.76±7.7 degree, (range) 20 to 55 degree.

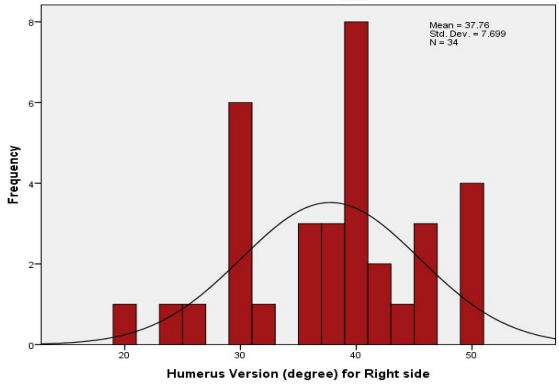
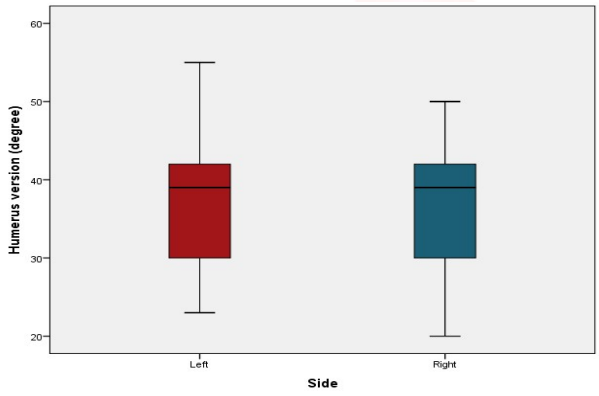


Fig. 16: HV-comparison Left and Right sides.



DISCUSSION

Our study reveals a large variation in shape, dimensions and orientation of the proximal humerus as compared to western data.[10, 11] The existing prostheses are having relatively fixed dimensions with variable modularity. Hence the restoration of normal anatomy during replacement surgery may be difficult, especially in trauma scenario. Many authors [1,2,12,13] have concluded, precision is required to match the normal anatomy for better function of shoulder. The Anatomic replacement should restore normal soft tissue tension and replicate the original position of the centre of rotation. Poor reconstruction of shoulder joint will lead to eccentric loading of the joint, increasing wear rate and prosthesis loosening. Harryman et al [13] on a cadaveric model demonstrated that all motions, including flexion, external and internal rotation, and maximum elevation, were diminished with use of the non-anatomical, large humeral head component. Similarly if the humeral head thickness is decreased by 5 mm, it may reduce range of movement by reducing the surface arc available for differential motion between the humeral head and glenoid component [14].

Smaller size head will cause point loading on the glenoid and tuberosity impingement on the acromion and on the edge of the glenoid.Variable amount of glenoid bone loss and hillsachs lesions can lead to shoulder instability. Management of these lesions and precise mapping of this defect requires knowledge of the native shoulder joint. Burkhart and De Beer [15] recognised the effect of significant bone defect of glenoid and humerus head. These engaging type of hillsachs lesion are at higher risk of recurrence if only bankart repair is done. They emphasized the importance of detecting bone defect and reported that most arthroscopic repair failures were not due to inadequate soft tissue repair. Extending the concept of Burkhart and De Beer, Itoi et al [16] put forth more objective concept of “Glenoid track.” The Glenoid track on humerus head is equivalent to 84 % of the glenoid. If the medial margin of the hillsach is more medial to glenoid track then it’s a “off track lesion.” They had categorized all the anterior instability patients on the basis of degree of glenoid bone loss and Hillsachs lesion. They advised to add remplissage surgery with glenoid procedures for all “off track lesions.” They concluded that it is essential to convert “off track hillsachs lesion” to “on track hillsachs lesion” for stability of shoulder. For this, better understanding of native anatomy and native morphology is crucial.

The sizes of Humeri & Glenoid can impact decision making during surgery for Shoulder replacement and Shoulder instability. The authors [17] have emphasized the importance of Glenoid sizes in Asian population and its impact on decision of Bankart Vs Latarjet procedure.

Similarly, the size of Humerus when correlated with size of Hill Sachs deriving a percentage bone loss on humeral side.

Hertel et al [18] studied dimensions of macerated humerus; they found difference of 12 % in the frontal and sagital plane radius. The mean diameter of head base in frontal plane was 44.5 ±4 mm and mean diameter of head base in sagital plane was 42± 3.8 mm. The mean head height was 17± 1.7 mm. The mean head height measured 71% of the radius in frontal plane. This ratio remains fairly constant. On comparison of this data with our study, the mean diameter of head in both planes HAP(39.65±2.97 mm) and HML(43.11±3.73 mm) is much smaller, however the mean head height in our study is higher (18.58±2.82 mm) than the above study. These finding have direct implication on the prosthesis designing for reconstruction of proximal humerus. They also found mean retroversion of 23.3 ±11.75 degree, which is very low as compared to our study (37.30±7.85 degree). These variations could be explained by cultural aspects of population & activities indulged by the given population. Similarly other anatomic studies [3,5,10,19] also reflect large variations in retroversion, ranging from 18 degrees to 33 degrees. It was conventional wisdom to use 30 degree as an arbitrary version for all shoulder replacements. From the analysis of our data we suggest that this figure be 40 degree of version in Indian population when intra operative version cannot be assessed – such as in comminuted fracture proximal humerus. The retroversion measured in radiologic studies show less scattering. When compared with anatomic studies, the difference is around 10 degrees. This difference between anatomic & radiological studies may be due the methodology. In radiologic study, the reference axis is epicondylar axis while in anatomic studies its anterior tangent to the trochlea. Most authors [10,18] prefer anterior tangent as it correlate with axis of forearm (related to the posterior border of humerus), which we take it as a reference during surgery.

P. Boileau and G. Walch [10] studied the three-dimensional geometry of the 65 proximal humeri on Caucasian cadaver specimens using a digitised measuring device. The head height and articular surface diameter was 15.2 ±1.6 mm and 43.3 ±4.3 mm respectively. They measured retroversion with both method using transepicondylar axis and tangent elbow axis, they found 17.9 ±13.7 degree and 21.5 ±15.1 degree respectively. They have laid emphasis on both soft tissue and bony balancing to restore normal glenohumeral kinematics and decrease abnormal eccentric loads on the glenoid component.

CONCLUSION

Our study is consistent with the finding that dimensions of Asian proximal humerus are dissimilar to the available western literature. The sizes of humerus prosthesis are based on the western literature. These sizes do not cover all the required sizes for the Asian population, especially lower sizes. The sizes are not available in current set of prosthesis. This indicates that the smaller dimensions of the proximal humerus in the Asian population may have to be contemplated while designing and fitting prosthesis in shoulder replacement. In addition based on our study the average humeral version recorded is 37.3 degree. This data is useful to compile and utilize in prosthesis designing and surgical planning.

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ABBREVIATIONS:

HH- Humerus Head height
HAP- Humerus Head Antero-posterior diameter
HML- Humerus Head Medio-lateral diameter
HV – Humeus version

Conflicts of Interests: None

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