Sex Determination from Lower End of Humerus Using Morphological Traits in Indian Population

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Abstract

One of the main objective in forensic examination is identification. In case of skeletal remains examination sex determination is one of the important parameter for identification. Here in this study lower end of humerus is studied for sex determination by morphological method. As there is difference in carrying angle between male and female, there also should be observable difference existing in lower end of humerus. Hence four morphological characteristic features of distal humerus including shape of olecranon fossa, angle of medial epicondyle, trochlear symmetry and trochlear constriction were assessed for sexual dimorphism and their accuracy in sex determination. When each of these features considered individually the result was, shape of olecranon fossa showed more accuracy (m:87%, f:69%) in sex determination and if any three of these features considered collectively accuracy in sex determination was (m:61%, f:72%).

Keywords: *Sex determination, lower end of humerus, distal humerus, morphological traits.*

Introduction

Identification is an important parameter in forensic examination of the dead and in case of skeletal remains primary parameters of identification includes age, sex, stature and race.[1] Determination of age, stature, as well as race to an extent depends on the sex of the deceased. Sex determination is a simple task in fresh bodies, but in case of severely decomposed, commingled, dismembered or skeletonized bodies, sex determination is a challenging task.[2]

In this study attempt is made to determine sex from the Humerus bone as it is one of the long bone possibly recovered in most of the forensic cases either complete or in a fragmented state. There are two methodological approaches for Sex determination from bones, morphological method and the metric method. Morphological method uses the physical visual differences expressed between males and females known as sexual dimorphism. Metric method uses differences in measurements of the traits between the sexes.[3] Pelvis and skull shows more accuracy in sex differentiation by morphology method than any other bones.[4,5] Commonly used method for sex determination in long bones is by metric method. The metric method for determining sex in humerus have been studied frequently and also yielded more accuracy results.[6-8] Morphology method of assessments are studied, but to a lesser extent. In this study lower end of humerus is chosen for sex determination as it in articulated state with ulna and radius show sexual dimorphism in carrying angle. The lateral deviation of the human forearm from the axis of the upper arm is more in females than in males (10–15 degrees in males, 20–25 degrees in females).[9,10] The differences in carrying angles between male and female imply that there may be also differences in morphology of distal end of humerus. Here in this study morphological characteristics of distal end of humerus of south Indian population is assessed for any differences exist between male and female and whether can be used for sex determination.

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Materials and Method

The samples for study included dry human humerus bones collected from dept of forensic medicine and anatomy of a medical college hospital in Madurai South India. Total number of bones collected for the study included 100 bones out of which 71 were male bones and 29 were of female bones. Bones from both the sides were included in the study

Inclusion criteria:

Only matured skeletal bones were considered

Only specimens that were healthy were chosen

Exclusion criteria: Specimens exhibiting pathology, trauma, or any type of post-mortem damage were excluded

Bones showing advanced degenerative conditions were excluded

Distal end of humerus were studied for any visual morphological variation exist in male and female bones

- Morphological features considered were
- Olecranon fossa for its variation in shape
- Medial epicondyle for its angulation
- Trochlea for its shape and symmetry
- Trochlea for its constriction

These morphological features were outlined by Rogers.[11]

Each morphological feature is assessed for its sexual dimorphism and if any distinct feature is observed, they are grouped either into male or female

If does not show distinct feature grouped into indeterminate or ambiguous

Thus Bones are categorised into distinctly male, distinctly female and indeterminate or ambiguous

Their percentage of accuracy is calculated for sex determination from each of these morphological feature or as collectively from these morphological features.

A second observer was utilised to visually asses the morphological features independently to rule out intra observer error

Observation: Considering ***olecranon fossa,*** the shape ranged from triangular (where upper half of olecranon fossa forming an apex either pointed or rounded) to oval (where upper half of fossa is curved arc like). Triangular shape was more common in male and oval shape was more common in female (fig.1)

Considering the ***angle of Medial epicondyle***, posterior edge of medial epicondyle either remains flat (i.e., remains parallel with other features of distal humerus when placed posterior surface facing upwards on a table) or it may show raised angulation. Most of the female bones did show a raised angulation whereas most of male bones medial epicondyle was flat and did not show angulation (fig.2)

Trochlear symmetry- trochlea consist of medial and lateral rim with constriction inbetween these two. If the medial rim of trochlea extends markedly downwards, it is considered asymmetrical or if extension of medial rim is slightly inferior to level of capitulum it is considered symmetrical trochlea.

Asymmetrical trochlea is common in male and trochlear symmetry is more common in female (fig.3).

Trochlear constriction: The inferior border between two rims of trochlea may show a smooth curvature or a marked midline constriction. Smooth curvature is common in male bones and marked constriction is commonly seen in female bones. (fig.3)

Statistical analysis: To establish the accuracy in sex determination from these morphological features of distal humerus statistical analysis was conducted using chi square test from the observations made from the bones. Intra observer error was also assessed using chi square test.

Results

Four indicators for sex determination from lower end of humerus were considered

Shape of olecranon fossa: Out of 100 bones 69 were triangular in shape 21 were oval in shape 10 were not able to categorise into either of the two. Out of 100 humerus 71 were male bones. Out of which 62(87.32%) showed triangular shape 1 (1.4%) show oval shape and 8(11.26%) were not able to categorise into either of the two. Out of 29 female bones 20 (68.9%) showed oval shape 7 (24.13%) showed triangular and 2 (6.9%) were not able to categorise. The chi square value was 57.0557 which was statistically significant with p value <0.05.

Angle of medial epicondyle: Out of 100 bones, in 34 bones markedly raised angulation were made out, in 56 no angulation were made out and in 10 bones it was indeterminate(which neither did show marked angulation nor flat). Out of 71 male bones 50 (70.42%) showed no angulation and 13 (18.3%) showed markedly raised angulation and 8 (11.26 %) were indeterminate. Out of 29 female bones 21 (72.41%) showed no angulation and 6(20.69%) showed markedly raised angulation and 2 (6.9%) were indeterminate. The chi square value was 27.2144 which was statistically significant with p value <0.05

Trochlear symmetry: Out of total 100 bones 25 bones showed trochlear symmetry 54 showed asymmetry and 21 were ambiguous. Out of 71 male bones 49(69.01%) showed asymmetry trochlea 8(11.26%) showed trochlear symmetry and 14 (19.7%) were ambiguous. Out of 29 female bones 5 (17.24%) showed asymmetry trochlea 17(58.62%) showed trochlear symmetry and 7(24.13%) were ambiguous. The chi square value was 28.8795 which was statistically significant with p value <0.05

Trochlear constriction: Out of total 100 bones 43bones showed trochlear constriction 46 showed no constriction and 11 were ambiguous. Out of 71 male bones 20(28.16%) showed trochlear constriction, 43(60.56%) showed no constriction in trochlea and 8(11.26%) were ambiguous. Out of 29 female bones 23(79.31%) showed trochlear constriction, 3(10.34%) showed no constriction in trochlea and 3(10.34%) were ambiguous. The chi square value was 23.8279 which was statistically significant with p value <0.05

When these morphological features are considered collectively for sex determination. The male bones satisfying all four features of male characteristics were 29 in number (41%). The female bones satisfying all four features of female characteristics were 16 in number (55%). But if any three of the features together is considered, in male bones out of 71 bones 44 (61%) were accurately identified as male and in female bones out of 29 bones 21 (72%) were accurately identified as female.

Table 1

Morphological traits		**Male (Total 71 bones)**	**Female (Total 29 bones)**	**Chi square value**
Olecranon fossa	Oval	1 (1.40%)	20(68.9%)	
	Ambiguous	8 (11.26%)	2 (6.9%)	57.0557
	Triangular	62 (87.32%)	7 (24.13%)	p value < 0.05
Medial epicondyle angle	Raised angle	13 (18.3%)	21 (72.41%	
	Intermediate	8 (11.26%)	2 (6.9%)	27.2144
	Flat	50 (70.42%)	6 (20.69%)	p value < 0.05
Trochlear symmetry	Symmetrical	8 (11.26%)	17 (58.62%)	
	Ambiguous	14(19.7%)	7 (24.13%)	28.8795
	Asymmetry	49 (69.01%)	5 (17.24%)	p value < 0.05
Trochlear constriction	Constriction present	20 (28.16%)	23 (79.31%)	
	Ambiguous	8 (11.26%)	3 (10.34%)	23.8279
	No constriction	43 (60.56%)	3 (10.34%)	p value < 0.05

Table 2: Accuracy of sex determination using morphological features from lower end of Humerus

Features	**Male**	**Female**
Olecranon fossa	87.32%	69%
Medial epicondyle angle	70.42%	72.41%
Trochlear symmetry	69.01%	58.62%

Features	Male	Female
Trochlear constriction	60.56%	79.31%
All 4 features collectively taken	41%	55%
Any 3 features combined	61%	72%

Fig. 1: Left Humerus bone is female with oval olecranon fossa and right is male with triangular shape

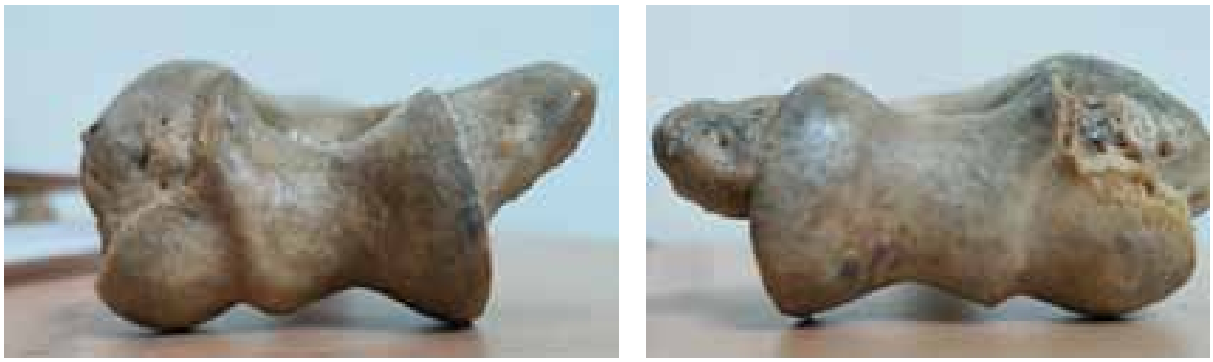
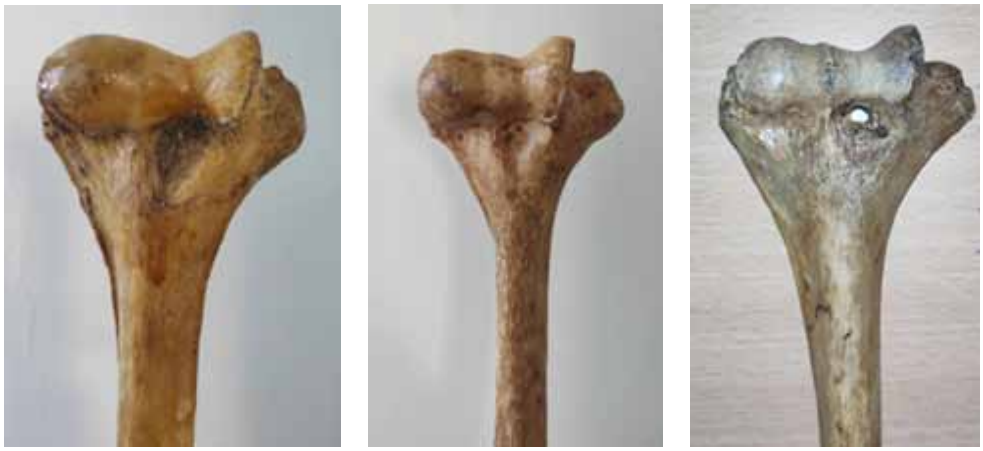


Fig. 2: Female humerus on left with raised medial epicondyle angle and on right male humerus with no angulation

Fig. 3: Left side 2 bones with trochlear asymmetry and without constriction, right side 2 bones with trochlear symmetry and constriction



4A **4B** **4C**

Fig. 4A, B, C: Different variations of capitulum and trochlea complex observed in this study.

Discussion

In this study sex determination from lower end of humerus was done using morphological method by assessing various characteristic features of lower end of humerus like shape of olecranon fossa, angulation of medial epicondyle, trochlear symmetry and constriction. As there is variation in carrying angle in male and female there should also be variation in anatomical features at the lower end of humerus. Hence variation in these morphological features were assessed for sexual dimorphism and also their accuracy in sex determination. When each of these morphological features were considered individually, on assessment of olecranon fossa shape, out of 71 male bones 62 showed triangular shape with 87.32 % accuracy and in female bones out of 29 bones 20 showed oval shape with 68.9% accuracy. In medial epicondyle 50 out of 71 male bones showed no angulation with 70.42% accuracy and 21 out of 29 bones show marked raised angulation with 72.41% accuracy. Considering trochlear symmetry 49 out of 71 male bones showed asymmetry with 69% accuracy and 17 out of 29 female bones showed symmetry with 58.62% accuracy. Considering trochlear constriction 43 out of 71 bones showed no marked constriction with 60.56% accuracy and 23 out of 29 female bones showed marked constriction with 79.31% accuracy. All were statistically significant with p value <0.05. When all these morphological features considered collectively in combination for sex determination accuracy was only 41% in male bones and 55% in female bones. When any three of these morphological features were considered for sex determination accuracy was 61% for male bones and 72% for female bones. The results obtained demonstrate that the morphological features of the lower end of humerus can be used for sex determination. Considered individually olecranon fossa shape was more accurate in sex determination followed by medial epicondyle, trochlear symmetry and trochlear constriction was less accurate compared to others at least in male bones. But when all four features combined are taken into consideration for sex determination it becomes less accurate as in only 41% of male bones showed all male characteristics, this may be due to bones satisfying all male features or all female features were less, as in many male bones trochlear constriction was unreliable. But any three of the features are taken into consideration for sex determination it was 61% for males and 72% for female bones which are statistically significant and reliable for sex determination. in study conducted by Vance et al.,[12] on south African population, when three morphological variants including olecranon fossa, medial epicondyle angle, trochlear symmetry and were used in conjunction all males were classified with a 74% accuracy rate, while all females were classified accurately 77% which is quite par with present study. Also their study showed the angle of the medial epicondyle was seen as the most accurate feature followed by olecranon fossa, but in present study it was olecranon fossa more accurate. In study conducted by Falys et al.,[13] on the documented skeletal assemblage of St. Bride's, London, showed when morphological variants considered individually

olecranon fossa was more accurate with 86.4% for male and 76.6% for female bones followed by angle of medial epicondyle 72.3% for male and 77.8% for female. Again which is quite par with present study. When considered collectively all features combined showed 72.4% in male and 80.4% in female. This was quite par when any three features taken in combination for assessing sex. But Rogers[11] study found 100% accuracy for females and 85.7% accuracy for males (average 88.6%) when using a combination of characteristics where present study is largely deviant from it.

There was also an other observation made in this study which include the shape of capitulum and trochlea complex, where in male bones they appeared in few different variations, like capitulum a large body gradually tapers and merge with trochlea where no distinction can be made out between capitulum and lateral rim of trochlea followed by marked constriction and medial rim of trochlea (*fig.4A),* other variation include capitulum is large but can be distinguished separately from lateral rim of trochlea by a smooth slight ridge formation of lateral rim of trochlea followed by smooth arched constriction from medial rim of trochlea *(fig. 4B).* In female bones this capitulum and trochlea complex where a clear distinction can be made out between capitulum and trochlea by a prominent, sharper lateral trochlear rim followed by a sharp constriction and then medial rim *(fig.4C).*

Conclusion

Sex determination using morphological variants have been done by different authors on different population but these are mainly done on western population mostly of Eurpoean and African population. As there are no any data or study on Indian population, this study was conducted and the results obtained indicate that, this morphological method of assessment of various features from lower end of humerus were statistically significant and can be used in sex determination of humerus bones.

Acknowledgements: Authors would like to thank, Prof. Dr R Sumana, Head of Dept Anatomy, Prof Dr Mahesh Krishna Head of Dept Forensic medicine, Velammal medical college hospital for providing the required bones for study.

Conflict of Interest: None

Ethical Clearance: Institutional ethical clearance taken.

Source of Funding: Self

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