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# Sex Assessment from Ulna : A New Approach

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KEY WORDS Sex Assessment. Ulna. Forensic Anthropology. Non-conventional Method.

ABSTRACT The present study varies from conventional methods and proposes alternate methods for the assessment of sex using the ulna. The present study is based on 100 male and 60 female adult ulnae from Madhya Pradesh, India. The results of different methods are reported independently and examined together. The data is then analysed using a discriminant function procedure for estimating sex. The resulting variables correctly assign sex for 99% of males and 91.7% of females. The calibrated discriminant functions correctly classified 100% of males and 88.23% of females of an independent test sameple.

## INTRODUCTION

A review of the existing literature on sex determination from various bones reveals few studies on the estimation of sex from the ulna (Krogman and Iscan, 1986).

Steel (1972) and Singh et al. (1974) contributed the results of their study on the physical dimensions of the length, midshaft circumference and width of lower end of ulna. The work related to sigmoid notch was done by Godycki (1957) and Maia Neto (1959). Oliver (1969) used maximum length, Physiological length and bone weight of fresh ulna and discriminated sex.

The methods adopted so far do not bring out results to a good predictability of sex assessment so that these could be used in the forensic field.

The approach in this work was to generate methods and studies not so far adopted and explore the possibilty of getting better predictability.

## MATERIAL AND METHODS

The study was conducted at the Medico-legal Institute Bhopal in Madhya Pradesh, India, where sets of bones are examined, classified and stored systematically in separate iron boxes.

The material for the present study comprises of 160 completely dry adult belonging to 100 males and 60 females of the residents of State of Madhya Pradesh, India. Abnormal or pathologically deformed bones were excluded from the present work.

On all the bones two conventional and two non-conventional measurements were recorded to the nearest 1/100 mm using Mitutoyo dial caliper.

### *Conventional Measurements*

Maximum length and mid-shaft circumference were recorded on each bone following the conventional techniques recommended by Bass (1971) and Martin and Saller (1957).

### *Non-Conventional Measurements*

**Olecranon-coronoid Angle :** The ulna was placed with its medial surface in contact with the board, specially designed for the purpose of measuring this angle (Fig.1). The bone was placed in such a position on the board that the point projecting most posteriorly on the styloid process 'D' touched the lateral wall of the board (Figs. 1, 2).

The thread was adjusted to lie parallel to the line joining upper lip of the olecranon process 'A' and the 'beak' of the coronoid process 'B'. The angle was measured between the lateral wall of the board as a base and the thread joining the line AB (Figs. 1, 2), extended to meet the base line. The angle was measured with a protractor.

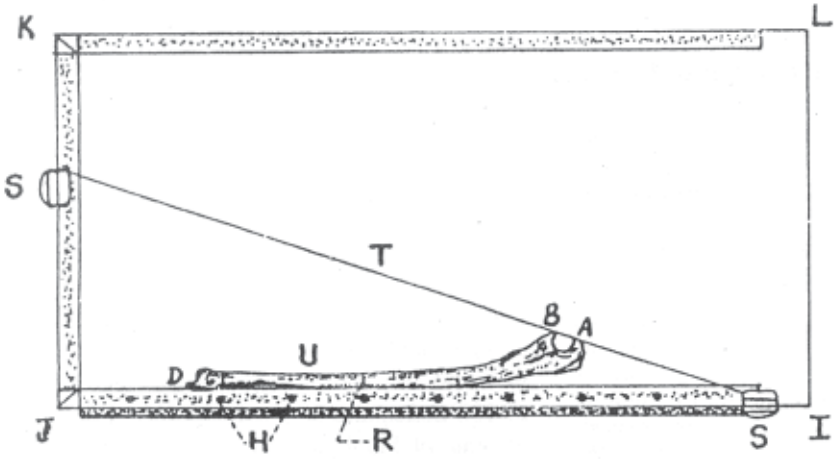



Fig - 1 (a)

**Fig. 1.** **ABCD is a rectangular board of size 50 x 30 cm. This has been provided with a side wall of 3 cm height on all the sides but for AD. The side AB has been provided with 4 mm diameter holes at 3 cm intervals - where ulna is approximated as shown in figure with the help of rubber band.**

**Fig. 1(a).** **It is a enlarged cross section view of the wall AB with a hole through which the method of passing the rubber band holding the bone is shown.**
**IJ, JK, KL = Board side walls H = Holes R = Rubber band S = Slider T = Thread U = Ulna bone W = Wooden stay.**

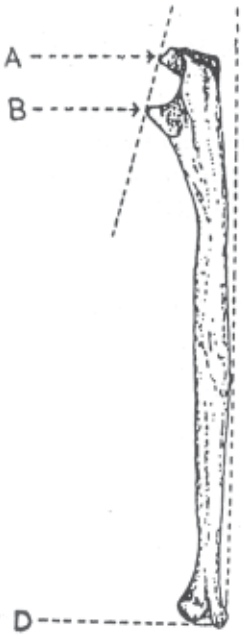


**Fig. 2.** **Left ulna viewed from lateral aspect showing olecranon-coronoid angle. The line 'AB' joins the apex of projecting 'beak' of processes, olecranon and coronoid marked 'A' and 'B', respectively. The bone is aligned with posteriomost surface of styloid process 'D' touching the horizontal side wall of the board.**

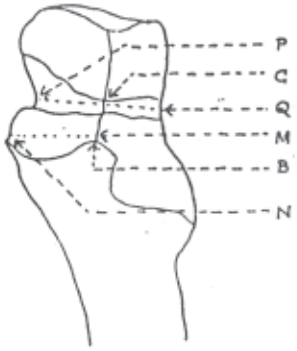


**Fig. 3.** **Outline diagram of anterior view of upper end of the left ulna - indicating the various landmarks for measurements described in the text.**

**Length and Width of Inferior Medial Trochelear Notch :** The ulna was held facing anteriorly and deepest constriction along the medial and lateral borders of the trochlear notch were labelled medially as 'P' and laterally as 'Q' as shown in figure 3. The highest point on the 'beak' of the coronoid process was labelled as 'B' and the line along the ridge from the point 'B' extending proximally to meet the line PQ at 'C' divid-

ing the coronoid articular surface into larger medial and smaller lateral part.

The length of the inferior medial trochlear notch was measured with the help of dial caliper between the point 'C' and the highest point 'B ' on coronoid 'beak'. The width was measured at right angles to the length 'MN', 'N' being the point projecting most medially on the border of trochlear notch on the 'Sublime Tubercle' and 'M' was the line drawn laterally from point 'N ' meeting the line at right angles.

Apart from the routine statistical analysis *i.e* mean, standard deviation, coefficient of variation and t-test, the data was anaysed using Scientific Subroutine Package of IBM for discriminant function analysis. To further test the efficiency of the discirminant functions derived from the previous analysis they were applied to a randomly chosen test group of 68 ulnae (34 males and 34 females), which were not part of the original sample.

## RESULTS

Table 1 presents the simple descriptive statistics of the data for the five measurements of ulna. The male ulnae exhibit greater dimensions than the female ones and the sex differences, using a t-test, are highly significant ($P<0.001$) for all the measurements, it is suggestive of the fact that all the measurements could help in discriminating the sexes.

Preliminary analysis of the data though exhibits slightly right side predominance over the left one, but the apparent bilateral differences statistically reveal non-significant variations at 5% level of significance in all the five measurements. Owing to the non-significant bilateral differences in all the measures, the bones have been pooled to assess the sex differences.

Table 2 gives the 'F' value of variance between and within sample as 20310.33 and the D-square value for discrimination as 317.6355. Table 3 presents the raw and standardized coefficients used for assigning sex. On the basis of Standardized coefficient the relative contribution of different variables (in descending order) in male are :

1. Length of inferomedial trochlear notch
2. Width of inferomedial trochlear notch
3. Olecranon-Coronoid angle
4. Maximum length
5. Midshaft circumference

and in female the order is same except for

4. Midshaft cicumference
5. Maximum length

The discriminant functions of the original sample were applied in the test. Table 4 presents the result obtained by the application of discriminant functions which rightly classified 99 out of 100 as male and 55 out of 60 as female in the original sample. In the test sample the success rate of identification of male is 100 per cent while that of the female is 88.23 per cent with an average of 94.12 per cent.

### *CONVENTIONAL MEASUREMENTS*

**Maximum Length** : To date few studies have been conducted on ulna from the point of view of sexual dimorphism. Singh et al. (1974) while studying sex difference in ulna of Varanasi region were of the opinion that maximum length was second best to weight, as judged by the number of correctly sexed bones by demarking point (12 males and no female). In the present study it is observed that the maximum length gives a significant sexual difference (Table 1). The mean maximum length of present sample (268.04 mm for male and 246.5 mm for female) when compared with ulna of Varanasi region in India (262.97 mm for male and 236.8 mm for female) shows higher value for both male and female.

**Midshaft Circumference** : Judging from the number of correctly sexed bones by demarking point (3 males and no females). Singh et al. (1974) were of the opinion that

midshaft circumference is of little value for differentiating sex. But the present study exhibit highly significant sex difference ($P<0.001$) in mid shaft circumference (Table 1). In other words it follows the general principle that in a given population or ethnic group the male bones are larger and stouter than the female. Comparison of the mid-shaft circumference with the Varanasi region reveal that the females of the present series have smaller girth of ulna while the males of the present series have slight edge over the Varanasi region males (Singh et al., 1974) 43 mm for male and 37.2 mm for female).

*NON-CONVENTIONAL MEASUREMENTS*

**Olecranon-Coronoid Angle** : In the method of measuring the olecranon-coronoid angle, we fix the posterior border and styloid process of ulna to the side wall of the ulna board (Fig. 1, 1 a) permitting the proximal end so elevated to its free position. The proximal and distal medial surfaces of the ulna lie in contact along the flat surface of the board. We have no literature on similar type of work and as such there can be no comparative discussion on the results. The result anaysed (Table 1) show high statistical significance with male exhibiting 8.26 degrees greater angle than the females.

The conventional anthropometric method (Martin and Saller, 1957; Singh and Bhasin, 1989) described for the measurement of this angle, is only different as far as the base line is concerned. In the conventional method the long axis of the ulna is extended to meet the line joining the tips of olecranon and coronoid process. For the purpose of screening we took some measurements as per conventional anthropemetric method but the results were not statistically significant and therefore we devised this non-conventional method as described and the results are highly significant.

**Length and Width of Inferior-medial Trochlear Notch** : The olecranon and coronoid process form the articular surface of trochlear notch which are actually the superior and inferior articular surfaces of trochlear notch, respectively. These are divided by a vertical ridge into medial and lateral parts. We are actually naming and concerned with the inferior medial articular facet which is the medial articular surface of coronoid process. Length and Width of inferior medial trochlear notch was measured and when test of significance was applied, it yielded highly significant differences (Table 1). Both these measurements have not been used for sexual dimorphism by earlier researchers. But it stands to logic that there is bound to be different and our expectation has been validated by our non-conventional method indicated in the result. An advantage of measuring the length and width of inferior medial trochlear notch for sex determination is that the measurements can be taken on fragmentary bone where only the upper end is available.

It is interesting to note that in the contribution of different variables, the non-conventional measurements are making a greater contrubution than conventional ones as can be judged by the absolute value of standardised coefficients (Table 3). Table 4 shows a notable differece in the relative accuracy of classifying male *versus* female bones in the same race. Specifically in the studies by DiBennardo and Taylor (1982) on American Black femora and Black's (1978) study of American Indian femora, there is consistently greater accuracy in predicting males. The present study on ulna also follows the same trend both in the original and test samples.

As mentioned earlier Singh et al. (1974) worked out a sectioning point for different variables for deciding sex. Yet the number of correct estimates judged by the sectioning

**Table 1 : Routine statistical analysis**

| *Measurements* | *Sex* | *N* | *Mean (mm)* | *S.D.* | *C.V.* | *Significance t-test* |
|---|---|---|---|---|---|---|
| Max. Length | M | 100 | 268.04 | 13.584 | 5.068 | P<0.001 |
| | F | 60 | 246.50 | 12.473 | 5.060 | |
| Mid. Circf. | M | 100 | 43.55 | 2.913 | 6.689 | P<0.001 |
| | F | 60 | 35.50 | 3.939 | 11.096 | |
| 01.-Cor. angle* | M | 100 | 22.99 | 7.675 | 33. 385 | P<0.001 |
| | F | 60 | 14.73 | 0.978 | 29.242 | |
| Length IMTN | M | 100 | 16.01 | 0.972 | 6.076 | P<0.001 |
| | F | 60 | 14.38 | 0.978 | 6.801 | |
| Width IMTN | M | 100 | 14.10 | 0.724 | 5.139 | P<0.001 |
| | F | 60 | 12.47 | 1.224 | 9.814 | |

*N = Number of bones*
*C.V. = Coefficient of Variation*
*Ol. -cor. angle = Olecreanon-coronoid angle*
** = in degrees*
*S.D. = Standard Diviation*
*Mid-circf. = Mid-shaft circumference*
*IMTN = Inferomedial Trochlear Notch*

**Table 2 : Analysis of variance of discriminant function**

| *Sources of variation* | *Degrees of Freedom* | *Sum of square* | *Mean square* | *F-value* |
|---|---|---|---|---|
| Between samples | 5 | 11752.5100 | 2350.50300 | 20310.330 |
| Within samples | 154 | 17.8222 | 0.11572 | |

Generalized Mahalanobis D-Square = 317.6335

**Table 3 : Discriminant function coefficients**

| *Variables* | *Raw coefficients* | | *Standardized coefficients* | |
|---|---|---|---|---|
| | *Male* | *Female* | *Male* | *Female* |
| Max. length | 1.44897 | 1.35955 | 0 .10666 | 0.10899 |
| Mid-cricf. | -0.09387 | -0.49048 | -0.03222 | -0.12452 |
| Ol. -cor. angle | 1.85333 | 1.38626 | 0.24147 | 0.32176 |
| Length IMTN | 5.45907 | 4.98779 | 5.61170 | 5.09790 |
| Width IMTN | -1.31277 | -0.74216 | -1.81122 | -0.60624 |
| Constant | -247.21720 | -200.31620 | | |

**Table 4 : Percentage of correct prediction for original and test sample using discriminant function**

| *Variables* | *Sample used to derive functions* | | | *Test Sample* | | |
|---|---|---|---|---|---|---|
| | *Male* | *Female* | *Average* | *Male* | *Female* | *Average* |
| | *(N = 100)* | *(N = 60)* | | *(N = 34)* | *(N = 34)* | |
| Max. Length<br>Mid- Circf<br>Ol.-Cor Angle<br>Length IMTN<br>Width IMTN | 99<br><br><br><br>(99) | 91.7<br><br><br><br>(55) | 95.33 | 100<br><br><br><br>(34) | 88.23<br><br><br><br>(30) | 94.12 |

N = Number of bones

Numbers in parentheses represent correctly predicted cases

point is very low whereas by applying discriminant function as in our sample the number of correctly sexed bones is far greater (Table 4).

Though our conclusions must be limited to the population sampled, the results show that the measurements on ulna might prove equally effective in sexing other populations as well.

## CONCLUSIONS

1. The conventional measurements, *i.e.* maximum length and midshaft circumference and the non-conventional measurements *i.e.* olecranon-coronoid angle, length and width of inferior medial trochlear notch of ulna show statistically significant sexual difference.
2. In the field of Forensic Anthropology the length and width of inferior medial trochlear notch has an additional advantage of being used in fragmentary ulna where only upper end is available.
3. The five parameters (two conventional and three non-conventional) of ulna exposed to discriminant anaysis, produced 99% accuracy for male and 91.7% accuracy for female in the original sample. The proportion of correct classification for male and female combined is 95.33%. In the test sample the discriminant coefficient classified 100% males and 88.23% females.
4. It is found that the non-conventional measurements provide better contribution towards sex discrimination than do conventional ones.

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