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ORIGINAL RESEARCH

Reconstructions Of Length Of Ulna From Its Fragments-A Pilot Study In Eastern Indian Population

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ABSTRACT

Background: In a densely populate, demographically diverse and vast country like India, the identity establishment of a dead person assumes great medico-legal importance. It also poses a true challenge to the forensic pathologist working in an environment where decomposition and taphonomic process are highly rapid and variable. One of the important pillars for identification is the stature. The estimation of age, sex and stature are vital for skeletal samples, when found from sites in mixed lot. So, a technique is urgently needed for reconstruction of total length of long bones from their fragments. This investigation was designed to estimate the total length of ulnas using its fragmentary bone length in a population specific study. In addition to this, the goal was to deploy them in stature formulae for population specific cases and lastly to estimate the stature of the individual.

Materials and Methods: After getting institutional ethical committee clearance, the study over 50 Ulna Bone revealed linear equation where total length of ulna was used as dependent variable and the different fragmentary length being the independent variables.

Results: The measurements of both sides (left and right) were grouped and noted separately but the results were pooled to obtain the regression equation. This was done because no significant difference in measurement between the left and right side in the sample of 50 ulna bones. The following Regression Equation was obtained:-

TOTAL LENGTH OF ULNA = 3.85+ 4.53QR +0.71ST +1.81PQ+0.32 TU

R SQUARED VALUE = 0.97.

Conclusion: This study was a preliminary work and a pilot project for estimating the regression equation to reconstruct the total length of ulna from its fragmentary lengths in a population specific sample (Eastern Indian population). Being population specific, it can be applied in disputed cases of identification of mutilated and fragmentary human remains of that geographic region and can be of immense help in future, especially for the law enforcement agencies in the case of mass disasters.

Keywords: Reconstruction; Ulnar Fragments; Total Ulnar Length; Anthropometry.

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INTRODUCTION

In a densely populate, demographically diverse and vast country like India, the identity establishment of a dead person assumes great medico-legal importance. It also poses a true challenge to the forensic pathologist working in an environment where decomposition and taphonomic process are highly rapid and variable. Structurally bones resist common break-down and putrefactive changes and remain longer as material for evidential value. Human skeletal remains which are found under suspicious circumstances, are needed to be examined to give an opinion in the Court of Law.

One of the important pillars for identification is the stature. The estimation of age, sex and stature are vital for skeletal samples, when found from sites in mixed lot. So, a technique is urgently needed for reconstruction of total length of long bones from their fragments.

This investigation was designed to estimate the total length of ulnas using its fragmentary bone length in a population specific study. In addition to this, the goal was to deploy them in stature formulae for population specific cases and lastly to estimate the stature of the individual.

Dismembered human body parts challenge the forensic experts in order to reconstruct the length of long bones from their fragmentary remains and has been attempted by numerous anatomists, anthropologists and forensic experts. Studies showed established methods with varying degrees of precision. Those calculations showed that the fragmentary parts show evidence of consistent ratios relative to the total length of long bones. This plays the pivotal role in the identification of individuals from their skeletal remains. Among different mathematical methods used, Regression formulae based on long bone measurements appear to be the appropriate and trustworthy method yielding consistent and accurate results.

In India unidentified dead bodies are often get mutilated by different animals. Gnawing of the skeletal remains cause the loss of structural integrity and makes identification very difficult. Bone fragments often with destroyed ends are brought for medicolegal purpose. In both forensic and anthropological practice, fragments of long bones are often presented as the only available source for identification.

Reconstruction of total length of long bones from their fragments have been published earlier on various populations. Several attempts have been made by researchers from different continents to establish authentic population related models for practical use in forensic anthropology. Studies from India are also significant in number and relevance.

Mukhopadhyay et al (2010) presented a useful insight on the stature estimation from maximum femoral length and the epicondylar breadth. The study was conducted among the Indian Bengali male's population for which the authors presented a correlation between the aforementioned parts of the bony fragments. Specimens consisted of 65 adult male human femur bones (23 taken from the right side and 42 from the left side) which were dried and ossified. Anthropometric set consisting mainly of Osteometric board and Callipers were used to take the measurements of the specimens. In this work, the maximum length had been defined as the distance between the highest point on the head of the femur to the lowest point on the distal condyles. The epicondylar breadth has been defined as the distance between the two most laterally projecting points on the epicondyles. Software used in this study was the SPSS statistical software for windows 10. The regression equation obtained was $y=7.02 + 4.83x$, where the dependent variable (x) is the epicondylar breadth (cm) and the independent variable (y) is the maximum femoral length(feet). 95% confidence interval with a p-value of less than

0.001 was obtained with Pearson's coefficient of 0.85, a standard error of 1.68 and R squared value of 0.722. The mean value of femoral length and the epicondylar breadth were found to be 41.82 and 7.16 respectively. A correlation was done between the epicondylar breadth and the maximum femoral length. Regression equation was obtained using the epicondylar breadth as the independent variable and the maximum length of femur as dependent variable with a total sample (N=65). The Multiplying factor of 3.82 was used after suitable conversion of the units. From the above measurements it was seen that the maximum length of the femur correlated well with the Epicondylar breadth.[1]

Shende M.R and Parekh N.A.J, in their study tried to reconstruct the total length of ulna from its fragments and its medicolegal perspectives. Here 145 random normal ulna bones were collected from the dissection halls of various colleges of Nagpur. The total length of ulna was measured using osteometric board and further analysis was done using the studies of Muller and Steel. The total length of ulna was divided into 9 segments and measurements were taken up to nearest millimetres. The mean, SD and coefficient of variation were calculated. The results showed that the segment g-h (the point of maximum convexity along the proximal part of interosseous border where supinator crest approaches closure to it to the point of A-P minimum cross-sectional diameter at the lower end) contributed to average of 58.48%; and a-b segment(the most proximal point on top of olecranon process to the point at the tip of olecranon on its ventral aspect) upto 2.41%.The confidence interval was 95% for this work. As per guidelines of Nat.B.S (1931), the multiplication factor for calculating total height from ulna is 6.3.[2]

Significant effort had also been put on the value of radius bone in prediction of sex and height in the Iranian population by Mitra Akhlaghi, et al. The study was conducted on 106 (61 male, 57 female) cadavers of Iranian population. The total length of the cadaver was measured. Along with it, the maximum length of radius and ulna were measured. Statistical analysis was done using SPSS software version. P value of 65 years old. The mean age of individual was 39.19 yrs. age (female=41.27; male=37.66). According to the regression test, there was a statistically significant (p =0.00) relation between the height of persons and the length of radius bone. The following equation was obtained to estimate the height on the basis of length of radius bone: Height (cm) = 74:79 + [3:91x the length of radius (cm)]. With the help of the above equation the stature and sex can be determined.[3]

A study conducted by Abhisekh Karn, et al, determined the stature from length of ulna in Nepalese population. The study was carried out in 600 (330 males;270 females) randomly selected asymptomatic, healthy living Nepalese of age group of 25-40 years . The height of the individual was measured (in centimetres) in standing anatomical position with bare foot and head in Frankfurt's plane from crown to heel with Standard Height measuring instrument. Right and left ulnar length were measured separately (in centimetres) from the apex of the olecranon to the styloid process with the elbow in full flexion and palm spread over opposite shoulder with spreading calliper. Statistical analysis was done using SPSS 12 software. The mean heights was 163.50 cm, with a standard deviation of 7.35. The mean values of the left and the right ulnar lengths in males and females were calculated as 27.20 cm (SD = 1.18) and 23.67 cm (SD = 1.17) respectively. Regression analysis was carried out to find the relationship of ulnar length with body height. The association between ulnar length and body height was found to be positive. Two-tailed Student's t-test was used for correlation, and was found to be strongly significant.[4]

Agreement between measured height, and height predicted from ulna length, in adult patients in Bloemfontein, South African population was done by Louise van den Berg, et al. The study was conducted on 226 subjects of age group between 20-60 yrs. Ulna measurement was done using anthropometric tape. The following equations were obtained: Males: Predicted height (cm) = 79.2 + [3.60 x ulna length (cm)]; Females: Predicted height (cm) = 95.6 + [2.77 x ulna length (cm)]. The median height estimated from ulna length (170.2 cm; range: 154.2– 213.0 cm) was statistically significant (95% CI) longer than the median reference height (163.9 cm; range: 145.1–188. Median BMI based on estimated height (20.1 kg/m2) was significantly (95% CI [–1.9; –1.6]) lower than median BMI calculated from reference height (21.8 kg/m2).[5]

MATERIALS & METHODS

After getting the clearance from the institutional ethical committee, examination and measurements of all the fully ossified, dried and processed ulnar bones (50 in number from the Departmental Archive of Forensic Medicine, Burdwan Medical College, Burdwan for the teaching programme of undergraduate and postgraduate students (museum specimens) were done to conduct a Cross-sectional study. Using Anthropometric set consisting of Osteometric Board, Electronic Digital calliper, measuring tape, flexible tape, Dusting brush, Pencil, OHP Marker, standard prepared master charts for data recording. All the 50 Ulna were arbitrarily divided into different fragments by taking important anatomical landmarks on the bones, on the basis of their morphological characters. Measurements were taken using anthropometric set consisting mainly of Osteometric Board and Electronic Digital Callipers. The author along with other three observers took four readings, and the mean value of these readings was recorded to minimize the inter-observer biasness. Record was taken in centimetre (cm.) and the measurement was up to one decimal place (nearest millimetre).

The maximum length of the ulna was the distance measured from the highest point of the olecranon process of ulna to the distal tip of ulnar styloid process, with the help of an Osteometric board. The tip of the styloid process was placed against the vertical end-board while applying the movable upright to the olecranon process of ulna. The different fragments were measured by the electronic digital calliper.

The measurements obtained were initially inserted in the excel sheets and were later analyzed using SPSS Statistical software for windows version 10.0. Metric data was reported as Mean, Standard deviation, Median and 95% confidence interval. P value of <0.05 was taken as significant Pearson's correlation to examine the association between the total lengths of humerus and their fragmentary lengths.

After finding a positive correlation between length of ulna and their respective fragments, Regression equation was obtained for the humerus with the fragmentary lengths as the independent variable and the maximum length as the dependent variable, using the total sample (N= 50 Ulna).

The ulnar bone was divided into 6 segments where measurements were taken from the pre-determined anatomical points which are as follows:-

1. p= Highest point of olecranon process
2. q=Highest point of trochlear notch
3. r=Highest point of radial notch
4. s=Distal part of coronoid process
5. t= Midpoint of interosseus crest
6. u= Distal tip of ulnar styloid.

The measurements of ulna were done following under mentioned criteria--

Inclusion Criteria: Fully ossified, dried, processed ulnar bones (50in numberof both sides, irrespective of age, sex and race.

Exclusion Criteria: Unossified bones, bones with apparent disease or injury.

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RESULTS

Table 1: Descriptive Statistics of Ulna, Showing Its Total Length and Individual Lengths of Its Five Fragments

Descriptive Statistics ULNA							
	N	**Range**	**Minimum**	**Maximum**	**Mean**		**Std. Deviation**
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**
Total Length	50	10.70	21.30	32.00	25.0560	.27828	1.96771
p to q	50	.50	.40	.90	.5400	.01807	.12778
q to r	50	1.10	1.50	2.60	2.0380	.03294	.23290
r to s	50	.40	.30	.70	.4860	.01738	.12291
s to t	50	5.70	9.20	14.90	10.5820	.12645	.89413
t to u	50	3.80	9.00	12.80	10.8120	.11772	.83241
Valid N (listwise)	50						

Table 1 shows the descriptive statistics of the ulna showing their total lengths and the individual fragmentary lengths of all the 50 ulna (n=50) in my study. The mean value of ulnar length was 25.0560 and the mean values of each of the segments are noted in the said table.

Table 2: The Correlations of the Total Length and Five Fragmentary Segments of the Ulna with Its Proximal Four Segments (i.e. p to q, q to r, r to s and s to t)

Correlations						
		Total Length	p to q	q to r	r to s	s to t
Pearson Correlation	Total Length	1.000	.466	.952	.215	.898
	p to q	.466	1.000	.352	.166	.287
	q to r	.952	.352	1.000	.219	.806
	r to s	.215	.166	.219	1.000	.113
	s to t	.898	.287	.806	.113	1.000
	t to u	.902	.489	.837	.191	.804
Sig. (1-tailed)	Total Length	.	.000	.000	.067	.000
	p to q	.000	.	.006	.124	.022
	q to r	.000	.006	.	.064	.000
	r to s	.067	.124	.064	.	.218
	s to t	.000	.022	.000	.218	.
	t to u	.000	.000	.000	.092	.000
N	Total Length	50	50	50	50	50
	p to q	50	50	50	50	50
	q to r	50	50	50	50	50
	r to s	50	50	50	50	50

	s to t	50	50	50	50	50
	t to u	50	50	50	50	50

Table 2 depicts the Correlations of the total length of ulna and all its five fragmentary lengths with their proximal four segments.

Table 3: The Correlations of the Total Length and Five Fragmentary Segments of the Ulna with Its Distal Segment (i.e. t to u)

Correlations		
		t to u
Pearson Correlation	Total Length	.902
	p to q	.489
	q to r	.837
	r to s	.191
	s to t	.804
	t to u	1.000
Sig. (1-tailed)	Total Length	.000
	p to q	.000
	q to r	.000
	r to s	.092
	s to t	.000
	t to u	.
N	Total Length	50
	p to q	50
	q to r	50
	r to s	50
	s to t	50
	t to u	50

Table 3 depicts the Correlations of the total length of ulna and all its five fragmentary lengths with its distal segment, i.e. (t to u).

Table 4: Model Summary Depicting the R-Squared Values and Standard Error of Estimate of the Different Ulnar Fragments

Model Summary[e]					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	.952[a]	.906	.904	.60965	
2	.977[b]	.955	.953	.42689	
3	.987[c]	.974	.972	.32799	
4	.989[d]	.978	.976	.30607	2.231

Table 4 shows the Model Summary of the ulnar measurements depicting the R Squared values and standard errors of estimate of the different ulnar fragments. The Durbin-Watson statistic is

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mentioned in the last column (2.231).This indicates that there is no autocorrelation in the residuals from this statistical regression analysis, since the value is greater than 2.

Table 5: Standardised Coefficients and Correlations of the Total Length with the Different Fragmentary Lengths of the Ulna

Coefficients[a]							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations
		B	Std. Error	Beta			Zero-order
1	(Constant)	8.667	.767		11.300	.000	
	q to r	8.042	.374	.952	21.505	.000	.952
2	(Constant)	5.152	.729		7.069	.000	
	q to r	5.498	.442	.651	12.428	.000	.952
	s to t	.822	.115	.374	7.134	.000	.898
3	(Constant)	4.831	.563		8.586	.000	
	q to r	5.067	.348	.600	14.562	.000	.952
	s to t	.819	.089	.372	9.256	.000	.898
	p to q	2.272	.392	.148	5.798	.000	.466
4	(Constant)	3.855	.631		6.113	.000	
	q to r	4.536	.376	.537	12.064	.000	.952
	s to t	.710	.091	.322	7.760	.000	.898
	p to q	1.813	.401	.118	4.522	.000	.466
	t to u	.321	.115	.136	2.798	.008	.902

Table 5 highlights the standardized coefficients and correlations of the total length with the different fragmentary lengths of the ulna.

Table 6: Standardised Coefficients Showing the Correlations, Tolerance and VIF (Variance Inflation Factor) Of the Total Length with Different Fragmentary Lengths of the Ulna To Detect The Severity Of Multi-Collinearity In The OLS Regresion Analysis

Coefficients[a]					
Model		Correlations			
		Partial	Part	Tolerance	VIF
1	(Constant)				
	q to r	.952	.952	1.000	1.000
2	(Constant)				
	q to r	.876	.385	.350	2.854
	s to t	.721	.221	.350	2.854
3	(Constant)				
	q to r	.906	.347	.334	2.991
	s to t	.807	.220	.350	2.854
	p to q	.650	.138	.876	1.142
4	(Constant)				
	q to r	.874	.268	.249	4.011
	s to t	.757	.172	.286	3.498
	p to q	.559	.100	.729	1.372
	t to u	.385	.062	.210	4.763

a. Dependent Variable: TOTAL LENGTH

Table 6 tabulates the standardized coefficients showing the correlations, tolerance and VIF (Variance Inflation Factor) of the total length with the different fragmentary lengths of ulna to detect the severity of multi-collinearity in the Ordinary Least Squares Regression Analysis.

Table 7: Collinearity Diagnostics Showing the Variance Proportions of Three Ulnar Segments (i.e. p to q, q to r and s to t)

Collinearity Diagnostics[a]							
Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	q to r	s to t	p to q
1	1	1.994	1.000	.00	.00		
	2	.006	17.735	1.00	1.00		

2	1	2.992	1.000	.00	.00	.00	
	2	.006	21.545	.62	.28	.01	
	3	.002	43.309	.38	.72	.99	
3	1	3.957	1.000	.00	.00	.00	.00
	2	.035	10.624	.02	.01	.01	.98
	3	.006	24.918	.59	.28	.01	.01
	4	.002	49.965	.39	.71	.99	.01
4	1	4.955	1.000	.00	.00	.00	.00
	2	.036	11.696	.01	.00	.00	.84
	3	.006	27.867	.42	.20	.01	.01
	4	.002	55.882	.29	.56	.77	.00
	5	.001	72.791	.28	.23	.22	.15

Table 7 depicts the Collinearity Diagnostics showing the variance proportion of the three ulnar fragments; i.e. (p to q), (q to r) and (s to t).

TABLE 8: Collinearity Diagnostics Showing the Variance Proportion of One Ulnar Segment (i.e. t to u)

Collinearity Diagnostics[a]		
Model	Dimension	Variance Proportions
		t to u
1	1	
	2	
2	1	
	2	
	3	
3	1	
	2	
	3	
	4	
4	1	.00
	2	.00
	3	.00

	4	.00
	5	1.00

a. Dependent Variable: TOTAL LENGTH

Table 8 highlights the Collinearity Diagnostics showing the variance proportion of one ulnar fragment; i.e. (t to u).

TABLE 9: Residual Statistics Showing the Mean and Standard Deviation According To Valued Measures of the Ulnar Fragments

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	21.0520	31.5975	25.0560	1.94573	50
Std. Predicted Value	-2.058	3.362	.000	1.000	50
Standard Error of Predicted Value	.051	.253	.092	.031	50
Adjusted Predicted Value	21.0010	30.7191	25.0367	1.89185	50
Residual	-.75954	.96145	.00000	.29331	50
Std. Residual	-2.482	3.141	.000	.958	50
Stud. Residual	-2.591	3.203	.023	1.040	50
Deleted Residual	-.82807	1.28088	.01932	.36535	50
Stud. Deleted Residual	-2.778	3.605	.031	1.094	50
Mahal. Distance	.382	32.623	3.920	4.672	50
Cook's Distance	.000	2.402	.068	.341	50
Centered Leverage Value	.008	.666	.080	.095	50

a. Dependent Variable: TOTAL LENGTH

Table 9 shows the Residual Statistics showing the mean and standard deviation, according to valued measures of the ulnar fragments

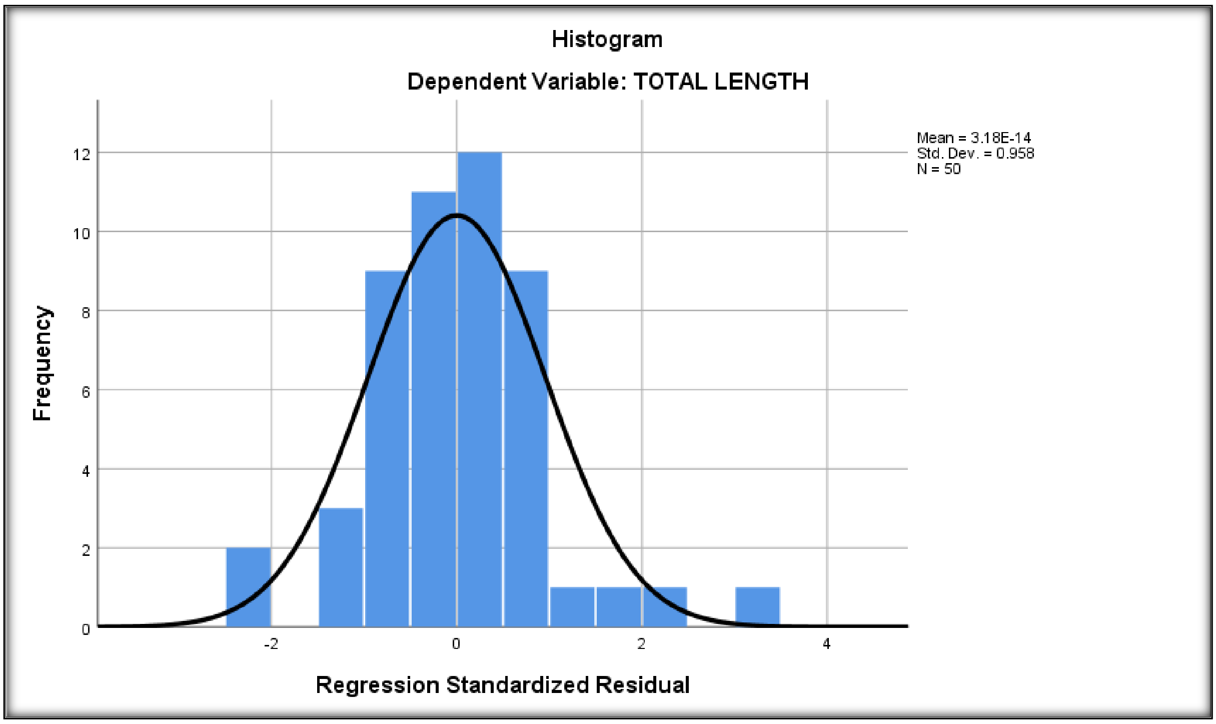

FIGURE 1: HISTOGRAM DEPICTING THE FREQUENCY OF THE SEGMENTAL LENGTHS AGAINST THE REGRESSION STANDARDISED RESIDUAL OF ULNA

Figure 1 portrays the Histogram showing the frequency of the different segmental/fragmentary lengths of ulna against their regression standardized residuals. The curve shows an almost normal distribution curve, with the mean=3.186 and standard deviation of 0.958 with the sample size 50 in number. The graph clearly demonstrates that most of the measurements fell within +/- 2 SD confidence intervals, thereby indicating a statistically significant and accurate measurement.

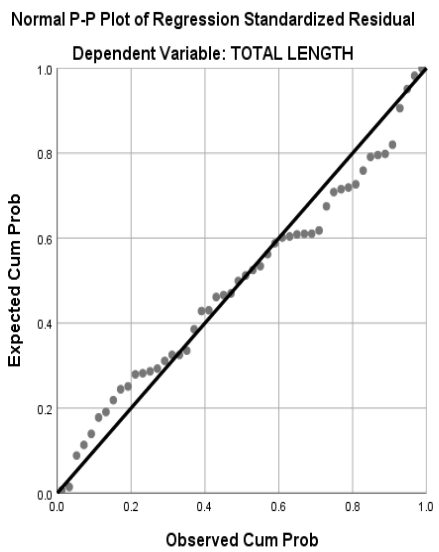

FIGURE 2: NORMAL PROBABILITY PLOT SHOWING EXPECTED CUMLATIVE PROBABILITY VERSUS OBSERVED CUMULATIVE PROBABILITY OF THE DIFFERENT ULNAR FRAGMENTS

Figure 2 illustrates the Normal Probability Plot showing expected cumulative probability versus observed probability of the different ulnar fragments; with the total radial length as the dependent variable. The points are found distributed along a straight line (y = mx + c) indicating a satisfactory degree of correlation amongst the different ulnar fragments.

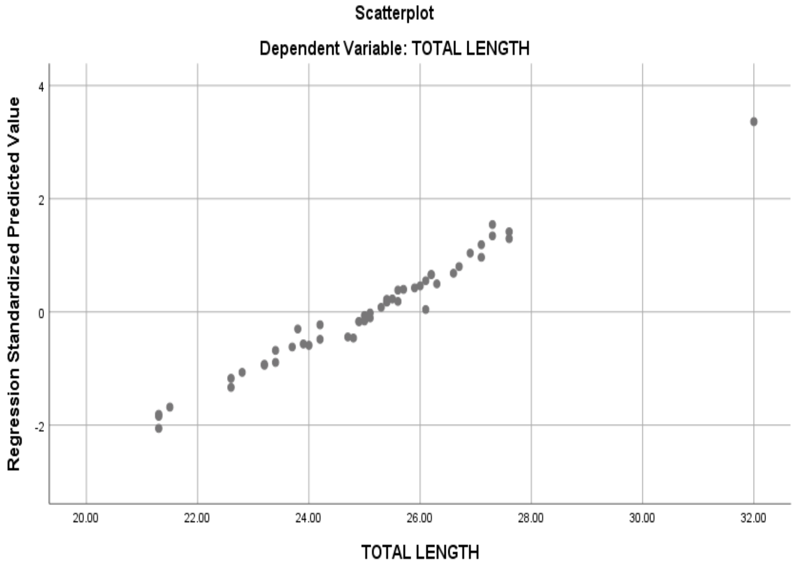

FIGURE 3: SCATTER PLOT DEPICTING THE REGRESSION STANDARDISED PREDICTED VALUES OF THE DIFFERENT FRAGMENTARY LENGTHS AGAINST THE TOTAL LENGTH OF ULNA

Figure 3 portrays the Scatter plot depicting the regression standardized predicted values of the different fragmentary lengths against the total length of the ulna. This figure also shows the clustering of the different plots along a straight line.

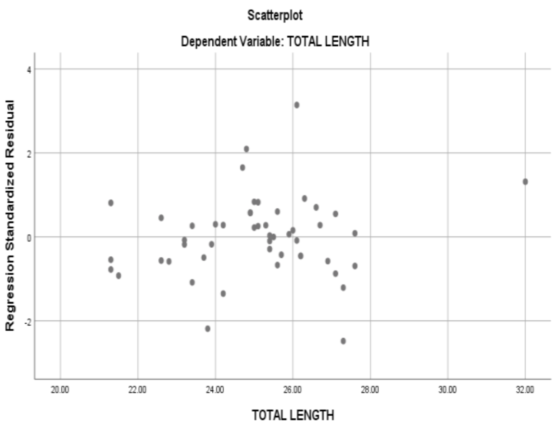

FIGURE 4: SCATTER PLOT DEPICTING THE REGRESSION STANDARDISED RESIDUAL OF THE DIFFERENT FRAGMENTARY LENGTHS AGAINST THE TOTAL LENGTH OF ULNA

Figure 4 portrays the Scatter plot depicting the regression standardized residual of the different fragmentary lengths against the total length of the ulna

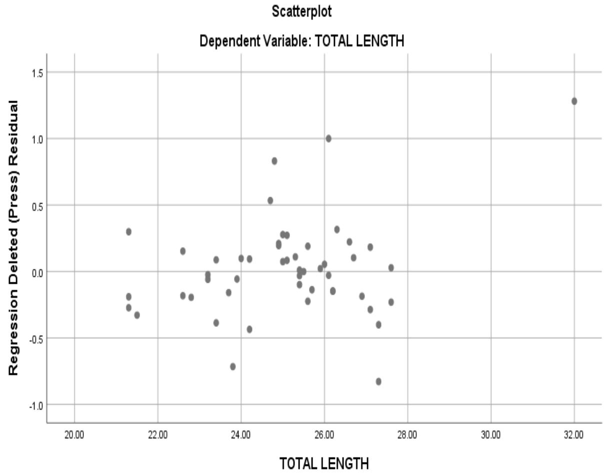

FIGURE 5: SCATTER PLOT DEPICTING THE REGRESSION DELETEDRESIDUAL OF THE DIFFERENT FRAGMENTARY LENGTHS AGAINST THE TOTAL LENGTH OF ULNA

Figure 5 shows the Scatter plot depicting the regression deleted (PRESS) residual of the different fragmentary lengths against the total length of the ulna. The Predicted Residual Error Sum of Squares (PRESS) statistic is a form of cross-validation which was used in this regression analysis to provide a summary measure of the fit of this model to the sample of observations, derived from the 50 ulnar measurements.

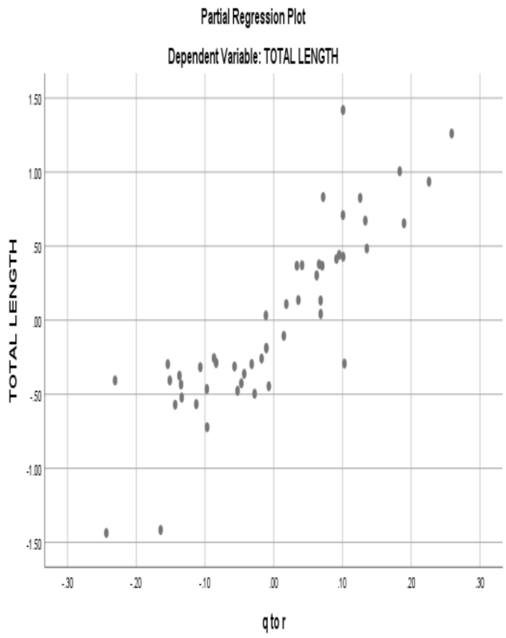

FIGURE 6: PARTIAL REGRESSION PLOT

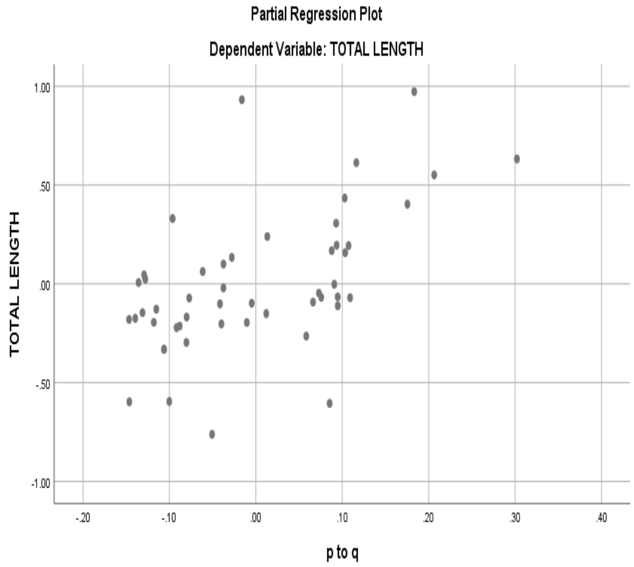

FIGURE 7: PARTIAL REGRESSION PLOT

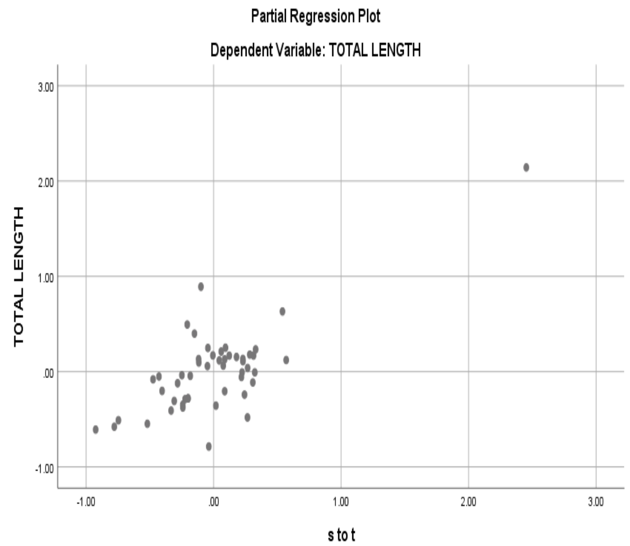

FIGURE 8: PARTIAL REGRESSION PLOT

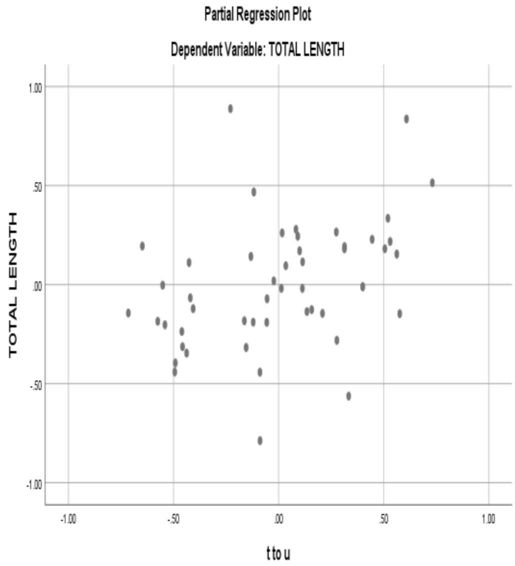

FIGURE 9: PARTIAL REGRESSION PLOT

Figures 6 to 9 demonstrates the partial regression plots showing the relationship between the different fragmentary/segmental lengths and the total length of the ulna. From these plots it is relevant that the segment (q to r) bears a better linear representation compared to the other segments; thus statistically this segment is more significant.

SL NO.	SIDE	TOTAL LENGTH	p to q	q to r	r to s	s to t	t to u
1	L	22.6	0.6	1.7	0.4	9.3	10
2	R	22.8	0.6	1.8	0.5	9.3	10.2
3	L	21.3	0.5	1.6	0.3	9.3	9.1
4	R	23.7	0.4	1.9	0.6	10.4	10.2
5	R	21.3	0.5	1.5	0.4	9.3	9
6	L	21.3	0.5	1.6	0.3	9.2	9.1
7	R	26.1	0.6	2.2	0.7	10.5	11.7
8	R	25.9	0.5	2.2	0.6	10.5	11.5
9	L	23.9	0.4	1.9	0.7	10.5	10.3
10	R	26.7	0.7	2.3	0.7	10.7	10.8
11	R	27.1	0.6	2.2	0.3	11.5	12
12	R	21.5	0.5	1.6	0.3	9.6	9.2
13	R	32	0.7	2.6	0.6	14.9	12.8
14	L	26.3	0.5	2.1	0.3	11.2	11.8
15	L	27.3	0.7	2.3	0.3	11.6	12.1
16	L	24.8	0.8	1.8	0.5	10	11.2
17	R	24.9	0.8	1.9	0.6	10.2	11.1
18	L	24.2	0.4	2	0.4	10.7	10.5
19	L	23.2	0.4	1.8	0.5	10.2	10.1
20	R	25.4	0.6	2.1	0.5	10.7	10.5

21	L	23.2	0.4	1.8	0.5	10.2	10.2
22	L	25.4	0.6	2.1	0.5	10.6	10.6
23	L	26.2	0.5	2.2	0.3	11.1	11.6
24	R	26	0.6	2.2	0.7	10.3	11.6
25	R	27.6	0.7	2.3	0.5	11.8	12.1
26	R	26.1	0.5	2.1	0.5	10.5	10.6
27	L	24.2	0.4	1.9	0.4	10.5	10.8
28	R	25.5	0.6	2.1	0.5	10.8	10.5
29	L	26.2	0.5	2.2	0.4	11.1	11.6
30	L	25	0.4	2.1	0.4	10.6	10.3
31	R	25.1	0.4	2.1	0.5	10.3	10.7
32	L	25.4	0.5	2.2	0.6	10.4	10.5
33	L	24.9	0.4	2.1	0.4	10.4	10.1
34	L	24.7	0.4	2	0.4	10.2	10.3
35	L	25.6	0.6	2.2	0.6	10.5	10.7
36	R	25	0.4	2.1	0.4	10.2	10.6
37	R	23.4	0.4	1.8	0.6	10.2	10.4
38	L	25.7	0.5	2.2	0.6	10.7	10.9
39	L	26.9	0.6	2.3	0.6	11.2	11.7
40	R	24	0.4	1.9	0.4	10.3	10.6
41	R	27.3	0.7	2.4	0.3	11.6	11.9
42	R	27.6	0.7	2.3	0.5	11.6	11.8
43	R	25.1	0.4	2.1	0.4	10.5	10.8
44	R	27.1	0.7	2.3	0.4	11.4	11.6
45	R	23.4	0.4	1.8	0.6	10.6	10.8
46	R	23.8	0.5	1.9	0.6	10.7	10.9
47	L	26.6	0.6	2.2	0.6	11	11.4
48	L	25.3	0.9	2	0.6	10	11.1
49	R	25.6	0.5	2.1	0.6	10.8	10.8
50	R	22.6	0.5	1.8	0.4	9.4	9.9

Regression equation with the ulnar fragments as the independent variable and the total length of the ulna as the dependent variable was obtained using the total sample (N=50). The measurements obtained were analysed by SPSS Statistical Software for Windows Version 10.0. P value of less than 0.05 was considered significant, and 95 % confidence intervals were employed in this study. Pearson's correlation was used to study the degree of association between the total ulnar length and their individual fragmentary lengths. The predicted cum observed lengths were calculated (as plotted in Figure 19) and they almost tallied and thus the results proved accurate and consistent. The fragment (r to s) was intentionally discarded, since the measurements were found statistically insignificant.

The measurements of both sides (left and right) were grouped and noted separately but the results were pooled to obtain the regression equation. This was done because no significant difference in measurement between the left and right side in the sample of 50 ulna bones.

The following Regression Equation was obtained;-

TOTAL LENGTH OF ULNA = 3.85+ 4.53QR +0.71ST +1.81PQ+0.32 TU

R SQUARED VALUE = 0.97

DISCUSSION

The current study was endeavoured to reconstruct the total length of ulna from their fragmentary lengths. In this study, the ulna was arbitrarily divided into 5 segments and the aim of the study was to reconstruct the total length of ulna from its fragmentary lengths and to derive a regression formula. So the objective of the study differed from Shende's study[2] .Above noted figures demonstrated the partial regression plots showing the relationship between the segmental length(q-r) and the total length of the ulna; it is relevant that the segment (q to r) bears a better linear representation compared to the other segments; thus statistically this segment was more significant in the present study.

The current study also differed from the above-mentioned study of Abhisekh Karn et al[4] since it was conducted on dried and ossified ulna (50 in number) and the objective of the current study was to ascertain the total length of ulna from its different fragmentary lengths. Current study showed that the mean value of total ulnar length was 25.0560; the minimum was 21.30 and the maximum was 32.00. The standard deviation was 1.9677 and the standard error of estimate was 0.278. In addition, the R-Squared values and standard error of estimates of the different ulnar fragments showed good statistical significance and precision.

Louise van den Berg et al[5] conducted a study on 226 adult subjects of age group between 20- 60 years in Bloemfontein over a South African population. Ulna measurement was done using anthropometric tape. He derived equations for predicting median height of the subjects from ulnar lengths. He also compared the median BMI based on estimated height with that calculated from reference height. However since the present study was confined to the anthropometric measurements over 50 dried and ossified ulna bones but not over living subjects, so estimation of BMI cannot be the objective of the current study. Further the aim of current study was reconstruction of total ulnar length from the fragmentary lengths and not estimation of stature from total ulnar length.

This study was a preliminary work and a pilot project for estimating the regression equation to reconstruct the total length of ulna from its fragmentary lengths in a population specific sample (Eastern Indian population). Being population specific, it can be applied in disputed cases of identification of mutilated and fragmentary human remains of that geographic region and can be of immense help in future, especially for the law enforcement agencies in the case of mass disasters.

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CONCLUSION

This study was a preliminary work and a pilot project for estimating the regression equation to reconstruct the total length of ulna from its fragmentary lengths in a population specific sample (Eastern Indian population). Being population specific, it can be applied in disputed cases of identification of mutilated and fragmentary human remains of that geographic region and can be of immense help in future, especially for the law enforcement agencies in the case of mass disasters.

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