

Original Research Article

Relationship of Anatomical Lengths of Forearm plus Hand to the Length of Femur in Healthy Subjects

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Abstract

The commonest procedure for adult diaphyseal femoral fractures is intramedullary nailing. A thorough preoperative examination of fracture pattern and its morphology are necessary. Previous studies are non-homogenous and with conflicting results. So the study was planned to find out, any relation between femur and forearm plus little finger length and its association with height/ arm span and upper segment/lower segment ratios in an individual, with its statistical validity. The study was carried on 75 male and 75 female students of more than 18 years of age, studying at AIIMS Rishikesh after taking their informed consent and ethical approval. The forearm plus hand length and the length of femur were measured as per protocol, by simple measuring tape. The mean forearm plus hand length and the length of femur were 42.85 (SD, ± 1.87) and 45.88 (SD, ± 2.95) cm, respectively with the mean difference between these 2 measurements of -3.03 (95% CI, -3.83 to -2.22) cm, in male and 39.56 (SD, ± 1.68), 40.96 (SD, ± 2.75) cm and -1.400 (95% CI, -1.917 to -0.883) cm in female volunteers. The Pearson correlation coefficient and p value 0.575, 0.0001 and 0.585, 0.0001 in male and female respectively. There was no significant variation with height, upper segment and lower segment ratios. So we conclude that there is extremely significant correlation between the forearm plus hand length and the length of femur of the individuals. The forearm plus hand length represents the maximum length of the nail to be used in femur. The length of the femur nail can be definitely predicted by the forearm plus hand length in both sexes but it has to be different in both, for the same femoral fracture and there is no significant variation in the femur length with height, upper segment and lower segment variation in the same individual.

Keywords: femur, forearm, healthy, individual, intramedullary nailing, sex, volunteers

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Introduction

The commonest procedure for adult diaphyseal femoral fractures is intramedullary nailing (1,2). A thorough preoperative examination of fracture pattern, comminution, extension of the fracture, length of femur and morphology is important (1-3). Previous studies have also described several methods to find out the approximate length of nail for the fractures of the femur (1,4-9). Measurement of the femur on the unaffected limb may provide a rough estimate of the length of the nail to be used, but it has its limitation in

obese patients (1). The problem can be solved by the use of radiographs but it has its own disadvantages like radiation exposure and radiological magnification which will lead to inaccuracy (4,8). Apart from this, use of a nail template, radio-opaque ruler, or Kuntscher ossimeter are the other described ways to measure the length of the nail of the femur (7-9). There is requirement of intact contralateral femur in all of these described methods. In fractures of femur of both sides, less damaged femur is taken for measurement (1,4). One can use the measurement of the forearm plus hand length as an alternative means to

determine the length of nail for femoral shaft fractures (5).

The commonest way described for the preoperative estimation of the length of nail for femoral shaft fractures is the measurement of length from tip of olecranon to tip of little finger. But there are few published studies measuring the validity of this measurement. The methods used in these studies are non-homogenous and the findings are conflicting. Also this measurement will depend upon relative lengths of the upper and lower limb (limb span and height ratio). Thus, we would correlate the femoral nail length estimate with forearm plus hand at the same time correlate the validity of these measurements with the stature of the patients (height, limb span, upper and lower body segment ratios).

Materials and Methods

The study was conducted on 150 students (75 male and 75 female) from North India studying at AIIMS Rishikesh after taking their informed consent and ethical approval. Students from North Eastern states and southern states of the country were not included, as sufficient number of student population from these states was not available for the study. All included students were more than 18 years of age and were screened for any skeletal deformities before including in the study.

The forearm plus hand length was measured from the tip of the olecranon to the tip of the little finger (Fig. 1), keeping elbow in fully flexed, the wrist and fingers in a neutral position. The measurement of femoral lengths was taken from highest point of greater trochanter to the base of the patella (Fig. 2), while keeping the thigh fully flexed and adducted. Other anthropometric measurements were also taken, including Height (length from the plantar surface of the foot to the crown of the head), Weight, Arm Span and Trunk and leg ratio i.e. US/LS (Upper segment and lower segment). Arm Span was measured as a distance between the tips of the middle fingers keeping the arms parallel to the horizontal plane and shoulders at an angle of one-hundred eighty-degree with each other. The length of the trunk or upper segment (US) was measured from the head top to the top of the pubic symphysis and the length of the lower segment (LS) was measured from the top of the pubic symphysis to the standing ground. All measurements were done by simple measuring tape.

Data were collected, mean, standard deviation, Pearson's correlation coefficient and two tail (paired t-tests) tests were applied and the results were analysed.



Figure 1: Showing measurement of Forearm plus hand length (A: Tip of Olecranon Process)



Figure 2: Showing measurement of Forearm plus hand length (B: Base of Patella)

Results

As seen from Table 1 and 3, the mean forearm plus hand length and length of the femur were found to be 42.85 (SD, ± 1.87) and 45.88 (SD, ± 2.95) cm, respectively with the mean difference between these 2 measurements of -3.03 (95% CI, -3.83 to -2.22) cm, in male volunteers. The Pearson correlation coefficient between these 2 measurements was 0.575 with a p value of 0.0001 (Student's t test) which is extremely significant.

With regard to Table 2 and 3 one can make out that the mean forearm plus hand length and length of the femur were found to be 39.56 (SD, ± 1.68) and 40.96 (SD, ± 2.75) cm, respectively with the mean difference between these 2 measurements of -1.400 (95% CI, -1.917 to -0.883) cm, in female volunteers. The Pearson correlation coefficient between these 2 measurements was 0.585 with a p value of 0.0001 (Student's t test) which is extremely significant.

With regard to Table 4, one can make out that Correlation (R) between the ratios of forearm plus hand length (FAH) and length of femur (LOF) i.e. FAH/ LOF and Height/Arm Span is -0.1319 with p value of 0.262597, and between FAH/LOF and US

Table 1: Showing different measurements, their means and standard deviations in 75 male volunteers

No of Cases (Male) = 75	FAH	LOF	LOF-FAH	HEIGHT	ARM SPAN	US/LS
Mean ± SD	42.85±1.87	45.88±2.95	3.026±2.42	169.33±5.54	176.44±6.84	0.98 ± 0.05

Table 2: Showing different measurements, their means and standard deviations in 75 female volunteers

No of Cases (Female) = 75	FAH	LOF	LOF-FAH	HEIGHT	ARM SPAN	US/LS
Mean ± SD	39.56±1.68	40.96±2.75	1.38±2.23	157.30±6.10	160.94±7.62	0.94±0.07

Table 3: Showing values of different statistical measurements in male and female volunteers

Mean ± SD, FAL (cm)	Mean ± SD FEL(cm)	Mean ± SD FEL- FAL (cm)	Mean difference (95% CI)	Correlation	p Value (Student's t-test)
42.85±1.87 (Male)	45.88±2.95 (Male)	3.026±2.42 (Male)	-3.03 (-3.83 to -2.22) (Male)	0.5751 (Male)	0.0001 (Male)
39.56±1.68 (Female)	40.96±2.75 (Female)	1.38±2.23 (Female)	-1.400(-1.917 to -0.883) (Female)	0.5856 (Female)	0.0001 (Female)

Table 4: Showing Correlations and p value among different ratios in male and female volunteers

Name of Correlations	Correlation (R) Value (Male)	Correlation (R) Value(Female)	p value (Male)	P value(Female)
Correlation b/w FAH/LOF and Height/Arm Span	-0.1319	-0.1598	0.262597	0.173028
Correlation b/w FAH/LOF and US/LS	0.1089	0.0097	0.352355	0.934173

(Upper Segment)/LS (Lower Segment) is 0.1089 and 0.352355 respectively in male subjects which means a non-significant relationship among them.

As seen from Table 4, one can make out that Correlation (R) between the ratios of FAH/LOF and Height/Arm Span was -0.1598 with p value of 0.173028, and between FAH/LOF and US/LS was 0.0097 and 0.934173, respectively in female subjects, which meant a non-significant relationship among them.

Discussion

One of the important objectives of the treatment of the femoral shaft fractures is, to restore the normal anatomical length of the femur (1). Because both shorter and longer nails are associated with problems like inadequate stability, fractures at distal tip, protrusion, bursitis and restriction of movements etc. There is description of several methods by using

measurements of different body parts, for preoperative estimation of the length of the femur and femoral nail to be used in femoral shaft fractures (4-7). The length of the normal femur is thought to be the standard length, for the calculation of the length of the femoral nail (1,5). It has been reported that the length of the fibula plus transverse diameter of the head of the femur correlates the medullary length of femur. But this radiological method mandates the intact fibula as well as femoral head (4). The forearm length has also been used as guide for preoperative femoral nail length estimation that can also be applied in day to day clinical practice (5,6).

In their studies on 100 volunteers Nazir et al (6) reported a strong correlation (Pearson correlation factor of 1) between the distances from tip of the olecranon to the tip of little finger and the tip of the greater trochanter to the joint line on the lateral side of the knee having only 0.16 mm of difference between their means.

Lakhey et al. (5) studied the difference in mean between the following measurements in five hundred people: a) Tip of the greater trochanter to lateral knee joint line minus 2cms, b) Tip of the olecranon process to the tip of little finger, and c) Tip of the greater trochanter to the upper pole of patella. They concluded that in patients with the fractures of both femurs the estimation of preoperative K – nail length can be achieved accurately by deducting 3 cm from the distance measured from the tip of the olecranon process to the tip of the little finger.

Digital radiographic views of the lower limbs of healthy volunteers were used to estimate the length of the femoral nail. The medullary length of the femur was compared with the length of the fibula and the transverse diameter of the head by Karakas et al. (4). There was a high degree of correlation between the two techniques ($r = 0.942$, $p < 0.0001$).

Naik et al (10) has studied the relationship between Femur Length and Forearm plus little finger length on 100 volunteers showing high degree of correlation between the two.

From the present study we can say that there is extremely significant (Table 3) correlation between the forearm plus hand length and length of the femur of the individuals, which is in correlation of the previous studies. The length of the femur being longer than the forearm plus hand length (Table 1 and 2) with the mean difference of 3.026 ± 2.42 cm and 1.38 ± 2.23 cm respectively in male and female. The length of the femur is definitely longer in most of the measurements (Table 1 and 2) in both the sexes i.e. male or female but the differences are not same. The male difference is approximately double (Table 3) that of the female. So the femoral nail sizes of male and female have to be different for the same femoral fracture. At the same time, we see from Table 4 that there is very poor association between Forearm plus hand length/ Length of the femur, Height/Arm Span and Upper Segment / Lower segment ratios (p value > 0.05). That means there is no significant variation in the femur length with height, upper segment and lower segment variation in the same individual.

Conclusion

Hence, it is concluded that there is extremely significant correlation between the forearm plus hand length and length of the femur of the individuals which is in correlation of the previous studies. The length of the femur being longer than the forearm plus hand length with the mean difference of 3.026 ± 2.42 cm and 1.38 ± 2.23 , cm respectively in males and females.

Hence, the maximum femoral nail length is represented by the forearm plus hand length. The length of the femur is definitely longer in most of the measurements in both the sexes i.e. male or female but the differences are not same. The male difference is approximately double that of the female. The femoral nail length can be definitely predicted by the forearm plus little finger length in both sexes but it has to be different in both, for the same femoral fracture and there is no significant variation in the femur length with height, upper segment and lower segment variation in the same individual.

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