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Original Research Article

ASSESSMENT OF RELATIONSHIP BETWEEN NECK SHAFT ANGLE AND NECK LENGTH WITH INTEREPICONDYLAR DISTANCE IN FEMUR

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ABSTRACT

Background: Femur is the longest and strongest bone of the body. It transmits body weight from hip bone to tibia in standing position. Femoral neck is a constricted part connecting head with shaft at an angle of about 125°-known as angle of inclination or neck shaft angle (NSA); this facilitates the movement of hip joint enabling the limb to swing clear of pelvis. Abnormal femoral neck angle (FNA) may be associated with various clinical problems ranging from harmless in toeing gait in childhood to disabling osteoarthritis in adults. The current study attempted to find out if a co-relation exists between those parameters and other clinically measurable variables like inter-epicondylar distance or distance between greater trochanter to lateral epicondyle. This may help to predict the risk of fracture neck femur without any risk of radiation exposure and proper prophylactic measures can be undertaken (Vit-D, calcium) to decrease risk of fracture.

Results: Measurements were taken in dry femora mostly in East Indian population. Variables that were measured in 158 dry femora (85 femora from left side and 73 from the right side) are: - a) Neck shaft angle of femur, b) Neck length of femur, c) Neck circumference of femur, d) Inter-epicondylar distance of femur, e) Distance between lateral epicondyle and greater trochanter of femur. No significant difference was found between the right and left sided femoral groups regarding any of the study variables. From the analysis it was revealed that no positive or negative correlation exists between the study variables. Therefore, it is not possible to predict the value of one or more of them from the magnitude of the other variable(s).

Conclusions: Our study attempted to find out if it was possible to predict the risk of fracture neck femur by simple clinical procedure without exposing the subjects to radiation hazards associated with a radiological imaging. A screening test and subsequent prophylactic measures could have been suggested to prevent the fracture. However, at the end of the study, no suitable alternative to the radiological assessment was detected.

KEY WORDS: Neck Shaft Angle (NSA), Femoral Neck Angle (FNA), Fracture Neck Femur.

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INTRODUCTION

Femur is the longest and strongest bone of the body. It transmits body weight from hip bone to tibia in standing position. Femoral neck is a constricted part connecting head with shaft at an angle of about 125°-known as angle of inclination or neck shaft angle (NSA); this facilitates the movement of hip joint enabling the limb to swing clear of pelvis. Abnormal femoral neck angle (FNA) may be associated with various clinical problems ranging from harmless in toeing gait in childhood to disabling osteoarthritis in adults [1].

The FNA varies among humans and the potential cause of such variation are sex, age, side (right or left), regional difference in body shape due to climatic adaptation, activity pattern (sedentary or mobile) etc. The trend shows a progressive narrowing of NSA which may be attributed to thermal insulation provided by improved cultural buffering from climate [2].

On the anterior surface of neck at the junction of shaft rough inter-trochanteric line is present. Similarly on the post surface of neck at junction of neck and shaft there is rounded inter-trochanteric crest.The greater trochanter is a large quadrangular projection from junction of neck and shaft. The apex or highest point of greater trochanter can be felt sub-cutaneously i.e palpable when muscles are relaxed. The distal end of femur is widely expanded for transmission of weight to tibia having two massive condyles -medial and lateral which are partly articular. Anteriorly the condyles unite and are continuous with the shaft, posteriorly the are separated by a deep inter-condylar fossa.The lateral condyle is less prominent but more massive than medial condyle and more directed in line with femoral shaft and hence transmits more weight to tibia.

The most prominent points on medial and lateral condyles are the two epicondyles which are palpable. The lateral epicondyle gives attachment to fibular collateral ligament. The medial epicondyle lies antero-inferior to adductor tubercle and gives attachment to tibial collateral ligament. Since neck is the most constricted part of proximal end of femur, fracture of femoral neck is very common due to tipping over obstacles. The abductors and rotators of thigh are attached mainly to the greater trochanter so they are pulling on a lever (the short limb of L) that is more laterally than vertically directed. This provides more leverage for the abductors and rotators of thigh and allows the considerable mass of abductors of thigh to be placed superior to femur(in the gluteal region),instead of lateral to it, freeing the lateral aspect of shaft of femur to provide increased area for fleshy attachment of extensors of knee joint. The neck shaft angle allows obliquity of femur within the thigh which is advantageous for bipedal walking-but this imposes considerable strain on neck of femur which makes it vulnerable for fracture. This type of fracture is most common in elderly osteoporotic women especially in developing country where dietary deficiencyacts as an aggravating factor. Normally, when the lower limb is aligned with the trunk, the apex of the greater trochanter is on the line joining the anterior-superior iliac spine and most prominent point of ischial tuberosity (Nelaton's Line).

In the fractures associated with displacement of neck, the greater trochanter may lies above this line. The present study deals with the co-relation between different anthropometric parameters of proximal and distal femur. Some of these parameters like neck shaft angle and neck length have been found to be useful as predictors for a risk of fracture neck femur [2,3,4]. However, measurement of these factors require imaging procedures like x-ray associated with a radiation exposure to the subject, thereby minimizing the acceptability of such measurement as a mass screening procedure for estimation of a fracture risk. The current study attempted to find out if a co-relation exists between those parameters and other clinically measurable variables like inter-epicondylar distance or distance between greater trochanter to lateral epicondyle. This may help to predict the risk of fracture neck femur without any risk of radiation exposure and proper prophylactic measures can be undertaken (Vit-D, calcium) to decrease risk of fracture.

MATERIALS AND METHODS

Measurements were taken in dry femora mostly in East Indian population. Variables that were measured in 158 dry femora (85 femora from left side and 73 from the right side) are: - a) Neck shaft angle of femur, b) Neck length of femur, c) Neck circumference of femur, d) Inter-epicondylar distance of femur, e) Distance between lateral epicondyle and greater trochanter of femur. Broken, deformed and eroded bones were excluded from the study objects. Instruments used for above measurements were vernier callipers, metric tape, and goniometer. Each parameter was measured thrice and then the mean was calculated. All parameters were measured by same observer. The neck-shaft angle was measured by goniometer. The inter-epicondylar distance and the neck length were measured by callipers. The neck circumference and distance between greater trochanter and lateral epicondyle were measured by the metric tape [5]. For measurement of the neck shaft angle the respective bone was first held in its anatomical position, then the two limbs of the goniometer were made to align along the axis of neck and shaft. The angle between the two limbs of goniometer gives the value of the corresponding neck-shaft angle of femur. Circumference of femoral neck was measured at midpoint between base of femoral head and inter-trochanteric line with the help of metric tape. For denoting the mid-point of the neck the neck length was first measured and then divided by two. The distance thus obtained is measured either from the inter-trochanteric line or from base of head. The point is demarcated with thehelp of pencil. Neck shaft angle was measured as the angle between major axis of shaft and major axis of neck (measured at posterior surface of neck). Length of femoral neck was measured as the distance between inferior region of base femoral head and lower end of inter-trochanteric line on the anterior aspect of femur measured with the help of metric tape. Inter-epicondylar distance was the distance between medial and lateral epicondyles which are the most prominent points on medial and lateral condyles respectively. The two ends of callipers are fixed on the two epicondyles and distance in between the two ends of callipers give the value of inter-epicondylar distance. Distance between lateral epicondyle and greater trochanter was the distance between highest points on greater trochanter to the lateral epicondyle measured by the metric tape. Software which were used to analyse the data, are Statistica version 6, SPSS version 16 and MedCalc version 11.6. All variables were skewed by Kolmogorov-Smirnoff goodness of fit test.

RESULTS AND DISCUSSION

Influence of laterality (side) of the bone: No significant difference was found between the right and left sided femoral groups regarding any of the study variables as depicted in the following tables (Tables 1-4):

Table 1: Descriptive statistics of numerical variables – Whole cohort [n = 158] (LL = lower limit, UL = upper limit).

	Valid N	Mean	95%CI	95%CI	Median	Min	Max	Lower	Upper	Std.Dev.
NeckLength	158	3.75	3.72	3.79	3.81	3.12	4.23	3.61	3.89	0.213
NeckCirc	158	9.71	9.64	9.79	9.83	8.52	10.5	9.4	10.15	0.481
NeckShaftAngle	158	127.1	126.7	127.49	127.75	118.5	133.5	125.35	128.87	2.489
InterEpiDist	158	5.49	5.43	5.55	5.55	4.58	5.98	5.23	5.8	0.36
Gr. Troc. Lat. Epi. Dist	158	35.03	34.95	35.12	34.99	33.47	35.98	34.82	35.43	0.54

Table 2: Descriptive statistics of numerical variables – Left cohort [n = 85].

	Valid N	Mean	95%CI	95%CI	Median	Min	Max	Lower	Upper	Std.Dev.
NeckLength	85	3.74	3.69	3.79	3.77	3.12	4.23	3.59	3.89	0.22
NeckCirc	85	9.75	9.64	9.87	9.87	8.53	10.5	9.47	10.15	0.511
NeckShaftAngle	85	126.84	126.23	127.44	127.89	118.5	133.4	124.9	128.82	2.804
InterEpiDist	85	5.45	5.37	5.54	5.51	4.58	5.98	5.15	5.8	0.383
Gr. Troc. Lat. Epi. Dist	85	34.99	34.88	35.11	34.96	33.47	35.98	34.82	35.24	0.531

Table 3: Descriptive statistics of numerical variables – Right cohort [n = 73].

	Valid N	Mean	95%CI	95%CI	Median	Min	Max	Lower	Upper	Std.Dev.
NeckLength	73	3.77	3.72	3.82	3.83	3.23	4.11	3.68	3.9	0.204
NeckCirc	73	9.67	9.56	9.77	9.72	8.52	10.33	9.29	9.95	0.441
NeckShaftAngle	73	127.4	126.92	127.87	127.58	121.97	133.5	125.88	128.87	2.041
InterEpiDist	73	5.53	5.46	5.61	5.65	4.85	5.97	5.23	5.8	0.329
Gr. Troc. Lat. Epi. Dist	73	35.08	34.95	35.2	35.15	33.75	35.92	34.82	35.5	0.55

Table 4: Comparison of numerical variables between Right and Left – Mann-Whitney U test.

	Rank Sum	Rank Sum	U	Z	p-level	Valid N	Valid N
NeckLength	6474.5	6086.5	2819.5	-0.987	0.324	85	73
NeckCirc	7170	5391	2690	1.439	0.15	85	73
NeckShaftAngle	6647	5914	2992	-0.385	0.7	85	73
InterEpiDist	6475	6086	2820	-0.985	0.325	85	73
Gr. Troc. Lat. Epi. Dist	6470.5	6090.5	2815.5	-1.001	0.317	85	73

Correlation analysis: All variables under consideration were subjected to correlation analysis by estimation of Spearman's coefficient of rank correlation (rho) as shown below:

Table 5: Correlation between neck length and inter epicondylar distance.

Sample size	158
Spearman's coefficient of rank correlation (rho)	0.00753
Significance level	P=0.9252
95% Confidence Interval for rho	-0.149 to 0.163

Table 6: Correlation between neck length and greater trochanter to lateral epicondylar distance.

Sample size	158
Spearman's coefficient of rank correlation (rho)	0.0522
Significance level	P=0.5151
95% Confidence Interval for rho	-0.105 to 0.207

Table 7: Correlation between neck shaft angle and inter epicondylar distance.

Sample size	158
Spearman's coefficient of rank correlation (rho)	0.0316
Significance level	P=0.6935
95% Confidence Interval for rho	-0.125 to 0.187

Table 8: Correlation between neck shaft angle and greater trochanter to lateral epicondylar distance.

Sample size	158
Spearman's coefficient of rank correlation (rho)	0.0633
Significance level	P=0.4297
95% Confidence Interval for rho	-0.0938 to 0.217

Table 9: Correlation matrix.

	Valid	Spearman	t(N-2)	p-level
Neck Length & Neck Circumference	158	0.15	1.9	0.059
Neck Length & Neck Shaft Angle	158	0.091	1.145	0.254
Neck Length & Inter Epicondylar Distance	158	0.008	0.094	0.925
Neck Length & Greater Trochanter Lateral Epicondylar Distance	158	0.052	0.652	0.515
Neck Circumference & Neck Length	158	0.15	1.9	0.059
Neck Circ & Neck Circumference				
Neck Circumference & Neck Shaft Angle	158	0.23	2.956	0.004
Neck Circumference & Inter Epicondylar Distance	158	-0.259	-3.351	0.001
Neck Circumference & Greater Trochanter Lateral Epicondylar Distance	158	0.072	0.902	0.369
Neck Shaft Angle & Neck Length	158	0.091	1.145	0.254
Neck Shaft Angle & Neck Circumference	158	0.23	2.956	0.004
Neck Shaft Angle &Neck Shaft Angle				
Neck Shaft Angle & Inter Epicondylar Distance	158	0.032	0.395	0.694
Neck Shaft Angle & Greater Trochanter Lateral Epicondylar Distance	158	0.063	0.792	0.43
Inter Epicondylar Distance & Neck Length	158	0.008	0.094	0.925
Inter Epicondylar Distance & Neck Circumference	158	-0.259	-3.351	0.001
Inter Epicondylar Distance & Neck Shaft Angle	158	0.032	0.395	0.694
Inter Epicondylar Distance & Inter Epicondylar Distance				
Inter Epicondylar Distance & Greater Trochanter Lateral Epicondyle Distance	158	0.176	2.233	0.027
Greater Trochanter Lateral Epicondylar Distance & Neck Length	158	0.052	0.652	0.515
Greater Trochanter Lateral Epicondylar Distance & Neck Circumference	158	0.072	0.902	0.369
Greater Trochanter Lateral Epicondylar Distance & Neck Shaft Angle	158	0.063	0.792	0.43
Greater Trochanter Lateral Epicondylar Distance & Inter Epicondylar Distance	158	0.176	2.233	0.027

Correlation coefficient 0 to <0.3: No relationship; 0.3 to <0.5: Fair relationship; 0.5 to <0.7: Good relationship; >0.7 to 1: Excellent relationship.

From the analysis it was revealed that no positive or negative correlation exists between the study variables. Therefore, it is not possible to predict the value of one or more of them from the magnitude of the other variable(s).

Osteoporotic fracture accounts for >90% of all fractures above 50 years of age with almost 25% mortality. Of the patients who survive more than 6 months following fracture only 60% regain their pre-fracture walking ability and 50% regain their pre-fracture activities of daily life [3, 4]. In elderly patients hip fracture mainly results due to fall from height or tipping over any obstacle but in younger patients high energy trauma like road traffic accident may be the cause. Pathological fracture may occur at any age associated with metastasis, hyper-parathyroidism, osteogenesisimperfecta, Paget's disease, steroid and alcohol use or infection. However osteoporosis remains the major cause of fracture which occurs mostly in elderly patients with low bone mineral density and risk of fracture doubles every decade after 50 years of age. Old age especially female sex or associated with excessive caffeine use, smoking, dementia, visual impairment, obesity, physical inactivity, arthritis, low body mass index further aggravate the risk [6]. In developing country like India risk is even higher due to vitamin-D or calcium deficiency especially in post-menopausal women.

The mortality and morbidity associated with fracture neck femur imposes immense physical, mental, social and economic trauma to both the patient and the family. It has been documented in various literature that neck-shaft angle of femur, neck-circumference, neck length i.e. proximal femoral geometry is well associated with risk of fracture neck femur [7]. Lower values of neck-circumferece is associated with low bone-mineral density and hence higher risk of fracture [8, 9]. The proximal femoral geometry can be accurately measured by either DEXA scan or CT-scan. Hence risk of fracture can be predicted in a person by doing DEXA or CT scan. Once the high risk group is identified proper preventive measures can be undertaken like Vitamin-D or calcium supplementation, exercise to strengthen bone mass, visual aids for elderly. DEXA or CT scan exposes the patient to radiation hazard which may predispose the patient to risk of development of leukemia, breast cancer and other forms of malignancy in later life [6]. DEXA or CT scan is not only expensive but facilities are also not available at all medical centres especially in rural and remote areas where lack of awareness, illiteracy, and nutritional deficiency are even more prominent. Hence there is a need for an inexpensive, authentic, safe, sensitive yet easy procedure to predict the risk of fracture neck femur.

This study was undertaken to find co-relation between proximal and distal femoral geometry i.e. between neck-shaft angle, neck-length, neck-circumference with inter-epicondylar distance and distance between lateral epicondyle to greater trochanter. The inter-epicondylar distance and distance between lateral epicondyle to greater trochanter are easily measurable in an individual by a pair of sensitive calipers and a metric tape. However, a more precise measurement of the aforementioned parameters could have been done by using a rectangular dioptograph which was not available in the study setting. Moreover, verniercalipers and metric tape were suitable instruments for use at the peripheral health centres if our study could find the study variables useful for the bigger purpose. Had there been an association between the clinically measurable parameters like interepicondylar distance or distance between greater trochanter to lateral epicondyle and the radiologically measurable parameters associated with a risk of fracture neck femur viz. neck shaft angle, neck length or neck circumference, it would have been very useful to predict the risk of fracture in an individual by simply measuring the first two parameters clinically instead of exposing the patient to radiation hazard associated with DEXA or CT scan. These simple measurements can be even taken by para-medical staff or other health workers since it does not require much of expertise.

After meticulous collection and analysis of data, it was revealed that there is no statistically significant association between the aforementioned clinical and radiological parameters. Therefore, for an estimation of the risk of fracture neck femur, radiological assessment cannot be replaced as yet. However, in view of the necessity and utility of a clinical procedure that can possibly be applied to a large population, future studies may be undertaken with a wide array of other anthropometric parameters to search for an interrelationship amongst them.

CONCLUSION

Our study attempted to find out if it was possible to predict the risk of fracture neck femur without exposing the subjects to radiation hazards associated with a radiological imaging. It would have also been very useful in developing countries with restricted resources, if a simple clinical procedure could estimate the value of parameters associated with a fracture risk and measurable only radiologically. A screening test and subsequent prophylactic measures could have been suggested to prevent the fracture. However, at the end of the study, no suitable alternative to the radiological assessment was detected. Nevertheless, the wide applicability of such a procedure, if ever developed, warrants a quest for other anthropometric variables that can serve the purpose and future studies may be undertaken accordingly.

Conflicts of Interests: None

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