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Research Paper

Correlation of Anthropometric and Upper Femoral, Morphometrics with Osteoporotic Related Hip Fracture Risk

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Abstract: Hip fractures have high morbidity and mortality among people and are generally seen in elderly population. In this study our focus was to know the relation of anthropometric factors and proximal femoral morphometry with fracture risk. Total of 107 women were recruited in this study. Determination of Bone mineral density by DXA scan is gold standard in prediction of osteoporotic related hip fracture. Based on scores of BMD we divide the Participants into two groups. 1. Fracture risk group and 2. Non fracture risk group. Age, BMI, hip axis length (HAL), neck shaft angle (NSA), and neck width (NW), were recorded and measured from the dual x-ray absorptiometry (DXA) print out. Age had negative relation with BMD and BMI had positive relation with BMD. HAL and NSA were more in fracture risk group. So our study suggests that, one should strive to use both geometry and BMD to predict the susceptibility to fracture in patients.

The number of hip fractures has been estimated to rise from 1.7 million in 1990 to 6.26 million by the year 2050, worldwide and this is mostly due to the increasing life expectancy and increasing size of the population in nearly all countries (Cooper *et al*., 1993). It increases the morbidity and mortality in elderly men and women (Baudoin *et al*., 1996).

Many risk factors are there to define the etiology of hip fracture. Age, diseases and trauma are the three main causes that play an important role in the etiopathology of hip fractures. (Alffran *et al*., 1964). It is also an outcome of age related osteoporosis. Alffran *et al.*, (1964) emphasize the importance of osteoporosis as a predisposing factor in hip fractures. Together with age and gender, bone mineral density measurement is one of the reliable methods to evaluate the risk of osteoporotic –related hip fractures

The other potential risk factors for hip fracture are lower body weight, cigarette smoking, caffeine intake, use of long acting sedatives and inactivity. Other risk factors such as density also relate to the strength of the bone (Cheng *et al*., 1997).The reduced bone mass during aging alone does not explain this phenomenon (Ramalho *et al*., 2001), and other factors such as decreased muscle mass (Dargent–Molina *et al.*, 1996), postural instability, bone quality (Cumming *et al*., 1995; Dargent–Molina *et al.,* 1996), genetic factors like polymorphism in the type 2 collagen synthesizing gene that would alter the bone structure (Quershi *et al.*, 2000) and also the geometry of the proximal femur (Gnudi *et al*., 2002) are also

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suggested to cause fracture. So Many studies have been carried out to prevent fractures, as most hip fractures follow a fall.

Recently authors tried to estimate the risk of fracture through measurement of hip geometry like hip axis length, neck shaft angle, neck width with DXA scan. (Pande *et al*., 2000; Gnudi *et al*., 2002; Alonso *et al*., 2000).

As the great majority have used the densitometry scan image to measure the geometric values mentioned above, we also used DXA scan to measure femoral geometry. To determine whether the geometric measurement of morphological features of the proximal femur are independent predictors of hip fracture and whether they improve the discriminate ability of the femoral bone mineral density (BMD), we measured and compared the hip axis length, the femoral neck width, neck shaft angle and the femoral BMD of randomly selected individuals with and without hip fracture risk by taking a hip scan using dual x- ray absorptiometry (DXA)). The recent interim report from the world health organization (WHO) task force for osteoporosis, recommends using only bone mineral density (BMD) for determining the fracture risk.

Earlier studies carried out in different ethnic groups have found that the incidence of hip fractures differ from country to country. This evidence suggests that like others factors, proximal femoral morphometry, may equally be important in determining hip fracture risk.

Materials and Methods

This study was conducted on 107 post menopausal women in the age group 50 - 60 years, who visited bone clinic for screening of osteoporosis. The experimental procedure was approved by the local ethics committee. We divided the participants into two groups based on the following criteria.

Control group (n= 57) Women who had normal BMD as per WHO criteria (T >-1 SD) were included in this group.

Fracture risk group (n= 50). Women who had osteopenia (T <-1SD TO >-2.5) or osteoporosis (T<-2.5 SD) were included in this group.

For both the groups age , BMI, HAL,NSA, NW, and BMD were recorded and measured from their DXA scan print out. All values were statistically correlated using SPSS statistical package.

Exclusion criteria for the study were hip fracture, any metabolic bone disease, or treatment with sex hormones like calcitonin. The information consent was obtained from the subjects to take secondary data from the DXA print out.

The following parameters were considered and measured for this study:

- BMD values of the proximal femur at neutral position, calculated by DXA scan (Lunar DPX).
- Age, recorded from patient's history.
- Body height and weight were measured with an anthropometer and beam-balance scale.
- Body mass index was calculated from height and weight measurements, using the formula Weight / Height in meter^2

Following morphometrics were measured (refer Fig. 1).

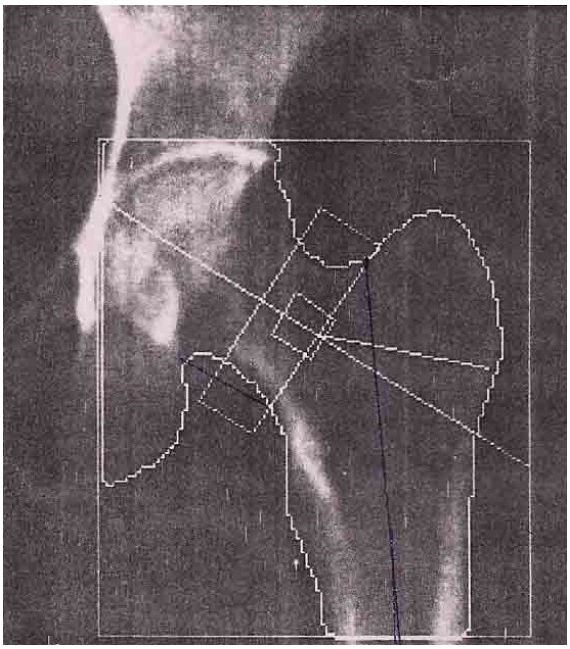
Hip axial length (HAL) was measured as the linear distance from the base of greater trochanter to the apex of the acetabular rim by aligning the ruler manually during the analysis procedure with the software provided with the device.

Femoral neck width (NW) was measured as the shortest distance within the femoral neck

perpendicular to the femoral neck axis.

The angle between the hip axial length and shaft axis gives neck shaft angle (NSA).

Fig. 1 DXA print out



Observations

The mean values of the anthropometric parameters like age , BMI, and upper femoral morphometric parameters like HAL, NSA, NW of 57 non fracture risk Chennai control group were found to be 50.44 kg, 26.87kg/m2, 5.55 cm, 127.8^{o}, and 1.74 cm (Table 1 and 2).

The mean values of the anthropometric parameters like age, BMI, and upper femoral morphometric parameters of 50 fracture risk group were found to be 53.6 kg, 26.87 kg/m2, 5.64, 128.78^{o}, and 1.76 cm (Table 3).

In this study the Pearson' correlation coefficients between anthropo-metric, upper femoral morphometric and BMD were calculated to evaluate the relationship between the above factors.

Age had positive correlations with HAL (r = 0.303; p = 0.002). BMI had positive correlation with BMD (r = 0.339 BMD, p = 0.000). HAL had positive correlation with age(r=0.303; p = 0.002), and NW (r=0.342; p = 0.000). NSA had negative correlation with BMD (r = -0.239; p = 0.013). NSA had negative relation with age (r =-.282 p= .003). BMD had negative correlation with age, (r = - 0.267 p = 0.005), with HAL(r = - 0.389; p = 0.000).

Table 1 The mean and standard deviation of the Physical characteristics namely age, BMI, HAL, NW, NSA and BMD of the participants

	Mean	**Std. Deviation**	**N**
AGE	51.93	12.177	107
BMI	26.8741	4.39041	107
HAL(cm)	5.6514	0.31244	107
NW	1.7645	0.17170	107
NSA (degree)	128.29	7.464	107
Area	29.2547	3.42380	107
BMC	24.8940	6.09370	107
BMD	0.85468	0.177891	107

Table 2 Averages and standard deviations of anthropometrics and femoral morphometrics of non fracture risk group in women

	Mean	Std. Deviation	N
AGE	50.44	12.177	57
BMI	26.8741	4.39041	57
HAL (cm)	5.55	.31244	57
NW	1.74	.17170	57
N S A (degree)	127.8	7.464	57
B M D	0.8679	.177891	57

Table 3 Averages and standard deviations of anthropometrics and femoral morphometrics of fracture risk group in women

	Mean	Std. Deviation	N
AGE	53.60	12.517	50
BMI	26.8741	4.3224	50
HAL (cm)	5.6400	.31321	50
NW	1.7800	.17170	50
N S A (degree)	128.78	7.265	50
B M D	0.6370	.15789	50

Table 4 Correlation between femoral morphometrics, anthropometrics and BMD of both fracture and non fracture groups in women.

		AGE	BMI	HAL (cm)	NW	NSA (degree)	AREA	BMC	QMD
AGE	Person Correlation	1	0.109	0.303**	-0.18	-0.282**	0.375**	-0.066	-0.267**
	Sig.(2-tailed)	107	0.264	0.002	0.851	.003	0.000	0.501	0.005
	N		107	107	107	107	107	107	107
BMI	Person Correlation	0.109	1	-0.182	0.106	0.072	0.154	0.380**	0.339**
	Sig. (2-tailed)	0.264		0.061	0.276	0.464.	0.113	0.000	0.000
	N	107	107	107	107	107	107	107	107
HAL(cm)	Person Correlation	0-303**	-0.182	1	0.342**	-0.004	0.342**	-0.199*	-0.389**
	Sig.(2-tailed)	0.002	0.061		0.000	0.964	0.000	0.040	0.000
	N	107	107	107	107	107	107	107	107
NW(cm)	Person Correlation	-0.018	0.106	0.342**	1	-0.102	0.515**	0.220*	-0.025
	Sig.(2-tailed)	0.851	0.276	0.000		0.298	0.000	0.023	0.801
	N	107	107	107	107	107	107	107	107
NSA(degree)	Person Correlation	-0.282**	0.072	-0.004	-0.102	1	-0.099	0.136	-0.239*
	Sig.(2-tailed)	0.003	0.464	0.964	0.298		0.311	0.163	0.013
	N	107	107	107	107	107	107	107	107
AREA	Person Correlation	0.375**	0.154	0.342**	0.515**	-0.099	1	0.512**	0.036
	Sig.(2-tailed)	0.000	0.113	0.000	0.000	0.311		0.000	0.716
	N	107	107	107	107	107	107	107	107
BMC	Person Correlation	-0.066	0.380**	-0.199*	0.220	0.136	0.512**	1	0.862**
	Sig.(2-tailed)	0.501	0.000	0.040	0.023	0.163	0.000		0.000
	N	107	107	107	107	107	107	107	107
BMD	Person Correlation	-0267**	0.339**	-0.389**	-0.025	-0.239*	0.036	0.862**	1
	Sig.(2-tailed)	0.005	0.000	0.000	0.801	0.013	0.716	0.000	
	N	107	107	107	107	107	107	107	107

** Correlation Is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Discussion

India is a large country with a wide variety of environmental conditions. It shows ethnic multiplicity and is characterized by an interracial mixing rarely seen in other countries. Taking into account of these factors the data base obtained in our study may not be representative of the entire Indian population and therefore our normative data should be used only for a population sharing the same genetic potential and living under similar environmental conditions. One limitation of our study was the recruitment of volunteers. The study sample was not population based but recruited from the subjects who visited bone clinic. It is possible that this may introduce a selection bias focusing on the wealthier and better educated part of the

population or alternatively on those who through life style or living conditions are prone to osteoporosis. To our knowledge, this is the first study of BMD in a large south Indian population using DXA measurements. In the present study we cannot exclude cohort effects such as socio economic status, life time exercise patterns or nutritional habitat. A survival bias may also have occurred since we made bone measurements only in the individuals able to come to the outpatient clinic.

The hip axis length has been found to be correlated with the risk of fracture (Nakamura *et al*., 1994). Our result also shows higher value of HAL in fracture risk group ref table 3.The precise physical mechanism of this is unknown. However Faulkner is of the opinion that a longer hip axis length leads to a higher probability of impacting the great trochanter and to lower impact absorption after a fall. (Faulkner, 1995; Schwartz *et al*., 1999).

In our study the neck shaft angle also discriminated healthy from osteoporotic subjects. Neck –shaft angle varies among the published studies on fracture risk. In every comparison study except those of Cody and Nahigian in 1993 (a CT study) and Ferris *et al.*, in 1989, (where hips were held in maximum internal rotation), the NSA is larger in the fracture – prone group. Our method of femoral NSA measurement proved both reliable and precise. Furthermore the mean values and ranges are similar to those reported in other studies (Alonso *et al*., 2000; Gnudi *et al*., 2002; Faulkner *et al*., 1993; Quershii *et al*., 2001). Our study also anticipates that larger NSA to be associated to an increased hip fracture risk in later life. But our data regarding NSA was in contrast to those of Faulkner *et al.*, (1993) who report no association between neck shaft angle and hip fracture risk.

Ex vivo biomechanical tests also shows that neck shaft angle does not correlate with femoral neck strength (Cheng *et al*., 1997; Schwartz *et al*., 1999). So it correlation to fracture risk may involve other mechanism. It may be hypothesized that neck shaft angle or the ante version angles interact with the direction of the fall, thus affecting the femoral neck loading angle. This angle, according to Pinilla *et al*., (1996) is inversely related to fracture load and its variation may therefore be associated with different fracture risk.

These discrepancies may be due to racial differences in the neck shaft angle Nakamura *et al.*, (1994) or to different compensations of the anteversion angle during positioning of patients on the scan bed producing different effects on this measurement. The occurrence of hip fracture may also be influenced by anthropoimetric factors (Farmer *et al*., 1989). Aging is one of the important reasons for hip fracture. It increases exponentially with age (Cumming *et al*., 1989). Many studies show that short individuals have a lower risk of hip fracture compared to tall individuals (Hemenway *et al*., 1995).

Conclusion

Non invasive imaging techniques can provide measures of geometry and a correlate to macroscopic material properties (BMD). Until we have effective methods for measuring micro architecture and genetic or other biomarkers for individual response dynamics, we should strive to use both geometry and BMD to predict the susceptibility to type of fracture in patients

References

Alffram PA (1964) An epidemiological study of cervical and trochanteric fractures of the femur in an urban population. *Acta Orthop Scand Suppl* 65.

Alonso CG, Curiel MD, Caranza FH, Cano RP, Perez AD (2000) Femoral bone mineral density, neck –shaft angle and mean femoral neck width as predictor of hip fractures in men and women.

Multi center project for research in osteoporosis. *Oteoporos Int,* 11: 714 -720.

Baudoin C Fardellone P, Bean K, Ostertag-Ezembe, Hervy F (1996) Clinical outcomes and mortality after hip fracture; a 2-year follow up study. *Bone,* 18: 1495-1575.

Cheng XG, Lowet G, Boonen S, Nicholson PH, Brys P, Hijs J (1997) Assessment of the strength of Proximal femur in vitro; relationship to femoral bone mineral density and femoral geometry. *Bone,* 20: 213-218.

Cody DD, Nahigian KK, Divine G, Ciarelli J, Sard B (1993) Does bone density or bone shape discriminate between subjects at high and low risk of hip fracture? *Proceedings of the Thirty – ninth annual meeting of the Orthopaedic Research Society*. San Francisco, CA. p. 19

Cooper C (1998) A case finding strategy: European Perspective. *Osteoporos Int,* 7 Suppl 1:S70-S74;

Cooper C, Campion G, Melton LJ (1992) Hip fracture in the elderly: world wide projection. *Osteoporosis Int,* 12: 285-289.

Cummings SR, Nevitt MC (1989) A hyphothesis: the cause of Hip fractures. *J Gerentol,* 44: M107-M111.

Dargent–Molina P, Favier F, Grandjean H, Baudoin C, Schott AM, Hausherr E, Meunier PJ, Breart G (1996) For EPIDOS group. Fall – related factors and risk of hip fractures: the EPIDOS prospective study. *Lancet,* 348: 145 – 149.

Farmer ME, Harris T, Madans JH, Wallace RB, Cornoni-Huntley J, White LR (1989) Anthro pometric indicators and hip fracture. The NHANES / epidemiologic follow up study, *JAM Geriatr Soc,* 37: 9-16.

Faulkner K G, Cummings S R, Black D, Palermo L, Gluer CC,and Genant HK (1993) Simple measurment of Femoral Geometry predicts hip fracture: The study of Osteoporotic fractures. *J Bone Miner Res,* 10: 1211-1217.

Faulkner KG, Letter to the editor; (1995). Hip axis length and osteoporotic fractures. *J Bone Miner Res,* 10; 1211-1217.

Ferris BD, Kennedy C, Bhamra M, Muirhead-Allwood W (1989) Morphology of the femur in proximal femoral fractures. *J Bone Joint Surg Br,* 71: 475-477.

Hemenway D, Feskanich D, Coldits GA (1995) Body height and hip fracture: a Cohort study of 90000 women. *Int J Epidemiol,* 24: 783-786.

Gnudi S, Ripamonti C, Lisi L, Fini M, Giardino R, Giavaresi G (2002) Proximal femur geometry to detect and distinguish femoral neck fracture from trochanteric in postmenopausal women. *Osteoporos Int,* 13: 69 – 73.

Hoaglund FT, Low WD (1980) Anatomy of the femoral neck and head, with comparative data from Caucasians and Hong Kong Chinese. *Clinical Orthopaedics and Related Res*, 152: 10-16.

Nakamura T, Turner CH, Yoshikawa T, Slemenda CW, Peacock M, Burr D, Mizuno Y, Orimo H, Ouchi Y, Johnston CC Jr (1994) Do variations in hip geometry explain differences in hip fracture risk between Japanese and white Americans? *J Bone Miner Res,* 9: 1071-1076.

Pande I, O'Neill TW, Pritchard C, Scott DL, Woolf AD (2000) Bone mineral density hip axis length and risk of hip fracture in men. From the Cornwall hip fracture study. *Osteoporosis Int,* 11: 866-870.

Pinilla TP, Boardman KC, Hayes WC (1996) Impact direction from a fall influences the failure load of the proximal femur as much as age –related bone loss. *Calcif Tissue Int*, 58: 231-235.

Qureshi AM, Mcguigan FEA, Seymour DG, Hutchison JD,Reid DM, & Ralston SH (2001).Association between COLIA1 Sp1 alleles and femoral neck geometry. Calcif tissue Int, 69:67-72.

Ramalho AC, Lazaretti-Castro M, Hauache O, Vieira JG,Takata E, Cafalli F, Tavares F (2001) Osteoporotic fratures of proximal femur, clinical and epidemiological features in a population of the city of Sao Paulo. *Rev Paul Med,* 119: 48-53.

Schwartz AV, Sellmeyer DE, Ensrud KE, Cauley JA, Tabor HK, Schreiner PJ, Jamal SA, Black DM, Cummings SR (2001) Older women with diabetes have an increased risk of fracture: a prospective study. *J Clin Endocrinol Metab* 86: 32 – 38.