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Is the femoral neck-shaft angle an independent risk factor for hip fractures? An observational study

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ABSTRACT

Background: The femoral neck-shaft angle (FNSA) has been implicated in the aetiology of hip fractures. The longer moment arm of a higher FNSA has been theorized to impart a greater deforming force to the greater trochanter, which may cause a hip fracture.
Methods: A prospective study that involves adults with hip fractures and a control group matched for age and sex. The FNSA of both groups were measured on an anteroposterior X-ray of the pelvis. The mean FNSA were compared with a paired samples t-test, and a binary logistic regression analysis was run with the FNSA as a predictor variable and the presence of hip fracture as an outcome variable.
Results: A total of 150 patients were recruited for the study, 75 per group. The mean age of patients with hip fractures was 71.30 years (S.D.=14.34), and that of the control group was 73.94 years (S.D.=12.55), p=0.264. The mean FNSA of the study group was 133.96^{o} (S.D.=3.77) while that of the control group was 131.05^{o} (S.D.=3.86), p<0.001. Increasing FNSA imparts a higher risk of having a hip fracture, O.R.=1.24 (95% C.I, 1.12-1.37).
Conclusions: Individuals with higher FNSA demonstrated a significantly increased risk of developing hip fractures. However, the exact cut-off point of the FNSA, which predisposes to the risk of these fractures, remains to be elucidated.

Keywords: Femur, Neck-shaft angle, Hip, Fractures

INTRODUCTION

Hip fractures are common injuries and cause significant morbidity in patients.[1] They include femoral neck fractures, intertrochanteric fractures and subtrochanteric fractures. Most cases of hip fractures occur in elderly individuals and are usually low-energy injuries frequently caused by ground-level fall. A significant proportion of these fractures are treated by operative fixation to enhance early mobilization in this cohort of patients. Despite this aggressive management protocol, it has been estimated that the mortality rate one year after a hip fracture could reach 30%.[1-3] Furthermore, the rehabilitation of such elderly patients after operative fixation is a gradual and tasking process. Many of the patients may never walk without aid, and a few elderly ones may be confined to wheelchair mobilization.

Therefore, emphasis should be placed on preventing these fractures. Algorithms have been developed to help predict the risk of developing hip fractures in the population. Osteoporosis has been identified as a significant risk factor for hip fractures in geriatric subjects.[4] It is diagnosed by measuring the bone mineral density using the dual X-ray absorptiometry (DXA) scan or the quantitative computed tomography (QCT) scan. T-scores are calculated after the DXA scan and converted to Z-scores for comparison. A Z-score of less than 2.5 from the mean is regarded as diagnostic for osteoporosis. It has been shown that a decrease of one standard deviation in the BMD results in a 2.6-fold increase in the risk of having a hip fracture.[4]

Recently, the geometry of the proximal femur has gained attention in the aetiology of hip fractures.[5] It has been suggested that a higher femoral neck-shaft angle (FNSA) predisposes to developing hip fractures.[6,7] With a fall on the side, the greater trochanter of the femur acts as a pivot, while the body weight acts as a downward force on the femoral head. A higher FNSA imparts a longer lever arm to the body weight than does a lower FNSA (Figure 1). This moment may cause a fracture to occur in the proximal femur. Many studies have demonstrated an association between a higher FNSA and the risk of hip fractures.[8-11]

Most studies that looked at the association between FNSA and the risk of hip fractures were done in the western regions of the world. The average FNSA in standard Western Anatomy and Orthopaedic textbooks is 125°.[12,13] This value differs from the average values of 130.77° in Nigeria, 132.3° in Chad, 130.8° in Mali and 132.5° in Senegal.[14,15] Thus, there exists a racial variation in the geometry of the proximal femur between the temperate and the tropical countries. Since no documented studies in Nigeria have looked at the association between the FNSA and the risk of hip fractures, this work aims to evaluate this relationship among patients presenting to our hospital.

METHODS

This work was a cross-sectional comparative study conducted at National Orthopaedic Hospital in Enugu, South-East Nigeria. The hospital is a tertiary centre and the regional centre for Orthopaedics and trauma, receiving referrals from the entire south-east geopolitical zone and some parts of north-central region. The study was conducted for 12 months, starting from November 2015 to October 2016. The authors obtained ethical approval from the Ethics Committee and written informed consent from each patient. The radiographers were involved so that the magnification of the X-ray and patient positioning will be standardized.

The sample size was calculated based on the number of hip fractures seen in the preceding year. Out of a total number of 192 femoral fractures seen in the previous year, 38 of them were hip fractures (femoral neck, intertrochanteric and subtrochanteric fractures). This gives a proportion of 5.1%. Substituting this value into the equation, $n=z^2p(1-p)/d^2$, gives a sample size of 75 subjects. Here, d is precision, which was set at 5%. Hence, we selected 75 patients with hip fractures and 75 controls who were matched for age (within two years of the patient's age) and gender. These controls are patients coming for pelvic X-rays for other diagnoses other than hip fractures, and whose hips are normal on the film.

All the patients coming for a pelvic X-ray within the study period were approached, and the study explained to them. The inclusion criteria were adults presenting to the radiology department for pelvic X-rays that have hip fractures. The control group was adults presenting for pelvic X-rays for other pathologies other than hip fractures whose films were normal. These groups were matched for age and sex with the cases. Exclusion criteria include bilateral hip fractures where the FNSA cannot be measured, presence of other hip pathologies such as osteoarthritis that distort the anatomy of the proximal femur, and patients that refuse consent.

In patients with hip fractures, we measured the FNSA of the nonpathological side. In the control group, we measured the two sides, and where there was a discrepancy, we took the average of the two measurements. The procedure was standardized with the magnification set at 100 and the film-focus distance at 100 cm. Both limbs were gently put in slight internal rotation to account for the 15° anteversion of the proximal femur, in the patient with hip fracture only the normal leg was put into internal rotation. The mid-axis line of the femoral neck was determined by measuring the width of the neck and noting the central point at a proximal and a distal end of the neck and then joining these two central points with a straight line. The process was also used to draw the mid-diaphyseal line of the femoral shaft. The angle subtended by the intersection of the neck mid-axis line and the shaft mid-diaphyseal line is the femoral neck-shaft angle (Figure 2).

We represented the data with the means and standard deviations for continuous variables and as frequencies for categorical variables. A paired samples t-test was used to test for any difference in the mean age and the mean FNSA between the two groups. A binary logistic regression was used to predict the probability of hip fracture using the FNSA as the independent variable. All the tests were 2-tailed, and a p value of less than 0.05 was considered significant.

RESULTS

A total of 75 subjects were recruited in each group, with 34 males and 41 females. There was no statistically significant difference in the mean age of the two groups (p=0.264). Femoral neck fracture was the most common hip fracture seen in this study, while the 70 to 79-year age group was mostly involved. Tables 1 and 2 show the characteristics of the study groups, while Figure 3 illustrates the age distribution of the participants.

The mean FNSA was significantly higher in patients with hip fractures compared to those without fractures, p<0.001. Regression analysis showed that a higher FNSA results in an increased risk of having a hip fracture, O.R.=1.24 (95% C.I: 1.12-1.37). Table 3 is a table of the regression coefficient.

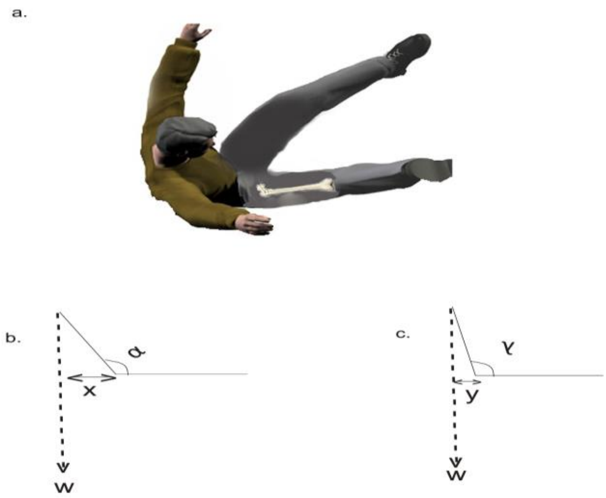

Figure 1: (a) Fall on the hip, (b) a bigger FNSA, α, with a longer moment arm, x, (c) a smaller FNSA, ϒ, with a shorter moment arm, y. Force transmitted=weight (w) × moment arm (x or y).

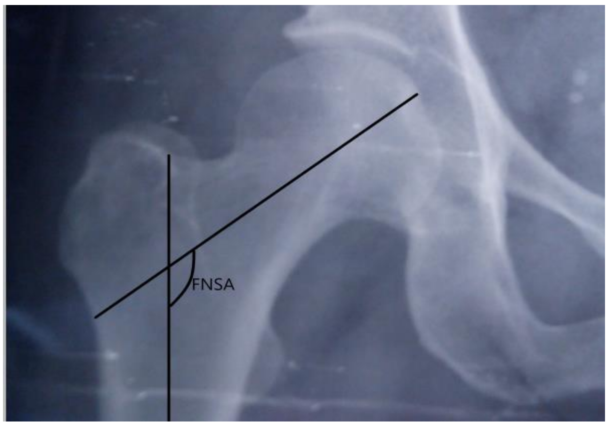

Figure 2: The FNSA is formed by the intersection of the neck mid-axis and shaft mid-diaphysis line.

Table 1: The characteristics of the study groups.

Variable	Frequency	%
Gender (with hip fractures)		
Male	34	22.7
Female	41	27.3
Gender (without fractures)		
Male	34	22.7
Female	41	27.3
Types of hip fractures		
Femoral neck	47	62.7
Pertrochanteric	21	28.0
Subtrochanteric	7	9.3

Table 2: Further characteristics of the participants.

Variable	Mean	Standard deviation
Age (years)		
With fractures	71.30	14.34
Without fractures	73.94	12.55
Neck-shaft angle (°)		
With fractures	133.96	3.77
Without fractures	131.05	3.86

Table 3: The regression coefficient of the FNSA as a predictor of the risk of hip fracture.

β	S.E.	P value	O.R.	95% C.I. (O.R.)
0.213	0.053	<0.001	1.24	1.12 – 1.37

β=regression coefficient (slope); S.E.=standard error of the slope; O.R.=odds ratio; C.I.=confidence interval.

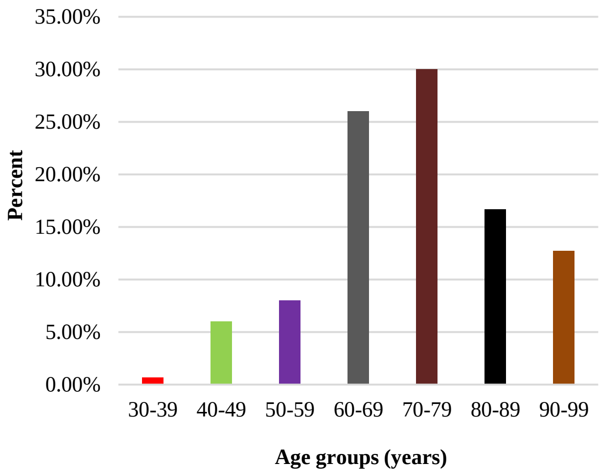

Figure 3: The age categories of the study groups showing the 70 to 79 year group as the modal group.

DISCUSSION

Our study has found an increased risk of hip fracture in those with a higher FNSA. This agrees with the findings of other studies.[7,9,16,17] According to Orlin in Asia, the FNSA was significantly higher in those with increased risk of hip fracture. He found that Asian women have a lower risk of hip fracture than Caucasians due to the smaller neck-shaft angle, and a shorter hip axis length. He concluded that a longer hip axis length and a greater neck-shaft angle increase the risk of proximal femoral fracture.[17]

Alonso et al. have also demonstrated that the FNSA is an independent risk factor for hip fractures.[9] They noted that the relative risk of having a hip fracture increases by 3.48 for women and 2.45 in men for one standard deviation increase in the FNSA value. Gnudi and Ripamonti have found that the predictive accuracy of their model for hip fracture risk is improved when the FNSA is added to the bone mineral density value.[11,18] However, a study done in the United Kingdom demonstrated no significant difference in the FNSA of men with and without hip fractures.[19]

However, despite these associations, it is known that correlation does not imply causation. There are still a lot of questions to answer. First, what is the exact cut-off of the FNSA that imparts a significant risk of hip fracture? Second, there is no way to conclusively prove that the subjects in the control arm may not have a hip fracture if subjected to the exact injury mechanism as the cases. Third, it is difficult to rule out other confounding variables such as the bone mineral density, fat padding of the hip region and the energy of the trauma. Such factors may play a more critical role than the FNSA in causing a fracture.

Still, there is increasing evidence that the proximal femoral geometry, and particularly the FNSA, may play a role in determining the occurrence of a hip fracture. Perhaps, a multicenter prospective cohort study in which individuals with different FNSA are followed up for a long time to see if the incidence of hip fractures will differ significantly will further buttress the role of the FNSA in the aetiology of hip fractures. But even this may still suffer from the effect of confounding variables.

CONCLUSION

A higher FNSA seems to increase the risk of a hip fracture. While the exact cut-off value is not yet known, this relationship may form the basis of prevention in those with a high value, at least more than 132° from this study.

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