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Original Article

Evaluation of proximal femoral geometry and its relationship with body mass index in Iranian people: a cross sectional study

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Abstract: Introduction: There are several studies on the angle of the femoral neck in different countries. It seems that data of diverse races might help the prediction of femoral neck fractures. The present study aimed to evaluate the femoral neck-shaft angle (FNSA) as a predictive factor of neck fracture in Iranian people. Methods: In this cross-sectional study, the FNSA was measured using radiographs in 635 patients referred to Poursina Hospital in Rasht from September 2018 to October 2019. The body mass index (BMI) was calculated, age and sex of patients were recorded. Data were analyzed by SPSS. The level of statistical significance was adjusted to P<0.05. Results: According to the measured variables, gender, age, BMI and right FNSA are significant in the way that participants with normal BMI have higher FNSA. FNSA decreased with age and height. Obese people had lower FNSA than normal and overweight people. Comparison of left and right angles using the Wilcoxon test showed a statistically significant difference (P<0.001). The right side FNSA was more than the left (59.94%). Only in 39.9%, the left FNSA was more than the right, and in 0.15% both were the same. Conclusion: The present cross-sectional study shows a significant relationship between BMI and FNSA. It is suggested that physician evaluates these parameters for prediction of fracture risk in individuals.

Keywords: Femur geometry, fracture, neck-shaft angle, body mass index

Introduction

Femur fractures are a serious health care problem. The costs of the direct treatment of patients and indirect costs of caring for people returning to work in different countries are very high [1, 2]. It is reported that about 100,000 femur fractures occur in the United States each year, and care costs are estimated at 10.3 to 15.2 billion [1]. Some studies suggest that the geometry of the femur can use as a factor in predicting femoral neck fractures [3]. It seems the results of hip geometry measurement are different in the world. Various factors such as ethnicity, genetics, and environmental conditions could affect the geometric of the proximal part of the femur [4]. Evaluation of bone strength based on measurement criteria for the proximal femoral bone and hip joint is often associated with femoral neck fractures [5].

The femur is the tallest and strongest bone in the human skeleton. The femoral neck-shaft angle (FNSA) is located in the proximal part of the femur between the longitudinal axis of the bone shaft and the axis of the head [6, 7]. This angle is known to be very important in lateral balance control during mobility [7]. The typical FNSA varies between 120-140 degrees. If the NSA is less than 120, it is known as coxa vara, and coxa valga is more than 140. Studies showed various amounts of FNSA based on musculoskeletal power, gender, body mass index (BMI), and between right and left limb. Thigh muscle balance and femoral morphology play an important role in body weight-bearing. The article showed that people with higher BMI had prolonged and poorer muscles recovery [8]. It has been shown that body mass index may be associated with femoral neck bone density in postmenopausal women [9].

Measurements of FNSA are valuable in the diagnosis and treatment of upper femoral fractures [10]. FNSA can be calculated by estimating the angle between the neck and the trunk of the femur. It is an important factor in designing prostheses and implant for repairing femoral fractures [11]. Of note, considering the geometry of the proximal femoral region might be useful for preoperative procedures such as osteoporosis, arthroplasty, or fracture fixation [12]. The prevalence of femur fracture and its financial burden in Iran is different from developed countries [13]. FNSA might consider as a factor for designing suitable implants with a more accurate angle in each ethnicity. The small and large size of the femur implants can lead to improper tension in the soft tissue and more stress on joints such as the patellofemoral [14]. If the physician chooses the femur implant incorrectly, it may cause severe problems for patients in the long term [15].

Epidemiological studies in different regions can provide accurate information on the design of prostheses and appropriate medical equipment for researchers and medical companies. With the increase in the elderly population in various countries [16], the importance of maintaining their health and improving their quality of life has led to extensive research to increase community health and reduce treatment costs. Besides, many studies have been conducted to find factors affecting femoral fractures to identify people at high fracture risk [16-18]. So, due to the lack of the proximal geometry of femur and BMI data in the north of Iran, this study investigates FSNA and BMI to identify the normality of these parameters in this region.

Material and methods

Study design

In this cross-sectional study, data of 659 patients were collected from September 2018 to October 2019. The study was done on patients referring to the emergency ward of the hospital. The study protocol was approved by the ethics committee of Guilan University of Medical Sciences (No: IR.GUMS.REC.1399.125).

Inclusion and exclusion criteria

The inclusion criteria were patients that were referred to the emergency ward of the hospital, had simple anterior-posterior (AP) pelvic radiography based on emergency medicine specialist prescription. All patients signed the written informed consent to participate in the study. The exclusion criteria were: having ipsilateral or bilateral congenital pelvic deformity, history of pelvic fracture, history of the previous femur or hip surgeries, having hip prosthesis, diseases such as renal failure, hyperparathyroidism, rheumatoid arthritis, Paget's disease, bone malignancies, prolonged immobility and use of osteoporotic drugs.

Data collection

The emergency medicine specialist prescribed all pelvic radiographs for controlling the health of the patients at the administration. Demographic data of all patients were collected, and BMI was calculated (= weight/height squared). AM D, and E N have done the data collection and all the measurements.

FNSA measurements

FNSA measurements were performed as following by using the Marco Pacs version 10.1 (Tahavolat Novin Yademan Company, Iran): the angle was calculated between the axis of the trunk and neck.

The neck axis was stretched by taking two points, one in the center of the head (B) and the other at the end of the middle part of the narrowest part of the neck (GF). The two points were then joined together and its extension in the neck area was connected to point H.

Then the trunk axis was obtained to two midpoints, one at the upper end of the shaft (IJ) and the other at the midpoint of the trunk (KL), the two points were connected (HN) and expanded at the upper end of the same line, thus Angle was measured by using Marco Pacs verssion10.1 (**Figure 1**).

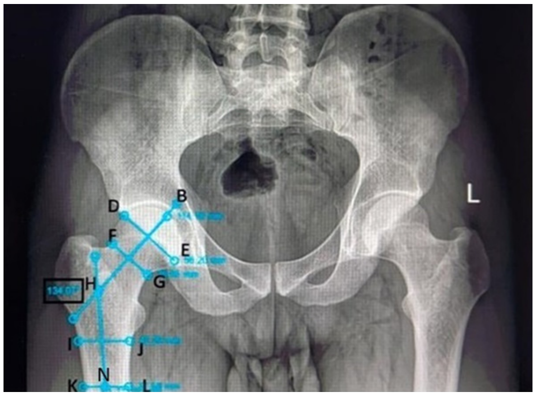

Figure 1. Calculation of proximal femoral geometry.

Statistical analysis

Statistical analysis was performed by SPSS version 24. All quantitative variables were described by the mean and standard deviation (SD). The qualitative variables were presented by frequency and percentages. Comparison of an FNSA according to the qualitative variable, Kruskal Wallis ANOVA, Mann Whitney U, and Wilcoxon test were used (distribution of FNSA is abnormal). To determine related factors, we applied the generalized linear model (GLM) in the GEE method (Generalized Estimating Equations). *P*-value <0.05 was set significant.

Results

Study population

In the present study, data of 659 patients were analyzed. The mean age of patients was 41.6±21.1 years, 480 patients (72.8%) were males, the mean height of patients was 169.6±16.7 cm. The mean BMI was 26.4±4.1 and 47.2% of patients had overweight. We observed that 18.4% of cases had medical history including diabetes (7.9%), hypertension (13.1%) and dyslipidemia (8.8%). The cause of admission to our medical center was trauma in 100% of cases. The baseline data of patients are summarized in **Table 1**.

FNSA results

The majority of samples of this study (81.64%) did not have underlying diseases. Fifty-two had diabetes, 86 had high blood pressure, and 58 had dyslipidemia. Evaluation of the FNSA showed that the mean FNSA of patients was 131.16±5.96. The measurement of FNSA on the right and left sides revealed that the mean angle of the left side was 130.97±5.94 and in the right limb was 131.35±5.98. Of note, 60% of cases had higher FNSA in the right limb in comparison to the left limb (P<0.001) (**Table 2**).

FNSA and demographics

We evaluated the differences in the FNSA of patients based on demographic and anthropometric characteristics of patients and showed that the FNSA was significantly higher in males (P=0.028). Male younger than 20 years (P<0.001), participants with normal BMI have higher FNSA (P=0.001). We found that the FNSA decreases with increasing age and height. No significant differences were observed between FNSA of patients with or without medical history (P>0.005) (**Table 3**). In addition, in multivariate variables analysis by adjusting gender, age, and BMI, FNSA of right and left sides are statistically significant (P=0.025) (**Figure 2**).

According to GLM by GEE method of the studied variables, gender variable (men compared to women) had a higher angle (β=1.074, P=0.003). FNSA decreases with age (β=-0.046, P<0.001). In addition, FNSA declines with increasing body mass index (β=-0.146, P<0.001). There was no significant difference based on the medical history, but the right FNSA was 0.381 more than the left side (β=0.381, P<0.001) (**Table 4**).

Discussion

There are differences in the anatomy of the proximal femur in people of different races concerning age, sex, and height. Identifying these racial differences in bone morphology might help predict bone fractures, identify at-risk individuals and fracture risk factors [19]. In the present study, BMI and FNSA of the general population were evaluated in Guilan province (north part of Iran). FNSA in the left limb was lower than the right limbs, and the majority of the general population had normal FNSA on the right side.

Some studies have investigated the FNSA in patients with femoral fractures and the general population. In 2020, Zia Ziabari et al. conduct-

Table 1. General demographic data of the participants

Variable	Number (%)	Mean ± SD
Gender		
Male	480 (72.84)	
Female	179 (27.16)	
Age		41.63±21.07
Height		169.58±16.74
Weight		77.5±18.3
BMI		26.43±4.01
Normal or Healthy weight	234 (35.51)	
Overweight	311 (47.19)	
Obese	114 (17.30)	

BMI: body mass index.

Table 2. Frequency distribution of the right and left FNSA of the participants

Variable	Number (%)	Mean ± SD	Median
Right FNSA		131.35±5.98	130.61
Coxa vara	16 (2.43)		
normal range	584 (88.62)		
Coxa valga	59 (8.95)		
Left FNSA		130.97±5.94	130.41
Coxa vara	14 (2.12)		
normal range	579 (87.86)		
Coxa valga	66 (10.02)		
Left FNSA < right FNSA	395 (59.94)[*,b]		
Left FNSA > right FNSA	263 (39.91)		
Left FNSA = right FNSA	1 (0.15)		

FNSA: femoral neck shaft angle, *: P<0.001, b: Wilcoxon test.

ed a cross-sectional study in patients with femoral neck and intertrochanteric fractures and reported that the FNSA was 131.04° and 132.07°, respectively [20]. Jiang and colleagues showed that the mean FNSA in China was 133.02° that decreases with age in the general population [21]. These data are in line with the findings of our study. Albite, we found lower mean FNSA in the general population, and FNSA decreases significantly with age.

Boese et al. showed that the mean FNSA for male adults was 129.6° and 131.9° for females and the gender differences were significant. They mentioned that there was no significant difference between FNSA of right and left limbs [22]. Another article by Boese et al. in Germany reported the FNSA of normal adult subjects and patients with osteoarthritis. This study showed that the mean FNSA of healthy adults was 128.8° and in patients with osteoarthritis was 131.5°. They reported a high variance of FNSA and discussed that these differences could be due to the inconsistency of measurement methods such as a central issue and ethnical variations [23]. Another study from Germany reported the opposite result. Fischer et al.'s results indicated the mean FNSA was 127°, and men had a lower FNSA than women. They revealed that Body height and age had positively, and BMI had negatively associated with FNSA [24]. The results of our study were not consistent with these findings. On the other hand, Panola et al. in Finland evaluated the geometric effect of the proximal femoral region with intertrochanteric fractures, and they found that FNSA in men (136±4.6) was significantly higher than in women (133.2±0.6).

Assessments of FNSA and different relationships with various factors could have high clinical importance. The most important aspect of this issue could be designing the prosthesis for eligible patients. Furthermore, during surgical operations and repairing procedures, providing the best FNSA is critical for having the best results. The results of our study showed differences in FNSA among cases with different gender, age and BMI.

We found that FNSA was significantly higher in males. These data support our findings that the FNSA varies in different populations. As the results of anthropometry measurement differed in Germany, the same has happened in the result obtained from Iran. One study reported that the mean FNSA in this sample of the Iranian population was 6 to 7 degrees higher than the world average [25]. In another study, the average FNSA in the total population was 133.71° [26]. As these studies show, the mean FNSA of the general population could vary between different races in a country. In the present study, FNSA was higher than Jalali's results and lesser than Dehghan's, which may

Table 3. Comparison of FNSA of patients based on demographic and anthropometric characteristics

Variable		Mean	SD	Median	*P*-Value
Gender	Male	130.640	6.289	130.760	0.118[a]
	Female	130.570	4.982	130.450	
Age (years)	<20	136.067	5.590	136.485	0.001[b]
	20-39	130.272	5.599	129.920	
	40-59	131.346	5.622	130.460	
	>60	130.626	5.996	130.290	
BMI (kg/m^2)	Normal	132.149	6.091	131.240	0.030[b]
	Overweight	131.116	6.200	130.460	
	Obese	130.342	4.861	130.370	
Diabetes	No	131.368	5.996	130.580	0.878[a]
	Yes	131.129	5.809	130.735	
Hypertension	No	131.501	6.049	130.730	0.134[a]
	Yes	130.334	5.407	130.140	
Dyslipidemia	No	131.431	6.032	130.630	0.494[a]
	Yes	130.496	5.364	130.570	
Medical history	No	131.504	6.083	130.715	0.244[a]
	Yes	130.659	5.457	130.510	

[a]Mann-Whitney test, [b]Kruskal-Wallis test. BMI: body mass index, FNSA: femoral neck shaft angle.

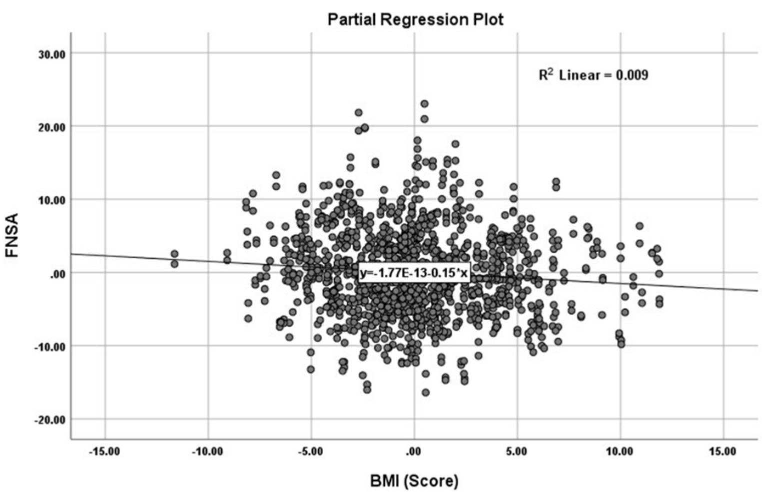

Figure 2. Evaluation of FNSA by adjusting gender, age, and BMI, FNSA of right and left sides.

indicate the influence of race and genetics of different areas in a country.

Furthermore, FSNA in Iran is different from other countries. FNSA of this study is significantly different from the study of India, Pakistan, East Asia, and France [27-30]. FNSA in Iran is similar to the results of the USA and England [31, 32], but the average of FNSA in this study is significantly higher than the study of the UK, France and India [5, 29].

In addition to the proximal geometry of the femur, factors such as BMI can be involved in fractures prediction. Therefore, some researchers have studied these factors in different societies. According to the present study, obese people had smaller FNSA than normal and overweight people. The study on the Indian population demonstrates a considerable correlation between BMI and FNSA in normal and obese BMI individuals [5]. Contrary to our results, another study from India showed no significant relationship between FNSA and BMI [33]. A study in Turkey reported a positive correlation between neck and shaft angle and BMI [34]. In another study from Iran, underweight people had a higher risk of proximal femoral fracture [26]. It seems that the variation in the results of existing studies may be due to differences in race and demographic characteristics of the selected samples.

Conclusion

The present cross-sectional study shows a significant relationship between BMI and femoral neck angle in the way that participants with normal BMI have higher FNSA. Obese people have had a smaller FNSA than normal or overweight people. We suggest that the physician might evaluate these parameters to better predict fracture risk in individuals. Based on the results of this study, physicians can consider this average FNSA in men and women in the north of Iran when choosing the appropriate prosthesis for repairing the femoral fractures. In addition, this diversity in neck angles of different races may

Table 4. Related variables of FNSA in multivariate analyses in linear regression model

Parameter	Parameter Estimation	Standard Error	95% CI of OR		*P*-value
			Lower	Upper	
Constant	135.800	1.0698	133.704	137.897	0.000
Gender (male to female)	1.074	0.3667	0.355	1.792	0.003
With medical history	0.767	0.4887	-0.191	-0.027	0.117
Age	-0.046	0.0096	-0.064	-0.027	0.000
BMI	-0.146	0.0438	-0.232	-0.060	0.001
Right FNSA	0.381	0.0216	0.338	0.423	0.000

BMI: body mass index, FNSA: femoral neck shaft angle.

help prosthetic companies to design prostheses with proper sizes related to people in different regions.

Disclosure of conflict of interest

None.

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