Body Mass Index as a Predictor for Diagnosis of Associated Injuries in Femoral Head Fracture Patients: A Retrospective Study

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Abstract

Purpose: To investigate the relationship between associated injuries (AI) suffered at time of accident in femoral head fracture (FHF) patients with age, sex, location of FHF (right or left leg), height, weight and body mass index (BMI) with using Pipkin classification.

Method: we retrospectively identified patients between January 2003 to September 2017 with FHF in our hospital database. The patients were divided in two groups; with AI and without AI. These two groups where then statistically studied against selected the variables.

Results: 72 patients were eligible with an average follow-up of 17 months. There were 57 males (79.2%) and 15 females (20.8%). We had 33.8% cases of type I, 28.4% type II, 13.5% type III and 23.3% type IV. We found no association between age, sex, height, weight and location of FHF with the groups with or without AI. The ratio of lighter weight (<57 kg) to heavier weight (>57 kg) patients was 2:3 for AI respectively. Patients with height <167 cm had 72.2% reported cases of AI while 72.3% for those >167 cm. A 50-50% reported cases for with or without AI on left and right leg. However there is a significant association between BMI and the groups with or without AI. Patients with BMI <23 kg/m^2 had higher chances of suffering from AI as well as having longer follow-up than their heavier peers (BMI >23 kg/m^2).

Conclusion: On the basis of this dataset, the BMI of FHF patient is a critical factor to consider in the diagnosis of associated injuries suffered at time of accident.

Keywords: Femoral head fracture; Associated injuries; MBI; Sex; Height; Weight

Introduction

In 1895, an autopsy was performed on a 35-year-old woman who had fallen from 2nd floor story building by John [1]. He observed prior to the procedure that the left leg was inverted and slightly shorter than the right leg. This was the first report of femoral head fracture (FHF) in history. FHF is very uncommon, some literature has reported occurrence rates as two cases per one million [2]. Hence large patient study, meta-analysis and validated outcomes are difficult to find [3-6]. However, the recognition of this injury has led to their classification systems, standardized treatment approaches and last but not the least conduction of studies in this field. Reported causes of FHF include simple falls (especially in elderly), fall from heights and sports injury but the most common is vehicular motor accidents. Fracture diagnosis and classification are mostly done through radiographic analysis. Complications include heterotopic ossification (2%-54%), femoral head necrosis (0%-24%), peripheral nerve damage (7%-27%) and post-traumatic degenerative disease (0%-72%) [7-9].

Anatomically the femoral head is part of the complex structures of the hip. Hip fracture is fast growing due to increase in road accidents [10]. It has been estimated that by 2050 there will be 4.5 to 6.3 million incidence of hip fracture [11,12]. And posterior hip fractures have about 4%-17% association with FHF [13-18].

Age, sex, weight, height and BMI have been documented in some literatures as risk factors in the occurrences of hip fracture. Evidence of these reports is inconclusive and furthermore, there has been no association of these parameters with FHF. We therefore conducted this study to investigate the relationship in these patients using Pipkin Femoral head classification system.

Materials and Methods

We did a retrospective study of all FHF patients registered in our hospital database between January 2003 to September

2017. We collected selected variables from the computerized hospital records such as age, sex, height, weight, BMI, length of hospital stay, with associated injuries (AI) or not and time of follow-up. Injuries here were defined as major traumas to the head, trunk and to the lower and upper limbs that needed medical attention like those to nerves, ligaments, bone fractures, internal bleeding and others. Minor injuries like bruises and lacerations were excluded. Patients who received diagnosis of FHF but had no radiological findings were excluded. Exclusion criteria also included patients with pathological fractures and unavailable details of clinical records. FHF was classified using Pipkin classification system. The Pipkin classification system uses fracture pattern to categorize femoral head fracture as follows;

- Type I is a facture below the fovea capitis femoris.
- Type II is a fracture above the fovea capitis femoris.
- Type III is a Type I or Type II fracture with femoral neck fracture.
- Type IV is a Type I or Type II fracture with acetabulum fracture.

All medical records, radiographs and classifications were reviewed at least twice by qualified orthopedic specialist.

In cases where the BMI were unknown, height and weight ascertain from the medical record were used in calculating the BMI by dividing weight in Kilograms by height in meters squared. The patients were divided in two groups; group with associated injury (AI) and the group without other associated injury. These two groups where then statistically studied against the following variables; BMI (<23 kg/m^2 and >23 kg/m^2), age (<50 and >50 years), weight (<57 kg and >57 kg), height (<167 cm and >167 cm), and location of FHF on either the left and right leg.

Data were analyzed using IBM SPSS version 19 (SPSS Inc. Chicago Illinois, USA). Student's t test was used for comparing quantitative variables between the groups with and without other associated injuries. An association between the two groups was assessed using Chi-square test. A P value of $<5\%$ was considered as statistical significance. Origin 8E software was used in plotting the graphs.

Results

Between January 2003 and September 2017 there were a total of 72 patients eligible for the study with an average follow-up of 17 months (from 1/2 month-122 months). Two patients had bilateral Pipkin type I fractures. There were 57 males (79.2%) and 15 females (20.8%). We had 25 cases (33.8%) type I, 21 cases (28.4%) type II, 10 cases (13.5%) type III and 18 cases (23.3%) of type IV fractures. Details of medical records retrieved have been shown in **Table 1**. **Figures 1-3** show the plotted graphs of results retrieved from our dataset.

For statistical analysis using Chi-square test, the P value for the groups with and without AI for height was 0.872, weight was 0.055, Age was 0.217, Sex was 0.505 and location of FHF (right or left) was 0.081.

The level of significance is shown on **Tables 2 and 3.** The data indicates that taller patients (171 ± 5.5 cm) mostly suffered from Pipkin type II fractures, followed by type I (168 ± 7.2 cm), then closely by type IV (168.5 ± 7.8 cm) while type III fractures were mostly common in shorter patients (163.6 ± 8.0 cm). Furthermore, the average calculated weight for Pipkin type I was 60 ± 12.1 kg, type II 59.4 ± 18.0 kg, type III 49.1 ± 16.2 kg and type IV 69.1 ± 16.0 kg.

The data showed no association between occurrences of AI in FHF patients with regards to their height, weight, Age, Sex, and location of FHF respectively.

The P value for the association between BMI and the two groups (with and without AI) was 0.024 (P<0.05), showing a significant association. Meaning FHF patients with BMI less than 23 kg/m^2 had higher chances of suffering from other related injuries.

Table 1: Showing clinical variables obtained from 72 patients. Numerical data expressed as mean ± standard deviation.

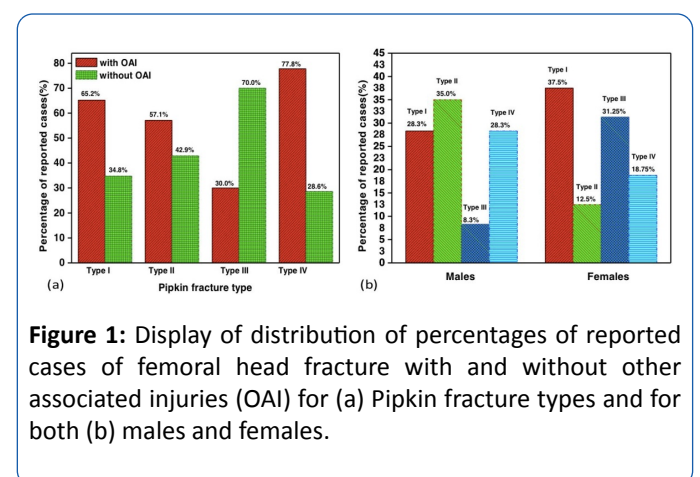| Variables	Pipkin Classification			
	Type I	**Type II**	**Type III**	**Type IV**
Age/Years	36.2+12.7	38.1+16.7	53.7+23.9	43.5 ± 13.0
Height/cm	168.7+7.2	171.1+5.5	163.6+8.0	168.5+7.8
Weight/cm	60.5+12.1	59.4 ± 18.2	49.1+16.2	69.1+16.0
BMI/(kg/m^2)	21.0+3.3	20.2 ± 5.4	18.9+4.9	24.8+7.4
Hospital stay/days	19.9 ± 2.1	13.1+9.0	13.5+3.5	25.7 ± 6.5

Figure 1: Display of distribution of percentages of reported cases of femoral head fracture with and without other associated injuries (OAI) for (a) Pipkin fracture types and for both (b) males and females.
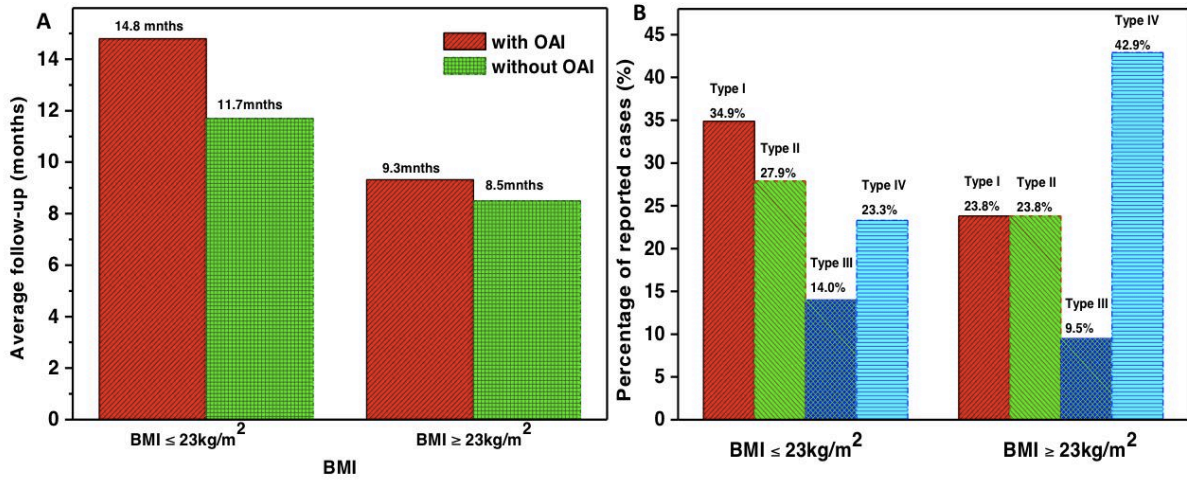
Figure 2: Distribution of relationship between BMI with (A) average follow-up with or without other associated injuries (OAI) and percentage of reported cases (B).
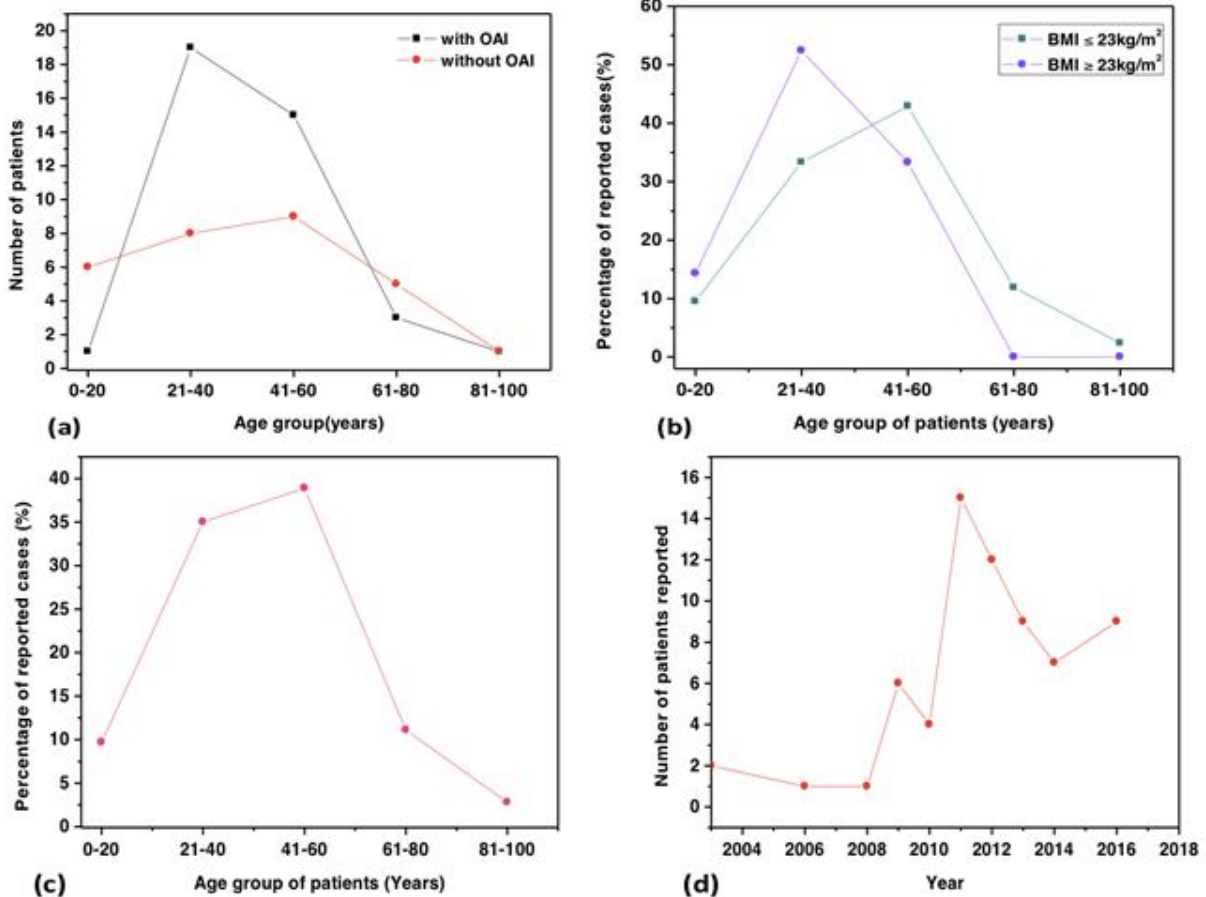

Figure 3: Shows the relationship between age groups of femoral head fracture patients (a) with or without other associated injuries (OAI), (b) body mass index (BMI), (c) reported age groups and (d) annual number of reported cases.

Table 2: Statistical assessment of age, sex and location of FHF (left and leg).

Group (%)				
Variables	with OAI	without OAI	P value	Comment

Age			0.217	No association found
<50 years	61.2	38.8		
>50 years	45	55		
Sex			0.505	No association found
Female	20	80		
Male	28.6	71.4		
Location of FHF			0.083	No association found
Right leg	70.3	29.7		
Left leg	50	50		

FHF: Femoral Head Fracture, OAI: Other Associated Injuries

Significance level was set at 5% (p<0.05)

Group (%)			
Variables	with OAI	without OAI	P value
Weight			
<57 kg	48	52	
57 kg	72.2	27.8	0.055
Height			
<167 cm	72.2	27.8	
>167 cm	72.3	25.7	0.872
BMI			
<23 kg/m^2	53.8	46.2	
>23 kg/m^2	84.2	15.8	0.024

BMI: Body Mass Index, OAI: Other Associated Injuries

Significance level was set at 5% (p<0.05)

Table 3: Statistical data.

Discussions

To our knowledge, this study is the first of its kind to assess the association of age, sex, fracture location, height, weight and BMI on FHF patients with or without other injuries acquired at time of accident. Our results suggest there is an association between the BMI of FHF patients and their injuries incurred during the time of accident. Patients with BMI less than 23 kg/m^2 suffered more from injuries like hip fractures, head trauma, lower and upper limb injuries as well as those to the torso. Moreover, apart from having a longer accumulative length of stay in hospital, these patients also had averagely longer follow-up period of 15 months (1/2 month-122 months) compared to their counterparts with BMI more than 23 kg/m^2 who had average follow-up of 13 months (1/2 month-45 months). However, we found no association of age, sex, weight and height with FHF injuries. The location of the FHF (left or right) was also neither a contributory factor.

Several studies have reported significant relationship of BMI on fracture injuries. Our results are consistent with several published reviews and meta-analysis which have concluded that there is an inverse association between BMI and fracture injuries [19-23]. A case-control study reported that a group of patients with significantly low BMI had more fractures occurring than the group without fracture [24]. Haakon and colleagues reported a lower BMI is important risk factor for fatal hip fractures [25] and a higher BMI was protective against subsequent hip fracture [26]. In a study by Kaze et al. an increase in BMI was associated with 15% reduction in vertebral fracture in men but not in women [27]. Obese women (classified by BMI) have been indicated to reduce hip fracture risks than their non-obese counterparts [28]. But it is worth mentioning that there are other authors who in contrast have reported that the risk of hip fracture increases with increasing BMI [29-32]. Overall, our study demonstrated a lower BMI increased the likelihood of other associated injuries.

Height which is a non-modifiable characteristic has been reported in several epidemiological studies to have potential risk factor for fracture. There has been the correlation of the geometric feature of the adult height with hip axis, angle of neck shaft and radius of femoral head [32]. It has also been argued that the center of gravity is higher in taller people than in shorter people and also the high risk due to reduced cortical thickness and bigger impact when falling caused possible heavier injuries [33-35]. Armstrong et al study in over 790,000 patients indicated that a proportionate increase of femoral neck fracture risk with increasing in height of 48% per 10 cm [35]. Furthermore, a meta-analysis by Xiao et al. also found a positive association between height and increased risk of hip fracture [36]. In contrast, this present study found no significant association of height with FHF. This could be because of the small population size due to the rare occurrence of FHF. However, it is important to note that when the height of the two groups with and without injury were analyzed, the two compared heights <167 cm and >167 cm had 72.2% and 72.3% reported cases of other associated injuries respectively. These indicated the taller and the shorter groups were equally affected and hence being tall or short was not a privilege against occurrences of other injuries.

When it comes to weight, it has been assumed that the overweight may have poorer balance which may increase risk of fall and therefore increasing risk of injury. The decrease in relative bone strength due to high ratio of weight to bone mass and bone area as well as a higher proportion of fat relative to muscle have been indicated in possible cause of fracture injuries. In our study groups however, when the weights were compared with having AI or not, there was a ratio of about 2:3 chances of injury for the lighter (<57 kg) and heavier (>57 kg) patients respectively. Pipkin classification was successfully used to classify all encountered fractures. For reported cases of FHF among the males and females **(Figure 1b),** type IV fracture was more common in men (35.0%) while type III was for the women (31.3%). Both females and males had similar reported cases of 20%-28.6% respectively for groups with other associated injuries. Hence, sex was not a protective factor against AI in FHF patients. When it came to

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the location of FHF, there was a 50%-50% reported cases of with and without AI for the left leg. The right leg however showed 70.3% of AI and 29.7% with no AI. This data adds to the sparse published works in this field of study.

It is interesting to note that the highest reported cases were found in 41-60 year group **(Figure 3c).** We have shown for the first time that FHF was more common among the middle ages (after young adulthood and before beginning of old age) than we traditionally thought was associated with the much younger patients. On the comparison with and without AI age groups, we found patients at 21-40 year group had more AI, this can be attributed to not just only the highly energy expenditure and physically active but also the increased exposure of the adult life to accidents. On the other hand, decline in number of cases was seen as the population ages (>60 years). This can be attributed to decreased physical activity in this age group that may decrease the level of exposure to injury and subsequently reduce risk of FHF.

Despite our finding on the relationship between BMI and associated injury in FHF patients, the exact mechanism of the association remains to be established. Several studies on BMI and injuries have made mention of possibilities like body fat mass distribution predicting bone mineral density [37], the influence of bone development and adult height intrauterine or childhood factors [38]. There has been also other implications of increased body mass in increasing bone mineral density that contribute to the integrity of bone structure [39], the protective value of obesity against fractures [40], effect of adipose tissue preservation on bone mineral density by endogenous estrogens [41] and their complex effects on bone quality, mass and strength. Robinovitch et al. have proposed that the state of the muscle activity at time of impact could be important in the risk of fracture by fall than the thickness of the hip soft tissue [42].

Our findings had limitations that deserve consideration. First is the standard limitation of any retrospective study. Second, the small patient numbers as FHF occurrence is very rear. And third, the quality of data was dependent on the completeness of patient history including the availability of medical images or radiographs for classification. A further prospective multicenter study setting would be helpful.

Conclusions

This manuscript thoroughly submerses the possible predictions for other injuries in FHF. We recommend for FHF patients with BMI <23 kg/m^2 extra caution should be considered when investigating other accompanying injuries. Beside the clinical complications related to FHF, the association of BMI with injury is highly relevant to better understand the dynamics in this field. This finding has good implication for patients and the orthopedic community. The present evidence suggests that FHF is much common in the middle age group that we thought was for much younger patients.

Funding

Conflict of Interest

Ghamor-Amegavi Prince Edem, Pan Zhijun, Wu Jiaqi and Jiangjun Jiang declare that have no conflicts of interest.

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