

# Distribution Characteristics Of New AO Classification In Different Age Groups Of Patients With Femoral Neck Fracture

**Yuxuan Jiang**

Xi'an Jiaotong University School of Medicine <https://orcid.org/0000-0003-1026-8038>

**Yangjun Zhu** (✉ [hyyccskzyj@163.com](mailto:hyyccskzyj@163.com))

Xi'an Jiaotong University School of Medicine

**Dongxu Feng**

Xi'an Jiaotong University School of Medicine

**Wei Huang**

Xi'an Jiaotong University School of Medicine

**Wuqiang Jiang**

Xi'an Jiaotong University School of Medicine

**Xiaolong Wang**

Xi'an Jiaotong University School of Medicine

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## Research article

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## **Abstract**

## **Objective**

The clinical and imaging data of patients diagnosed with femoral neck fractures (FNFs) in Xi 'an Honghui Hospital from 2018 to 2020.The epidemiological characteristics of these patients in different age groups were analyzed.

## **Methods**

In this study, patients with femoral neck fracture hospitalized in Xi 'an Honghui Hospital from January 2018 to January 2021 were divided into four groups according to age: the young group ( $\leq 44$  years old), the middle-aged group (45-59 years old),the young old group (60-74 years old), and the elderly group ( $\geq 75$  years old) to analyze age,sex,side,injury mechanism,new AO classification and other features. A total of 2071 patients were included for analysis.

## **Results**

There were 742 males (35.8%) and 1,329 females (64.2%).There were 1,106 patient s(53.4%) on the left side and 965 on the right side (46.6%).There were 1781 cases of low energy injury (86%) and 290 cases of high energy injury (14%), and the main injury mechanism was falling.The number of patients with femoral neck fracture in each year was 719 patients in 2018, 694 patients in 2019, and 661 patients in 2020, respectively. The number of patients showed a decreasing trend year by year, and the gender ratio and injury mechanism showed no significant trend of change. In the age group, the proportion of the young group was increasing year by year.Among the new AO classification, there were 1023 cases of B1.3, accounting for the highest proportion of 49.4%.The proportion of B2.2 was the highest in the young group (32.4%) .B1.3 and B2.2 were the main types in the middle-aged group, accounting for 31.7% and 32.0, respectively.B1.3 was dominant in the young old and elderly group (47.1% and 63.4%, respectively).

## **Conclusion**

The new classification combines the classic classification, which is easier to remember. The stability of fracture is more carefully distinguished,which is conducive to guiding the surgical treatment of many stable femoral neck fractures in middle-aged and young old people. ORIF treatment can be used to delay the age of hip replacement.

## **1. Introduction**

FNF is a common clinical proximal femoral fracture with high morbidity and mortality, especially in the elderly with osteoporosis (1).Three types of classification are commonly used in hospital: the Pauwels classification according to the Angle of the distal fracture line, the Garden classification according to displacement type of the fracture and the anatomical classification according to the location of the fracture line. The AO classification has been rarely used due to its complexity and low consistency among doctors (2, 3).

In 2018, AO proposed a new classification of FNFs (4), which combined the three commonly used classification.The new AO classification is easy to remember and distinguish fracture types more comprehensively.

So that doctors have a better classification method for FNFs. It will be of great help to guide clinical treatment.However, the treatment methods for FNF does not depend solely on fracture classification. Age is an important factor in this fracture to select treatment methods (5). Therefore, the purpose of this study was to explore the distribution characteristics of new AO types in different age groups.

## **2. Data And Methods**

### **2.1 General Information**

This retrospective study involved 2071 hospitalized patients with FNF from January 1, 2018 to January 1, 2021 in trauma Department of Hong Hui Hospital, Xi'an Jiaotong University School of Medicine (Xi'an, China). Number of fractures, gender distribution,side of fractures, age of patients, injury mechanism and New AO classification have been analyzed in this study. The patients were divided into four age groups according to Age classification standard(WHO,2020 ): the young group (< 44 years old), the middle-aged group (45-59 years old), the young old group (60-74 years old), and the elderly group (> 75 years old).

### **2.2 Inclusion and exclusion criteria**

#### **Inclusion criteria:**

1. New femoral neck fracture; 2. Complete medical records and imaging data.

#### **Exclusion criteria:**

1. Pathological fracture; 2. Combined with other ipsilateral proximal femoral fracture; 3. Severe hip deformity.

### **2.3 Method**

In this study, all imaging data were classified by 3 attending orthopedic surgeons and 2 radiologists. Before the start, the doctors participating in the film reading should be trained to ensure that they can master the classification standards. If a data has two or more results, the chief physician and 5 physicians discuss together to determine the final classification.

### 3. Result

#### 3.1 Number of patients

A total of 2,071 patients were registered. The mean age of the patients was  $68.31 \pm 15.85$  years old (range, 16-99 years old). There were 742 males (35.8%) and 1329 females (64.2%), and the ratio of male to female was 1:1.79. The proportion of female patients was significantly higher than that of male patients. By comparing the number of patients in different age groups, the elderly group had the highest proportion (43.5%), and the young group had the lowest proportion (8.9%).

By comparing the sex ratio of male and female in different age groups, the proportion of male in the young group was much higher than female, while the proportion of female patients was higher than male in other age groups, among which the proportion of female patients in the elderly group was the largest (70.6%). Among the fracture sides, there were 1106 cases on the left side and 965 cases on the right side, and the left side accounted for more (53.4%). In all age groups, the left side was more than the right side. According to the statistics of medical records, the injury mechanism were divided into low-energy injury (fall, sports injury, fight) and high-energy injury (traffic accident, fall from high, heavy pound injury, machine injury). Among them, there were 1,781 cases of low-energy injury and 290 cases of high-energy injury. The most common mechanism of injury was falling (1764 cases). The proportion of low-energy injury was higher than that of high-energy injury in all age groups, and the proportion of low-energy injury gradually increased with the increase of age (Table 2).

Table 1  
Characteristics of general information in different age groups

	Age groups (years)	Sex		Side		Mechanism of injury							
		Male	Female	left	right	Fall	Sports injury	Fight	Low-energy	Traffic accident	Fall from high	Heavy pound injury	M
Age groups (years)	The young( $\leq 44$ )	127 (68.6%)	58 (31.4%)	100 (54.1%)	85 (45.9%)	97	8	1	106 (57.3%)	49	29	1	0
	The middle-aged (45-59)	159 (45.8%)	188 (54.2%)	178 (51.3%)	169(48.7%)	238	6	0	244 (70.3%)	68	32	2	1
	The young old(60-74)	191(29.9%)	448(70.1%)	343 (53.7%)	296(46.3%)	551	2	0	553 (86.5%)	67	17	2	0
	The elderly( $\geq 75$ )	265(29.4%)	635(70.6%)	485 (53.9%)	415(46.1%)	878	0	0	878 (97.6%)	22	0	0	0
	Total	742 (35.8%)	1329 (64.2%)	1106(53.4%)	965(46.6%)	1764	16	1	1781 (86%)	206	78	5	1

Age classification standard(WHO,2020 ): the young group (< 44 years old), the middle-aged group (45-59 years old), the young old group (60-74 years old), an old).

Table 2  
Distribution of new AO classification in different age groups

	B1.1	B1.2	B1.3	B2.1	B2.2	B2.3	B3	□
The young( $\leq 44$ )	35(18.9%)	9(4.9%)	41(22.2%)	7(3.8%)	60(32.4%)	18(9.7%)	15(8.1%)	185
The middle-aged (45-59)	61(17.6%)	15(4.3%)	110(31.7%)	15(4.3%)	111(32.0%)	16(4.6%)	19(5.5%)	347
The young old(60-74)	96(15.0%)	20(3.1%)	301(47.1%)	34(5.3%)	124(19.4%)	18(2.8%)	46(7.2%)	639
The elderly( $\geq 75$ )	105(11.7%)	24(2.7%)	571(63.4%)	37(4.1%)	83(9.2%)	7(0.8%)	73(8.1%)	900
Total	297(14.3%)	68(3.3%)	1023(49.4%)	93(4.5%)	378(18.3%)	59(2.8%)	153(7.4%)	2071

In the new AO classification ,31B1, 31B2, 31B3 corresponds to subcapital ,transcervical and basicervical. B1.1 (valgus impacted), B1.2 (nondisplaced) and B1.3 (displaced). B2.1 ( $< 30^\circ$ , Simple fracture), B2.2 ( $30\text{-}70^\circ$ , multifragmentary fracture), B2.3 ( $> 70^\circ$ , shear fracture),B3(basicervical fracture).

#### 3.2 Incidence Trend

Of the hospitalized patients we counted, 719 in 2018, 694 in 2019, and 661 in 2020. The number of patients showed a decreasing trend year by year, and the gender ratio and injury mechanism showed no obvious trend of change. In age groups, the proportion of the young group increased year by year, accounting for 8.66% in 2018, 8.93% in 2019 and 9.23% in 2020, the aging trend of this fracture may be alleviated (Figure 1).

### 3.3 Distribution Of Fracture Classification

There were 1023 cases of B1.3, accounting for the highest proportion of 49.4%, 60 cases of B2.2 in the young group, accounting for the highest proportion of 32.4%. B1.3 and B2.2 in the middle-aged group were the main types of the group, accounting for 31.7% and 32.0%, respectively. B1.3 was the dominant type in the young old and elderly group. And the constituent proportions are 47.1% and 63.4% respectively.

## 4. Discussion

In the past application of the classification of FNF, the position of fracture line is not distinguished, and the classification of FNF is often confused.

Studies on the classification consistency of FNFs in recent years indicate that the previous AO classification, Pauwels classification and Garden classification have interobserver variation, and the AO classification is the most obvious(2, 3, 6). This is mainly because the original AO classification was based on X-ray images and was self-concluded based on patient imaging data. The rules for fracture typing are not used frequently and are not well understood by clinicians. However, the new AO classification cleverly combines the three types of FNF classification commonly used by clinicians, so that the widely used classification has been standardized and improved, which will bring great help to the clinical classification of FNF.

In this classification, 31B1, 31B2, 31B3 corresponds to subcapital ,transcervical and basicervical. 31B1 is divided into three subgroups, B1.1 (valgus impacted), B1.2 (nondisplaced) and B1.3 (displaced). 31B2 is also divided into three subgroups according to Pauwels Angle and bone block type, B2.1 (< 30°, Simple fracture), B2.2 (30-70°, multifragmentary fracture), B2.3 (> 70°, shear fracture). In 31B2,we mainly use the Pauwels Angle to judge the classification. However, in this classification, the Angle in the original Pauwels classification is not used, maybe a larger shear angle helps to distinguish between the stability of the fracture(7).

In the previous experience in the treatment of FNFs, B1.1, B1.2, B2.1 and B3 of the new AO classification are stable fractures. In B1.1, the cortex of the femoral neck is inserted into the cancellous bone, and the fracture ends overlap. It is a stable fracture, with high probability of healing. It is generally difficult to release the insertion state with closed reduction. If it can not be reset accurately, it should be fixed in situ(8).31B3 is basal FNF, which is closer to trochanteric region. It has good blood supply and a high probability of healing.In the clinical treatment in China, these two types of FNF have good curative effects in closed or open reduction and internal fixation. After comprehensive consideration of the patient's will, age, bone condition and complications, most of them choose to perform closed or open reduction and internal fixation to delay the time of arthroplasty.

The proportion of fracture types varied among age groups, B2.2 (60.32.4%) was predominant in the young group, B2.3 fractures with high shear angle had the largest proportion in the young group, 18 (9.7%). Young patients generally have better bone quality.High-energy mechanism can cause a FNF pattern that is vertically oriented with a shear component making it biomechanically more unstable. Most cause transcervical fractures. Young patients are the same with elderly people,big shear angle of the fracture non-union, implant failure,osteonecrosis rate is higher than other type in B2. But because of the active patients following high-speed trauma when a head-sparing technique is required, almost all young patients choose ORIF(9-11).

As Table 2, the proportion of B1.1,B2.1,B2.2 and B2.3 has decreased with age.And B1.3 has gradually increased with age. The risk of complications is high after internal fixation treatment. Therefore, in the elderly, most patients chose THA or HA.However, in the middle-aged group and the young old group, these stable fractures of B1.1,B1.2,B2.1 and B3 occupy a certain proportion, about 1 / 3 of the whole group. If the posterior tilt angle <20°in B1.1 and B1.2, we can choose internal fixation treatment(12, 13).After multiple considerations,we can devise a more rational protocol for these patients.

In previous studies on Garden classification of femoral neck fracture, the existence of Garden TYPE I has been controversial(14, 15).In this study, a total of 6 incomplete fractures based on radiographic evaluation. By observing its CT scan, only 1 patient looks like incomplete fracture and the patient was only 22 years old, similar to greenstick fracture.

Femoral neck fractures are affected by a variety of factors and are generally considered to be closely associated with Femoral neck bone mineral density and osteoporosis. In our study, FNFs were more common in women, with an overall male to female ratio of 1:1.79. In the young group, The male/female ratio was 2.19:1. In the middle-aged group, the ratio of male to female was 1:1.18, the male/female ratio was almost equal. In the young old group and the elderly group, the ratio of male to female was seriously unbalanced, which was 1:2.46 and 1:2.24.

Women in both age groups are in postmenopause.The loss of estrogen in the body leads to osteoporosis which leads to more serious bone loss than that of men. Elderly women are more likely to have such fractures(16). However, there are also articles that suggest that femoral neck bone mineral density, physical function were not associated with FNFs(17).

In the study of FNF, the main injury mechanism of the elderly is fall with low energy. And high energy injury is the main cause of femoral neck fracture in young people(18, 19).In our study, the main injury mechanism of all age groups is low energy injury dominated by fall, and high energy injury accounts for 42.7% of the young group and only 2.4% of the elderly group.A large sample survey of hip fracture in Japan found that fall was the injury mechanism of 80% of hip fracture patients.The number of patients is the highest in January of every year(19).In Catalonia, Spain and Czech Prague, the incidence rate of femoral neck fracture is related to seasonal changes, and more in winter(20, 21).

In recent years, international studies on the incidence trend of femoral neck fracture show that the incidence of the elderly population has a decreasing trend year by year, which may be related to the safety awareness of the elderly and the formation of prevention of osteoporosis(20, 22). In this study, there was no obvious trend in the proportion of the elderly over 60 years old, but the proportion of patients in the young group increased, which may mean the improvement of people's health awareness, indicating that the age of patients with femoral neck fracture is getting younger. In some European countries, the COVID-19 has great influence on the incidence of FNF, compared to the past few years have a certain percentage of the drop. This is related to the decrease in people going out during the pandemic. In the UK, the number of femoral neck fractures decreased from 410 to 327 during the 12-week coronavirus lockdown period, a decrease of 20.2% compared to the same period in the previous year(23). In Italy(ASST Sette Laghi, Varese, Lombardy, Italy), the number of femur neck fractures fell from 54 last year to 46 in the two months of the pandemic emergency, a decrease of 14.8%(24). The Clinical Center of Nis (Nis, Serbia) decreased from 28 to 17, with a decrease rate of 39.3%(25). Xi 'an city of Shaanxi Province is a medium-low risk area. From January 23, 2020 when Wuhan was closed to April 8, 2020 when Wuhan was lifted, a total of 199 patients with femoral neck fracture were admitted to our hospital during the three months from January to April, 190 in the same period in 19 and 192 in the same period in 18. The number of patients with femoral neck fracture was not affected.

## 5. Conclusion

The new AO classification is easy to remember after combining the Garden-Pauwels and anatomical classification. This classification can distinguish stable and unstable fractures and is more helpful to guide surgical treatment. In this study, stable fractures occupy a certain proportion in middle-aged and young old people. Garden I fracture exists, but it is rare. The proportion of young patients with femoral neck is increasing year by year, which may be related to the increase of private vehicles and the improvement of health awareness among the elderly. During the COVID-19 outbreak, the hospitalization of femoral neck fracture in the middle and low risk areas in China has not been affected.

## Limitations And Future Areas Of Research

The limitations of this study due to the short study period analysed it doesn't do a good job of showing age trends and the sample size of the single center analysis was too small to be representative of the entire region. Future studies will improve the age of ORIF in patients with FNFs based on the new AO classification, delaying hip replacement and avoiding repeated revision. A multi-center, multi-year big data study was conducted on patients with femoral neck fracture to observe the age-changing trend.

## Declarations

### Ethics approval and consent to participate

It was approved by the Ethics Committee of Hong Hui Hospital. All patients agreed to individual clinical details and accompanying images being published and provided written informed consent.

### Consent for publication

All authors gave their consent for publishing.

### Availability of data and materials

All data in this article are available.

### Competing interests

The authors declare that they have no competing interests.

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There is no financial or personal relationship with other people or organizations that could inappropriately influence (bias) our work. There is no employment, consultancies, stock ownership, honoraria, paid expert testimony, patient applications/registrations, and grants or other funding.

### Authors' contributions

Department of Orthopaedics and Trauma, Hong Hui Hospital, Xi'an Jiaotong University College of Medicine, Xi'an, Shaanxi, People's Republic of China.

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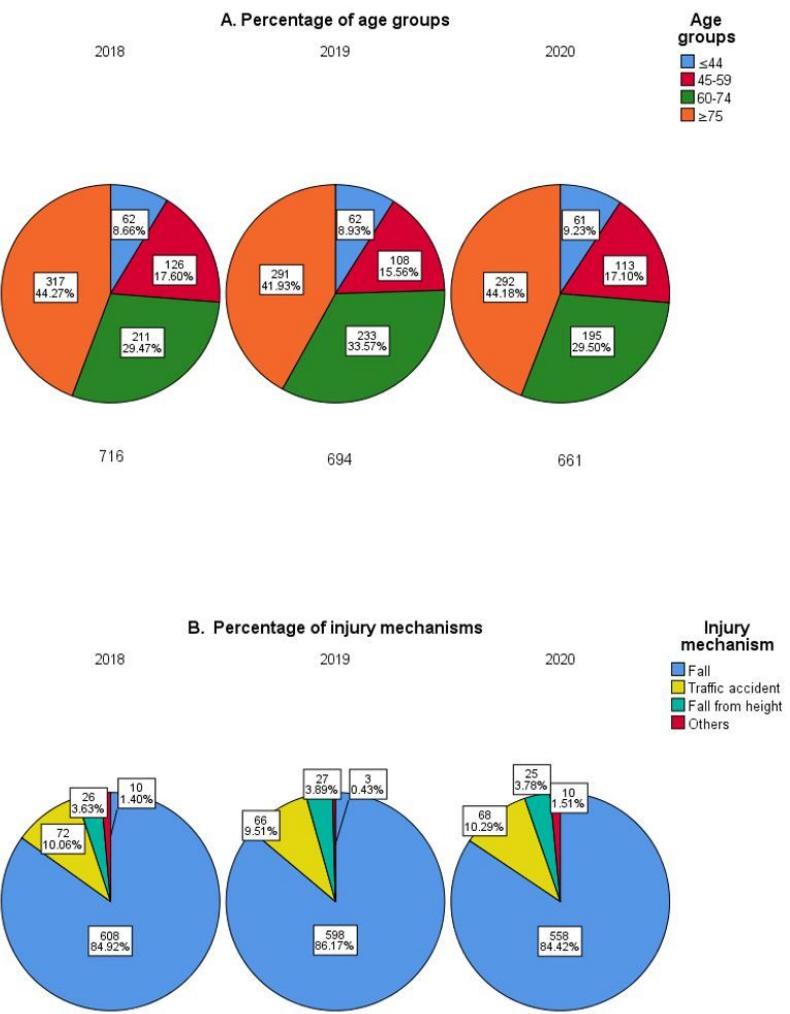
Not applicable.

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## Figures



**Figure 1**

(A)Percentage of different age groups in each year.(B)Percentage of different injury mechanisms in each year.

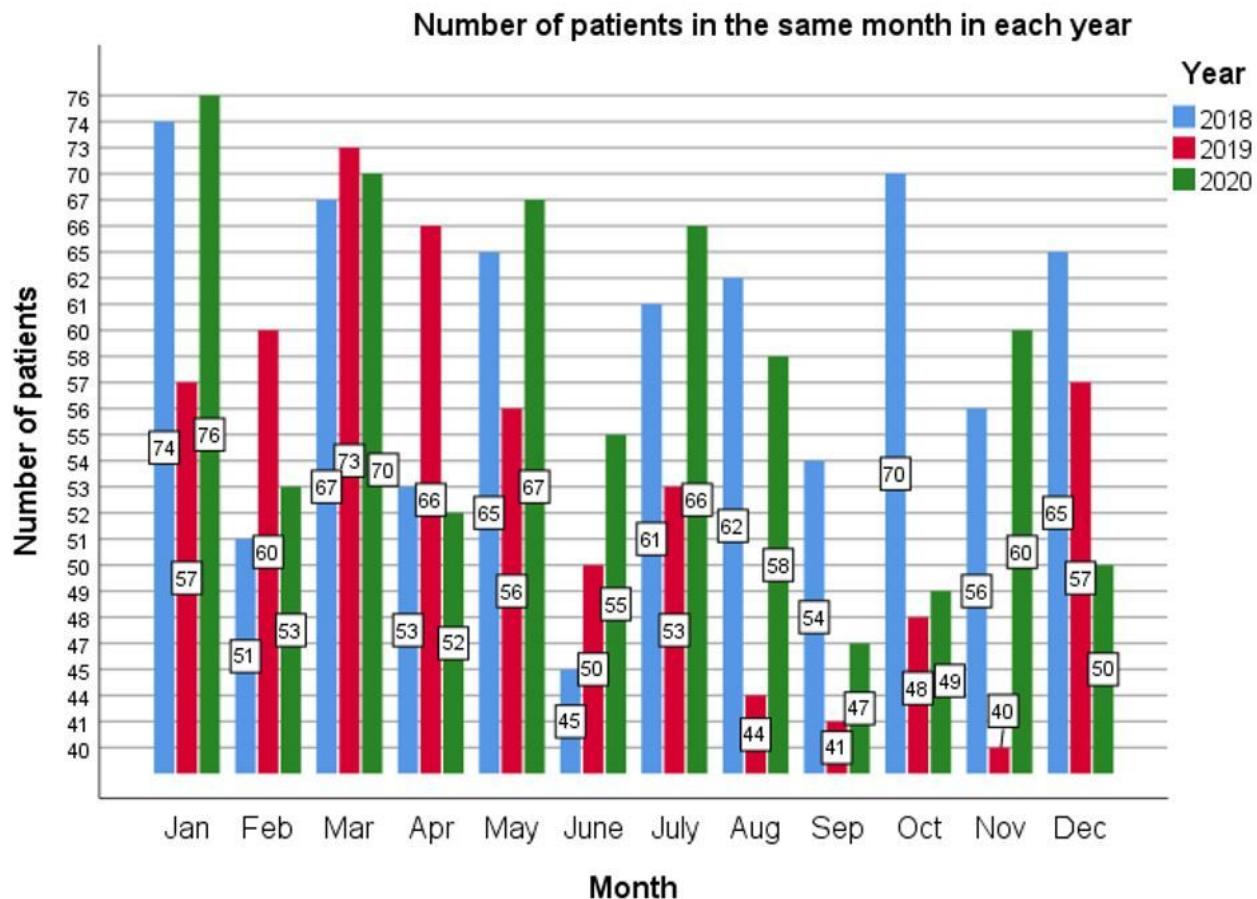


Figure 2

Number of patients in the same month in different years.