Distribution Characteristics of New AO Classification in Different Age Groups of Patients with Femoral Neck Fracture

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Research Article

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Abstract

Objective: Femoral neck fractures(FNFs) patients from 2018 to 2020 were classified according to the new AO classification. To observe the proportion of new AO classification and provide reference for improving the upper age limit of internal fixation(IF) treatment

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 (≤ 44 years old), the middle-aged group (45-59 years old), the young elderly group (60-74 years old), and the elderly group (≥ 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 patients (53.4%) on the left side and 965 on the right side (46.6%). There were 1781 patients of low energy injury (86%) and 290 patients 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 patients 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 elderly and elderly group (47.1% and 63.4%, respectively).

Conclusion: The new AO classification is more detailed and practical. 1/3 of the fracture types of middle aged and young elderly people may achieve satisfactory results through IF.

Level of evidence: III.

Highlights

The 2018 AO FNF classification mentioned in this study has rarely been used in clinical studies. In the elderly, there are many types of fractures can achieve good results through internal fixation. Among the patients in this study, these types account for a large proportion in the middle-aged and young elderly groups.

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 intra- and interobserver agreement (2, 3).

Usually we refer to Garden classification to select the treatment of elderly patients with FNF. Garden type I, II first choice is closed reduction and cannulated screw fixation. Garden type III-IV hip replacement is the preferred treatment (4). However, Garden classification is too simple to distinguish some stable or well vascularized FNFs. A portion of patients who can choose IF have adopted hip replacement, which makes the family of hospitalized patients and medical insurance institutions bear a higher economic burden (5). It also deprives patients of the opportunity to preserve the native hip joint. In 2018, the international comprehensive classification of fractures and dislocations committee proposed a new classification of FNFs (6), we called it new AO classification which combined the three commonly used classification. This classification is easy to remember and distinguish fracture types more comprehensively.

The treatment of FNF depends not only on the classification of fractures, but also on age (7, 8). In this study, patients with FNF were classified by new AO classification in different age groups. The purpose is to observe the proportion of new AO classification in FNF patients and provide reference for improving the upper age limit of IF treatment.

2. Materials and Methods

2.1 Study design and setting

This single-center, retrospective observational study involved hospitalized patients diagnosed with FNF in trauma Department of Xi'an Hong Hui Hospital from January 1, 2018 to January 1, 2021.

Epidemiological data on age, sex, fracture side, injury mechanism and new AO classification were analyzed. According to the statistics of medical records, the injury mechanism were categorized injury fall, sports injury, fight as low-energy and traffic accident, fall from high, heavy pound injury, machine injury as high-energy injury.

Any fracture centered between a line drawn at the distal extent of femoral head articular cartilage and the intertrochanteric line distally are FNFs which in new AO classification is type 31B. This type is divided into three groups, 31B1 is subcapital fracture, 31B2 is transcervical fracture and 31B3 is basicervical fracture. Type 31B1 is divided into three subgroups. Type 31B1.1 is valgus impacted fracture, type 31B1.2 is nondisplaced fracture, type 31B1.3 is displaced fracture. Type 31B2 is also divided into three subgroups according to Pauwels Angle and bone block type. In this study, we mainly use the Pauwels Angle to judge the classification. Type 31B2.1 is simple fracture (Pauwels angle $< 30^\circ$), type 31B2.2 is multifragmentary fracture (Pauwels angle $30^\circ - 70^\circ$), type 31B2.3 is shear fracture (Pauwels angle $> 70^\circ$). 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 (9). Details of the new AO classification of FNF are shown in Figure 1.

The patients were divided into four age groups: the young group (< 44 years old), the middle aged group (45-59 years old), the young elderly group (60-74 years old), and the elderly group (> 75 years old).

2.2 Patient selection

Inclusion criteria:(1)fresh femoral neck fracture;(2)complete medical records and imaging data.

Exclusion criteria: (1)peri-implant, periprosthetic, and pathological fractures; (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.

2.4 Statistics

Variables are presented as the proportion of all fractures(%), i.e., the available number of inputs in the register excluding any missing values.Nominal variables are presented as proportions of all

fractures and scale variables as means $\pm$ standard deviation ($\pm$ SD). An independent sample t test was used to compare scale variables. For the log-rank test $p < 0.05$ was considered significant.

2.5 Ethics

The study was approved by the Ethics Committee of Hong Hui Hospital and carried out according to the Helsinki Declaration.

3. Result

3.1 Number of patients

A total of 2,071 patients were registered.The mean age of the patients was 68.31 ± 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%).

There were 1106 patients on the left side and 965 patients 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. Among them, there were 1,781 patients of low-energy injury and 290 patients of high-energy injury. The most common mechanism of injury was falling (1764 patients). 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 1).

Table 1
Characteristics of general information in different age groups

		Sex		Side		Mechanism of injury							
		Male	Female	left	right	Fall	Sports injury	Fight	Low-energy	Traffic accident	Fall from high	Heavy pound injury	Ni
Age groups (years)	The young(≤ 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 elderly(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(≥ 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 elderly group (60–74 years old), the elderly group (≥ 75 years old).													

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 FNF may be alleviated (Fig. 2).

3.3 Distribution Of Fracture Classification

In new AO classification, 31B1.1 accounted for the highest proportion (49.4%), with 1023 patients. In the young group, 31B2.2 accounted for the highest proportion (32.4%), with 60 patients. Type B1.3 (31.7%) and 31B2.2 (32.0%) were the main types in the middle-aged group, with 110 and 111 patients respectively. Type 31B1.3 (47.1% and 63.4%) was the main type in the young and elderly group and the elderly group, with 301 patients and 571 patients 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, 10). 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 the previous experience in the treatment of FNFs, type 31B1.1, 31B1.2, 31B2.1, 31B2.2 and 31B3 of the new AO classification are stable fractures. These types usually have good results after IF. In 31B1.1, 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. In practice, type 31B1.1 (valgus impacted) and 31B1.2 fractures are often grouped together as nondisplaced fractures and are treated primarily with IF(11). 31B3 is basicervical FNF, which is closer to trochanteric region. It has good blood supply and a high probability of healing. Observational study of Sundkvist et al.(8) found 40,049 FNFs were registered in the Swedish Fracture Register. 11.6% was basi-cervical FNFs. The treatment of patients over 60 years old is almost equally divided into IF and arthroplasty. They are both valid procedures for the treatment of basi-cervical FNFs, There is no difference in terms of survivorship between IF and arthroplasty in the overall population. The incidence of postoperative complications in patients with arthroplasty was higher than that in patients with IF(12). In the study of patients with FNFs aged 50–60 years, Wang et al.(13) found that patients with Pauwels type II had optimal outcomes after successful IF. In a long-term follow-up study of FNFs treated with cannulated IF by Ju et al.(14) found that, Garden fracture type was not significantly associated with femoral head necrosis or Harris score. Elderly patients aged ≥ 60 years with Pauwels I and II fractures exhibited a significantly lower necrosis rate than those with Pauwels III fractures, which means 31B2.1 and 31B2.2 can also have good outcomes by IF in elderly patients.

Johnson et al.(15)reported that the use of total hip arthroplasty(THA) in treatment of FNFs in patients from the age of 45–64 increased 4.2-fold from 2002 to 2014. Among them, some patients may achieve satisfactory results as long as they are treated with IF.Their study demonstrates that patients undergoing THA had higher in hospital complication rates and longer length of stay than patients undergoing IF. The in-hospital mortality for patients undergoing a hip hemiarthroplasty(HA) was higher (1.2%) than either THA (0.2%) or IF (0.5%).Two studies of nondisplaced FNF patients over the age of 70 found that among patients receiving IF and the arthroplasty, patients treated with arthroplasty had higher 30-days mortality rate(11%)(16) and patients treated with internal fixation have a higher 2-year mortality rate(36%)(17).Several studies have shown that IF may be more cost-effective than hip arthroplasty because the total cost is less(15, 18, 19).Lagergren et al.(20)reported that HA with baseline results in patient reported outcome measure indicating poorer health and function, as well as higher mortality and lower response rates with patients aged 60–69.IF tend to fail in up to 1/3 of the cases but can offer the benefits of a biologically intact hip if successful.In young elderly people, it is still worth for doctors to choose IF to preserve the native hip joint among the appropriate fracture types.

As Table 2, the proportion of 31B1.1,31B2.1,31B2.2 and 31B2.3 has decreased with age.And B1.3 has gradually increased with age. This type of FNF has a higher risk of complications after IF(21). Therefore, in the elderly group, most patients chose THA or HA. However, in the middle-aged group and the young elderly group, these stable fractures of 31B1.1,31B1.2,31B2.1,31B2.2 and 31B3 occupy a certain proportion, about 1 / 3 of the whole group. Most of these types of fractures can get good treatment results when treated with IF.Doctors can give priority to preserving the original hip joint when treating elderly patients with these fracture types.Two studies have shown that patients with a posterior tilt of greater than 20° have a high rate of revision surgery when treated with IF and may benefit from primary arthroplasty(22, 23).In the IF treatment of middle-aged and young elderly group, we should pay more attention to the posterior tilt of the proximal femoral neck.

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(≤44)	35(18.9%)	9(4.9%)	41(22.2%)	7(3.8%)	60(32.4%)	18(9.7%)	15(8.1%)	185(100.0%)
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(100.0%)
The young elderly(60–74)	96(15.0%)	20(3.1%)	301(47.1%)	34(5.3%)	124(19.4%)	18(2.8%)	46(7.2%)	639(100.0%)
The elderly(≥75)	105(11.7%)	24(2.7%)	571(63.4%)	37(4.1%)	83(9.2%)	7(0.8%)	73(8.1%)	900(100.0%)
Total	297(14.3%)	68(3.3%)	1023(49.4%)	93(4.5%)	378(18.3%)	59(2.8%)	153(7.4%)	2071(100.0%)
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°, Simple fracture), B2.2 (30–70°, multifragmentary fracture), B2.3 (> 70°, shear fracture),B3(basicervical fracture).								

The proportion of fracture types varied among age groups, 31B2.2 (60,32.4%) was predominant in the young group. The proportion of type 31B2.3 shear fractures was the largest in the young group, with 18 patients (9.7%). Young patients generally have better bone quality.High-energy injury can cause a FNF pattern that is vertically oriented with a shear component making it biomechanically more unstable. In the young patients with shear FNFs, reoperations for painful implants, osteonecrosis, and nonunion are common. But because of the active patients following high-speed trauma when a head-sparing technique is required, almost all young patients choose IF. A 90-day reoperation rate was 9.4%, rate of conversion to THA was 6% and a 10-year reoperation rate was 34% and rate of conversion to THA was 14%, indicating that there is a substantial opportunity to improve the treatment of femoral neck fractures in the non-geriatric population(24, 25). Strict and accurate classification of fractures before operation is of great significance to reduce the reoperation rate of non-geriatric population.

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 elderly 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(26). However, there are also articles that suggest that femoral neck bone mineral density, physical function were not associated with FNFs(27).

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(28, 29).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(29).

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(30, 31). 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 indicating that people's health awareness is gradually improving, and the age of patients with FNF may be getting younger.

5. Conclusion

The new AO classification combined the Garden, Pauwels and anatomical classification, which can classify FNFs more accurately and help to guide surgical treatment. In the new AO classification, 1/3 of the fracture types of middle aged and young elderly people may achieve satisfactory results through internal fixation.

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. This classification is more specific to the classification of fracture types, but we have not evaluated the interobserver reliability in radiographic determination, which will be further improved in future research. Future studies will improve the age of IF in patients with FNFs based on the new AO classification, delaying hip replacement. A multi-center, multi-year big data study was conducted on patients with femoral neck fracture to observe the age-changing trend.

Abbreviations

FNFs
femoral neck fractures
IF
internal fixation
THA
total hip arthroplasty
HA
hemi arthroplasty

Declarations

Ethics approval

The study was approved by the Ethics Committee of Hong Hui Hospital and written informed consent was obtained from each patient or their legal guardian(s).

Consent for publication

All authors gave their consent for publishing.

Availability of data and materials

The datasets used/or analyzed during the current study are available from the corresponding author on a reasonable request.

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

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References

1. Fletcher J, Sommer C, Eckardt H, Knobe M, Gueorguiev B, Stoffel K. Intracapsular Femoral Neck Fractures-A Surgical Management Algorithm. *Medicina (Kaunas)* 2021; 57.
2. Masionis P, Uvarovas V, Mazarevičius G, et al. The reliability of a Garden, AO and simple II stage classifications for intracapsular hip fractures. *Orthop Traumatol Surg Res* 2019; 105: 29–33.
3. Crijns TJ, Janssen SJ, Davis JT, Ring D, Sanchez HB. Reliability of the classification of proximal femur fractures: Does clinical experience matter. *Injury* 2018; 49: 819 – 23.
4. Zhang LZ, Gao J, Zhang ZC, Wang XW, Zhang JZ, Sun TS. [Comparison of clinical effects of total artificial hip replacement and cannulated screw fixation for the treatment of displaced femoral neck fractures in elderly patients]. *Zhongguo Gu Shang* 2018; 31: 103 – 10.

5. Wang Y, Cui H, Zhang D, Zhang P. Hospitalisation cost analysis on hip fracture in China: a multicentre study among 73 tertiary hospitals. *BMJ Open* 2018; 8: e019147.
6. Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF. Fracture and Dislocation Classification Compendium-2018. *J Orthop Trauma* 2018; 32 Suppl 1: S1-S170.
7. Sekeitto AR, Sikhauli N, van der Jagt DR, Mokete L, Pietrzak J. The management of displaced femoral neck fractures: a narrative review. *EFORT Open Rev* 2021; 6: 139 – 44.
8. Sundkvist J, Bruggeman A, Sayed-Noor A, Möller M, Wolf O, Mukka S. Epidemiology, classification, treatment, and mortality of adult femoral neck and basicervical fractures: an observational study of 40,049 fractures from the Swedish Fracture Register. *J Orthop Surg Res* 2021; 16: 561.
9. Bartoníček J. Pauwels' classification of femoral neck fractures: correct interpretation of the original. *J Orthop Trauma* 2001; 15: 358 – 60.
10. Gašpar D, Crnković T, Durović D, Podsednik D, Slišurić F. AO group, AO subgroup, Garden and Pauwels classification systems of femoral neck fractures: are they reliable and reproducible. *Med Glas (Zenica)* 2012; 9: 243-7.
11. Cronin PK, Freccero DM, Kain MS, Marcantonio AJ, Horwitz DS, Tornetta P 3rd. Garden 1 and 2 Femoral Neck Fractures Collapse More Than Expected After Closed Reduction and Percutaneous Pinning. *J Orthop Trauma* 2019; 33: 116-9.
12. Davanzo D, Previtali D, Tamborini S, et al. Comparison of the survivorship between arthroplasty and ORIF for basi-cervical femoral neck fractures in the overall population and in polymorbid patients. *Orthop Traumatol Surg Res* 2021; 107: 102789.
13. Wang CT, Chen JW, Wu K, et al. Suboptimal outcomes after closed reduction and internal fixation of displaced femoral neck fractures in middle-aged patients: is internal fixation adequate in this age group. *BMC Musculoskelet Disord* 2018; 19: 190.
14. Ju FX, Hou RX, Xiong J, Shi HF, Chen YX, Wang JF. Outcomes of Femoral Neck Fractures Treated with Cannulated Internal Fixation in Elderly Patients: A Long-Term Follow-Up Study. *Orthop Surg* 2020; 12: 809 – 18.
15. Johnson JP, Kleiner J, Goodman AD, Gil JA, Daniels AH, Hayda RA. Treatment of femoral neck fractures in patients 45–64 years of age. *Injury* 2019; 50: 708 – 12.
16. Viberg B, Frøslev T, Overgaard S, Pedersen AB. Mortality and revision risk after femoral neck fracture: comparison of internal fixation for undisplaced fracture with arthroplasty for displaced fracture: a population-based study from Danish National Registries. *Acta Orthop* 2021; 92: 163-9.
17. Dolatowski FC, Frihagen F, Bartels S, et al. Screw Fixation Versus Hemiarthroplasty for Nondisplaced Femoral Neck Fractures in Elderly Patients: A Multicenter Randomized Controlled Trial. *J Bone Joint Surg Am* 2019; 101: 136 – 44.
18. Xu B, Wang Q, Jin H, et al. [Internal fixation and hemiarthroplasty for the treatment of displaced femoral neck fracture: a cost-utility analysis]. *Zhonghua Yi Xue Za Zhi* 2017; 97: 1650-4.
19. Liu H, Li N, Zhang X, et al. Internal fixation versus hemiarthroplasty for displaced femoral neck fractures in the elderly: A cost-effectiveness analysis. *Injury* 2020; 51: 1346-51.
20. Lagergren J, Möller M, Rogmark C. Displaced femoral neck fractures in patients 60–69 years old - treatment and patient reported outcomes in a register cohort. *Injury* 2020; 51: 2652-7.
21. Xu JL, Liang ZR, Xiong BL, et al. Risk factors associated with osteonecrosis of femoral head after internal fixation of femoral neck fracture: a systematic review and meta-analysis. *BMC Musculoskelet Disord* 2019; 20: 632.
22. Kamara E, Zvi YS, Vail TP. Treatment of Valgus-Impacted and Nondisplaced Femoral Neck Fragility Fractures in the Elderly. *J Am Acad Orthop Surg* 2021; 29: 470-7.
23. Okike K, Udogwu UN, Isaac M, et al. Not All Garden-I and II Femoral Neck Fractures in the Elderly Should Be Fixed: Effect of Posterior Tilt on Rates of Subsequent Arthroplasty. *J Bone Joint Surg Am* 2019; 101: 1852-9.
24. Stockton DJ, O'Hara LM, O'Hara NN, Lefaivre KA, O'Brien PJ, Slobogean GP. High rate of reoperation and conversion to total hip arthroplasty after internal fixation of young femoral neck fractures: a population-based study of 796 patients. *Acta Orthop* 2019; 90: 21 – 5.
25. DeKeyser GJ, Wilson JM, Kellam PJ, et al. Young Intertrochanteric Femur Fractures Are Associated With Fewer Complications than Young Femoral Neck Fractures. *J Orthop Trauma* 2021; 35: 356 – 60.
26. Billington EO, Leslie WD, Brown JP, et al. Simulated effects of early menopausal bone mineral density preservation on long-term fracture risk: a feasibility study. *Osteoporos Int* 2021; 32: 1313-20.
27. Dufour AB, Kiel DP, Williams SA, Weiss RJ, Samelson EJ. Risk Factors for Incident Fracture in Older Adults With Type 2 Diabetes: The Framingham Heart Study. *Diabetes Care* 2021; 44: 1547-55.
28. Al-Ani AN, Neander G, Samuelsson B, Blomfeldt R, Ekström W, Hedström M. Risk factors for osteoporosis are common in young and middle-aged patients with femoral neck fractures regardless of trauma mechanism. *Acta Orthop* 2013; 84: 54 – 9.
29. Hagino H, Endo N, Harada A, et al. Survey of hip fractures in Japan: Recent trends in prevalence and treatment. *J Orthop Sci* 2017; 22: 909 – 14.
30. Pueyo-Sánchez MJ, Larrosa M, Suris X, et al. Secular trend in the incidence of hip fracture in Catalonia, Spain, 2003–2014. *Age Ageing* 2017; 46: 324-8.
31. Ju DG, Rajaei SS, Mirocha J, Lin CA, Moon CN. Nationwide Analysis of Femoral Neck Fractures in Elderly Patients: A Receding Tide. *J Bone Joint Surg Am* 2017; 99: 1932-40.

Figures

Group:subcapital fracture 31B1

Subgroups:

Valgus impacted fracture
31B1.1

Nondisplaced fracture
31B1.2

Displaced fracture
31B1.3

Group:transcervical fracture 31B2

Subgroups:

Simple fracture(Pauwels < 30°)
31B2.1

Multifragmentary fracture(Pauwels 30-70°)
31B2.2

Shear fracture(Pauwels > 70°)
31B2.3

Group:basicervical fracture 31B3

Figure 1

2018 new AO classification of FNFs.

Figure 2

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