

# 1 Vertebral fractures as a precursor to potential hip 2 fractures in elderly women

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## 17 Abstract

18 Objective: The purpose of this study was to investigate the kind of low-energy  
19 fracture which is a precursor of hip fracture in the elderly, and to suggest the  
20 importance of osteoporosis treatment and gait training for fall prevention after this  
21 low-energy fracture to prevent the occurrence of secondary hip fracture.

22 Methods: From January 2017 to December 2020, a total of 564 patients who  
23 underwent surgical treatment for hip fractures were admitted to the Zhongda Hospital  
24 affiliated to Southeast University. Baseline information including gender, age,  
25 diagnosis and type of low-energy fracture before hip fracture were collected. Fracture  
26 Risk Assessment Tool (FRAX) score, the number of patients received functional  
27 training and the number of patients received anti-osteoporosis treatment were

28 analyzed.

29 Results: There were 180 male patients and 384 female patients in the total 564 patients.

30 The number of male patients with low-energy fractures before hip fracture was 28,

31 including hip fracture (8 cases), vertebral fracture (8 cases) and humeral fracture (7

32 cases), and radial fracture (5 cases). The number of female hip fracture patients with a

33 low-energy fracture before fracture was 62, containing vertebral fracture (31 cases),

34 hip fracture (15 cases), radial fracture (9 cases) and humeral fracture (7 cases). It was

35 found that vertebral fractures were the most frequent low-energy fractures that

36 preceded hip fractures in elderly women compared to other low-energy fractures. It

37 was showed that the 10-year probability of hip fracture and other site fractures was

38 significantly higher in the group with lumbar fractures and other site fractures than

39 those in the group without fractures assessed by using the FRAX measurement system.

40 There were no statistical significance among the three groups of patients who

41 underwent functional training and anti-osteoporosis treatment. We could not find

42 statistical significance among the three groups of patients who underwent functional

43 training and anti-osteoporosis treatment.

44 Conclusion: Vertebral fracture is a precursor of hip fracture in elderly women. In

45 face of the vertebral fractures, surgeons, especially orthopedic surgeons, should pay

46 extra attention to the treatment of osteoporosis and anti-fall functional training.

47 Keywords: Vertebral fractures; precursor; hip fractures; elderly women

48

## 49 **1. Background**

50 Osteoporotic fractures usually occur at sites of substantial bone loss, such as the hip,

51 distal radius, proximal humerus, and spine. Hip fractures are thought as the most

52 prevalent type of fracture in osteoporotic fractures and are usually associated with a

53 high mortality rate and high economic burden[1]. Osteoporotic fractures happened in

54 the bones with excessive bone mass loss, such as hip, humerus, radius and vertebrae.

55 Hip fractures were considered as the most common type of fractures in osteoporotic

56 fractures, and led to higher mortality rate[2]. It was reported that the increased

57 incidence of osteoporosis depends on many factors, such as increased life expectancy,

58 sedentary lifestyle and an increase in the malnourished elderly population[3].  
59 Osteoporosis as an important public health problem boosts the incidence of fractures  
60 and leads to an increase in mortality. If osteoporosis is not prevented or detected early  
61 and appropriate anti-osteoporosis treatment is not given for patients, the associated  
62 health expenditures are predicted to increase[4]. Previous studies have found that  
63 patients who have suffered prior fractures from low-energy trauma may be at  
64 increased risk for secondary hip fractures; thus, secondary prevention, such as  
65 functional training, is important[5]. Therefore, the aim of this study was to investigate  
66 the precursor causes of hip fracture in the elderly and to suggest that orthopedic  
67 surgeons should pay extra attention to osteoporosis treatment and fall prevention  
68 functional training.

69

## 70 **2. Materials and methods**

71 A total of 564 patients were enrolled in this study according to inclusion criteria and  
72 exclusion criteria. The baseline information was collected including gender, age,  
73 diagnosis, and type of first fracture. The probability of hip fracture and other major  
74 site fractures in older women with hip fractures over 10 years before the current hip  
75 fracture was assessed by using the Fracture Risk Assessment Tool (FRAX)  
76 measurement system. The study was informed consents and ethics committee  
77 approval.

78 Inclusion criteria: ① Patients who underwent the surgical treatment for hip fracture  
79 (including femoral neck fracture, intertrochanteric fracture and subtrochanteric  
80 fracture) admitted to the Zhongda Hospital of Southeast University from January  
81 2017 to December 2020; ② Operation methods including femoral head replacement,  
82 total hip arthroplasty, femoral intramedullary nail implantation, hollow nail fixation;  
83 ③ There was no obvious contraindication to surgery.

84 Exclusion criteria: ① Hip fracture caused by serious violence (such as: traffic  
85 accident, fall accident from high place, etc.); ② Pathological fracture, multiple  
86 fracture, old fracture (fracture to operation time >4 weeks); ③ cerebral hemorrhage or  
87 hemorrhagic disease in recent time, such as high risk of bleeding, coagulation

88 dysfunction; ④ Rheumatoid arthritis, avascular necrosis of the femoral head,  
89 deformed osteitis, osteogenesis incomplete, and other previous history seriously  
90 affecting the skeletal morphology of hip; ⑤ Previous history of cancer, chemotherapy  
91 drug use, glucocorticoid use and other clear effects on bone metabolism; ⑥  
92 Secondary osteoporosis (hyperparathyroidism, thyrotoxicosis, male hypogonadism,  
93 malabsorption syndrome, malignancy, chronic liver disease and other secondary  
94 causes of osteoporosis).

95 Statistical software SPSS 17.0 was used for data analysis. Measurement data were  
96 expressed as  $\bar{x} \pm s$ . Chi-square analysis was used for comparison between samples,  $P$   
97  $\leq 0.05$  was considered statistically significant.

98

### 99 **3. Results**

100 Among the 564 hip fracture patients, 180 were male and 384 were female. The age of  
101 male hip fracture patients who did not have a low-energy fracture before and those  
102 who had a low-energy fracture were  $80.17 \pm 1.05$  years old and  $80.41 \pm 1.84$  years old.  
103 There was no statistical difference between the two groups ( $P=0.98$ ). The age of  
104 female hip fracture patients who did not have a low-energy fracture before and those  
105 who had a low-energy fracture were  $80.95 \pm 0.55$  years old and  $82.38 \pm 1.12$  years old,  
106 and there was no statistical difference between the two groups ( $P=0.43$ )(Table 1).

107 Among male hip fracture patients, 28 patients (15.55%) had low-energy fractures  
108 before fracture(Table 2). Including: 8 hip fractures, 8 vertebral fractures, 7 humeral  
109 fractures, and 5 radius fractures (Table 3). 62 female patients (16.14%) had  
110 low-energy fractures before fracture, and the fracture types were: 31 vertebral fractures,  
111 17 hip fractures, 9 radius fractures, and 5 humeral fractures (Table 4).

112 The study found that among female hip fracture patients, vertebral fracture is the most  
113 common low-energy fractures that occur before fracture. It has statistically difference  
114 with the total incidence of low-energy fractures ( $p<0.01$ ); The incidence of vertebral  
115 fractures and low-energy fractures (hip, humerus, radius) in other parts of women  
116 before hip fracture had statistically significant differences ( $p<0.01$ ) (Table 4).

117 In addition, we found that among female hip fracture patients, the age of vertebral

118 fracture patients was older ( $83.94\pm 1.39$ ) than patients without fractures before  
119 ( $80.95\pm 0.55$  years) and patients who had fractures of other parts ( $80.46\pm 1.74$  years).  
120 However, we did not find the significant difference in age (Table 5). We used the  
121 FRAX evaluation system to evaluate the probability of hip fracture and other major  
122 part of body fractures (spine, forearm, hip or shoulder fracture) within 10 years before  
123 this hip fracture occurred. The functional training and anti-osteoporosis treatment  
124 before the occurrence of this hip fracture were retrospectively investigated and  
125 studied (Table 5). The results showed that the probability of hip fracture and other  
126 major fractures within 10 years of patients without low-energy fractures was  
127 significantly lower than the group with low-energy fractures; Compared with other  
128 types of fracture, the number of patients who received functional training in the  
129 vertebral fracture group was significantly lower. There was no significant difference  
130 in the number of patients who received anti-osteoporosis treatments between two  
131 groups.

132

#### 133 **4. Discussion**

134 Hip fracture is one of the most common causes of hospitalization in elderly patients.  
135 Hip fracture in elderly patients includes femoral neck fracture, intertrochanteric  
136 fracture, subtrochanteric fracture and acetabular fracture, which has the characteristics  
137 of high incidence, high consumption, high disability rate and high mortality[6,7]. At  
138 least one third of community residents over 65 years old fall every year, which was  
139 increasing with age. Falls may cause serious consequences, such as fractures and head  
140 injuries. According to previous study, about 10% of falls led to fractures[8]. Studies  
141 had shown that hip fracture was the most common secondary fracture. The occurrence  
142 of secondary fracture greatly promoted the incidence of complications and  
143 mortality[9].

144 Our study showed that among female patients with hip fractures, the vertebral  
145 fractures were the most common low-energy fractures that occurred before female hip  
146 fractures. Balasubramanian analyzed the secondary fracture of 377561 elderly women  
147 over 65 years old, and found that the most common type of the first low-energy

148 fracture of the elderly women with secondary hip fracture was vertebral  
149 fracture[10]. These results were in line with our findings.

150 Vertebral fracture after low-energy trauma might indicate the existence of potential  
151 osteoporosis. Lack of the fall prevention function training after vertebral fracture  
152 surgery led to hip fracture after falling down. This also indicated that even in the case  
153 of high incidence of hip fracture with high mortality, orthopedists were still lack of  
154 awareness of osteoporosis diagnosis and fall prevention function training. Various  
155 studies had shown that orthopedists' awareness of osteoporosis played an important  
156 role in reducing osteoporotic fractures[5,11]. In our study, compared with other  
157 fractures, vertebral fractures were the most common fractures that occurred before hip  
158 fractures in women( $p<0.01$ ). When falling, the patients faced forward and landed on  
159 the ground with palm or shoulder, resulting in wrist or shoulder fracture, however it  
160 could avoid the injury in head or hip when falling down. For patients with vertebral  
161 fracture, they fell backward, and their hips touched the ground, causing sacral and  
162 lumbar fractures. For patients with hip fracture, they fell sideways, with their hips  
163 touching the ground, resulting in hip fractures. Both ways of injure postures were  
164 relatively close, and the cause of the fall might have a certain relationship with gait  
165 instability. Hasan showed that vertebral fractures and Colles fractures were the most  
166 common fracture types before hip fracture[12]. These were the reasons for early  
167 intervention after osteoporotic fracture to avoid secondary fractures[13]. So it was  
168 very necessary to prevent osteoporosis and functional training to prevent falls.

169 We conducted a retrospective investigation on functional training and  
170 anti-osteoporosis treatment before hip fracture. We found a relatively low proportion  
171 of patients among all three groups who received functional training. There was a  
172 statistical significance in the number of patients with functional training between  
173 vertebral fracture group and other fracture group, indicating that patients with  
174 vertebral fractures did not have good functional training after surgery. Many aspects  
175 of physical function deteriorated with age and lack of exercise. The weakening of  
176 muscle strength, balance control and gait was strong risk factors for fall, and people  
177 with gait problems had twice the risk of fall as those without gait problems[14].

178 Therefore, exercises addressing these problems may reduce the risk of fall. As  
179 research has found, exercise could improve the strength of the elderly, and might  
180 prevent falls by affecting these key risk factors. A survey showed that exercise could  
181 reduce the fear of fall, which was also a powerful predictor of fall[15]. Sherrington  
182 classified the exercise plans included in the trial into the following main exercise  
183 categories, including gait, balance, coordination and functional task training, strength  
184 resistance training, flexibility training and walking plan for 18 months, the results  
185 showed that long-term balance and functional exercise could reduce the chance of  
186 fall[8].

187 Men who randomly participated in physical exercise had a 46% reduction in all  
188 serious fall injuries. Perhaps due to the physical exercise program, men showed  
189 greater improvements in gait, balance, and muscle strength than women, reducing fall  
190 injuries[16]. Mehrsheed Sinaki believed that patients who had already suffered  
191 vertebral fractures were at risk of further vertebral fractures and related morbidity.  
192 Functional exercise was part of the overall management of osteoporotic patients and  
193 was related to improve the quality of life and reduce the risk of future fractures[17].

194 Saran Thanapluetiwiwong recommended daily supplementation of vitamin D3 equal to  
195 or more than 800 IU and calcium supplementation to prevent falls[18]. It was showed  
196 that patients with primary fractures, especially those with hip and vertebral fractures,  
197 should be evaluated for re-fracture and given anti-osteoporosis treatment after fracture,  
198 as well as strengthened nursing, active treatment of basic diseases to prevent falls[6].

199 Meanwhile, this study was a single-center retrospective study with a small sample  
200 size. Further multi-center and prospective studies with a large sample are needed in  
201 order to provide more precise guidance for reducing the risk of secondary hip  
202 fractures.

203 Therefore, we believe that vertebral fractures are a precursor of underlying hip  
204 fractures in elderly women. Although there was no evidence that physical exercise  
205 had a significant protective effect on women in preventing fall injuries, more attention  
206 should be paid to the treatment of osteoporosis and functional training for fall  
207 prevention in the face of vertebral fractures in elderly women.

208

209 **Abbreviations**

210 FRAX: Fracture Risk Assessment Tool

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213 **Authors' contributions**

214 Xuan Wu carried out the manuscript preparation and experimental design. Xiang-xu  
215 Chen conducted data collection and statistical analysis. Li-yong Bai carried out  
216 statistical analysis of data. Yun-feng Rui and Hui Chen revised the manuscript  
217 critically for important intellectual content. Yun-feng Rui gave final approval of the  
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224 **Ethics approval and consent to participate**

225 The Ethics Committee of Zhongda Hospital affiliated to Southeast University  
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227 **Consent for publication**

228 Not applicable

229 **Competing interests**

230 This material has not been published and is not under consideration elsewhere. The  
231 authors declare that they have no competing interests.

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