European Journal of Orthopaedic Surgery & Traumatology (2023) 33:1599–1606
https://doi.org/10.1007/s00590-022-03309-9

ORIGINAL ARTICLE

Second hip fracture in older adults: incidence and risk factors

Christiana Zidrou[1] · Angelo V. Vasiliadis[1,2] · Stavroula Rizou[3] · Anastasios Beletsiotis[1]

Received: 28 February 2022 / Accepted: 31 May 2022 / Published online: 29 June 2022

Abstract

Purpose A second hip fracture can occur in older adults who have already suffered an initial hip fracture. The aim of this study was to determine the incidence, mortality and risk factors for second hip fractures in older adults with hip fractures.

Methods Between 2009 and 2019, 2013 patients (mean age: mean age 76.5 ± 5.4 SD) who were admitted to a tertiary care hospital for a hip fracture surgery were retrospectively analyzed. The patients were divided into two groups: those with a second hip fracture and those without a second hip fracture within the following two years after the initial fracture.

Results 321 patients (15.9%, mean age: 85.3 ± 4.9 SD) sustained a second contralateral hip fracture, the first two years after the initial hip fracture whereas 136 patients (6.8%) sustained a contralateral hip fracture within 12 months. In total 274 (13.6%) died in the first two years after the initial hip fracture; among these, 139 patients (43.3%) had a contralateral second hip fracture. The mean time from the first hip fracture to second hip fracture was 13.2 ± 7.6 months. The advance age, female gender, living alone, dementia, chest and urinary tract infection, chronic heart failure, peripheral vascular disease were identified as risk factors for a second contralateral hip fracture.

Conclusions Identifying risk factors for a second contralateral hip fracture can be particularly helpful in providing focused medical assistance.

Keywords Epidemiology · Clinical characteristics · Hip fracture · Second hip fracture · Risk factors

Introduction

Hip fracture is the most serious consequence of falling in elderly with osteoporosis and is associated with poor functional results, increasing dependence and a substantial financial burden on the health system [1]. The incidence of hip fracture progressively increases with age and is expected to increase predominantly among those 80-year-old, as the population is aging [2]. A multidisciplinary approach and orthogeriatric consultation allow timely surgical and medical interventions, which results in better and quicker recovery in terms of functionality, especially in biologically active patients [3–5].

✉ Christiana Zidrou
czidrou@gmail.com

1 2nd Orthopaedic Department, G. Papageorgiou General Hospital, Thessaloniki, Greece

2 School of Medicine, Aristotle University of Thessaloniki, University Campus, Thessaloniki, Greece

3 School of Medicine, National and Kapodistrian University of Athens, Athens, Greece

Many national and institutional studies have been published regarding the epidemiology of hip fractures [1, 2, 5]. However, a limited number of studies focus on the patient population with a contralateral hip fracture after the first hip fracture. Omsland et al. estimated that 11% of men and 15% of women will have suffered a second hip fracture within the first 10 years after the first hip fracture [6]. Furthermore, elderly patients with a second hip fracture frequently present lower walking ability, less social independence, increasing mortality and suffer from dementia at a higher frequency [7].

Currently, a number of easily observed risk factors are identified and seem to be the same as those associated with the first hip fracture, including advanced age, female gender, history of fragility fractures and the need for a walking aid [2].

A nationwide, population-based study conducted in Denmark supports that aging, alcoholism, previous fragility fractures and living alone are risk factors for a second contralateral hip fracture [8]. Moreover, studies from Taiwan, Japan and USA suggest that neurological disorders, walking inability and vision problems are additional risk factors for a second contralateral hip fracture [9–11]. However, these

studies have some limitations such as increased error rates and absence of concrete data for hospitalized patients, e.g., admission blood sampling.

One potential strategy to prevent hip fractures is the use of hip protector, a device that absorbs the energy of impact after an accidental fall [12]. Korall et al. demonstrated that the risk of hip fracture was reduced nearly threefold by wearing a hip protector at the time of falling [13]. Additionally, anti-osteoporotic drugs, especially bisphosphonates, have been proven to reduce fracture risk with favorable benefits in preventing bone loss and reducing fractures in postmenopausal women and men with established osteoporosis [9, 14, 15]. Unfortunately, anti-osteoporotic treatment is not always recommended after the initial hip fracture, whereas the level of patient compliance to anti-osteoporotic medication is unsatisfactory and the main reason is considered to be the nonuse of guidelines by the treating physicians [10, 16].

No recent studies have sought to identify the risk factors associated with the second hip fractures among older adults in Greece. Moreover, the majority of the risk factors mentioned in the literature concerned the long-term incidence of the second hip fracture within 10 years. Despite this, the riskiest period for a second hip fracture is the first year after the initial hip fracture, with half of them occurring within the first 2 years and over 70% occur within the first 4 years [17]. Thus, the primary objective of this study was to characterize risk of hip fracture in older people by describing the frequency and median time to subsequent hip contralateral fracture. The secondary aim was to describe clinical characteristics of patients experiencing this event and to identify the risk factors that are correlated with the second hip fracture and probably may be modified.

Materials and methods

Study design

This is a single-center, retrospective, electronic medical record-based observational study conducted in a tertiary care hospital "G.Papageorgiou" over a ten-year period (from September 2009 to August 2019).

Patients

The study included 2105 consecutive patients over the age of 50 who were treated for hip fractures [International Statistical Classification of Diseases and Related Health Problems (ICD) 10th Revision code: S72.0, fracture of the femoral neck; S72.1, intertrochanteric fracture; S72.2, subtrochanteric fracture] caused by low-energy trauma. Patients with (i) pathological fractures, (ii) open fractures, (iii) bone fractures due to high energy, (iv) post-irradiation fractures, (v) periprosthetic fractures or/and (vi) concurrent bilateral fractures were excluded from the study. Simultaneously, duplicate, incorrect or missing data in electronic health records were not included in the analysis (Fig. 1).

After applying the exclusion criteria, the study population consisted of 2013 patients (1456 females and 557, mean age 76.5 ± 5.4 SD) The patients were divided into two groups: those with a second fracture ($n_1 = 321$: 199 females and 122 males, mean age at first presentation: 85.3 ± 4.9 SD) and those without a second hip fracture ($n_2 = 1692$: 1257 females and 435 males, mean age at first presentation: 81.2 ± 7 SD).

Intervention

On presentation, a routine pelvic radiography with a typical clinical examination was performed for all the patients. Before the admission, all subjects underwent further electrocardiogram (ECG), chest radiograph. Blood samples of clinical chemistry testing, hematology and coagulation were requested. Our department was planning to perform surgical intervention of the fractures as soon as possible. The operative treatment for each patient was determined after a final review of the patient history and radiological imaging with an interdisciplinary group, consisting of many orthopedic surgeons and anesthesiologist. All surgical procedures were performed under the supervision of a senior consultant orthopedic surgeon. The majority of patients (aged over 65 years) with intracapsular hip fractures were treated with cemented hemiarthroplasty. For patients less than 60 years old and especially with undisplaced intracapsular hip fractures, percutaneous screw fixation was preferred. All the patients with extra-capsular fractures (intertrochanteric and subtrochanteric) were fixed with proximal femur nailing. Total hip arthroplasty was performed in patients who were not mentally affected, mobilized independently, or using one crutch. All the patients were managed via a standardized pathway. A physiotherapist reviewed the patients following hip fracture surgery or the day after the operation and daily thereafter. After hospital discharge, the follow-up of the patients in the outpatient clinic was performed at 3, 6 and 12 months and consisted of clinical examination and X-rays. Also, at 24 months information was collected by phone from patients or the caring persons.

Data collection

Data collected included patient demographics and clinical characteristics (gender, age at the time of the first hip, living status, pre-fracture walking ability, source of admission to the hospital), fracture type, anti-osteoporotic treatment, blood samples on admission to the hospital and comorbidities. Furthermore, the mean time from trauma to surgery,

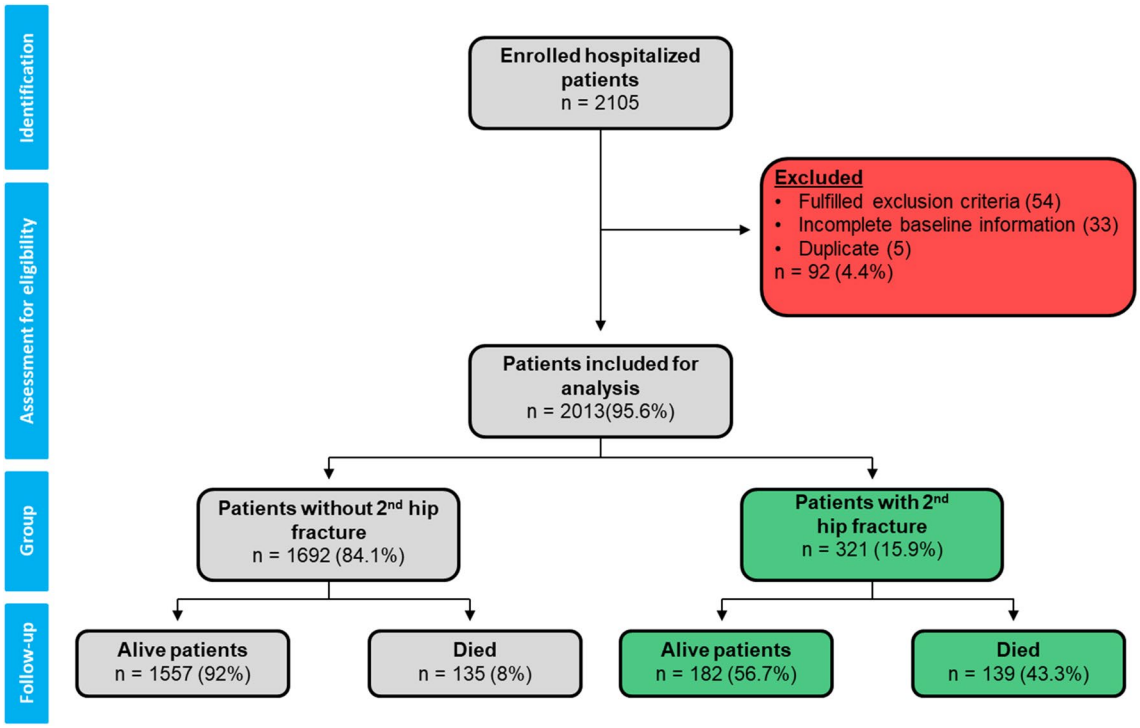

Fig. 1 Flowchart of the study of the population

average length of hospital stay, discharge destination and mortality were also recorded. Patients' demographic and clinical characteristics are shown in Table 1.

Ethics

The study was conducted in accordance with the World Medical Association Declaration of Helsinki-Ethical Principles for Medical Research Involving Human Subjects and the ethical approval for the study was granted by the Scientific Committee of G. Papageorgiou Hospital in Greece (21-04.2021).

Statistical analysis

All analyses were performed using the statistical package SPSS v.26.0. Continuous variables (age, hematology, clinical chemistry and coagulation tests, mean time to surgery, average length of stay) are expressed as mean ± standard deviation (SD) while categorical variables (gender, living status, medical comorbidities, alcohol excess, fracture type, admission source, discharge destination and mortality) are expressed as counts and percentages. The analysis was repeated for the following subgroups: age, gender, alcoholism, living alone, mortality and any comorbidity. Pearson's Chi-square test was used for the evaluation of the association between second hip fracture and categorical variables; Unifactorial analysis were made by using Mann–Whitney test to evaluate the association between second hip fracture and continuous variables in case of violation of normality. Statistical significance was set at $p < 0.05$.

Results

A total of 2013 cases of first hip fractures were the study population. Among these cases, 321 subjects (men: 122, women: 199) had subsequent hip fractures in the 24-month follow-up period. Table 1 shows the characteristics of the two patient groups. The mean time from the initial to the second fracture was 13.2 ± 7.6 months (13.2 ± 7.5 months for women and 13.2 ± 7.8 months for men).

Out of 2013 patients, 274 (13.61%) patients died in the first two years after the initial hip fracture and among them, 139 (43.3%) patients had a contralateral second hip fracture. The most common cause of death for both groups was malignancy, followed by cardiovascular and pulmonary diseases (Table 2). Fifty-four (2.7%) patients had a contralateral second hip fracture the first 3 months after the initial fracture, 136 (6.8%) patients the first year after the initial hip fracture and 321 (15.9%) patients within two years after the initial hip fracture (Fig. 2).

The overall mean time from trauma to surgery was 2.5 days for the first group and 3.3 days for the second one.

Table 1 Baseline characteristics of 2013 patients with and without a second hip fracture

	With 2nd hip fracture $N=321$	Without 2nd hip fracture $N=1692$	*P* value
Age (mean ± SD)	85.3 ± 4.9	81.2 ± 7	< 0.001
Gender n (%)			< 0.001
Male	122 (38)	435 (25.7)	
Female	199 (62)	1257 (74.3)	
Fracture type n (%)			0.946
IC-undisplaced	41 (12.7)	202 (11.9)	
IC-displaced	130 (40.5)	634 (37.5)	
Intertrochanteric	89 (27.7)	545 (32.2)	
Subtrochanteric	61 (19.1)	311 (18.4)	
Preoperative laboratory testing (mean ± SD)			
Hb (g/dL)	12.07 ± 0.28	11.91 ± 0.39	< 0.001
WCC ($\times 10^9$/L)	10.81 ± 0.76	10.78 ± 0.48	0.870
Platelets ($X10^9$/L)	317.74 ± 44.63	272.91 ± 50.45	< 0.001
Na^+ (mmol/L)	136.34 ± 2.37	137.10 ± 1.86	0.001
K^+ (mmol/L)	4.51 ± 0.32	4.53 ± 0.29	< 0.001
Creatinine (mg/dl)	1.072 ± 0.09	1.184 ± 0.05	< 0.001
INR	1.1 ± 0.13	1.2 ± 0.15	< 0.001
Admission from n (%)			< 0.001
Own home	233 (72.6)	1297 (76.7)	
Nursing home	51 (15.9)	304 (18)	
Inpatient	12 (3.7)	46 (2.7)	
Unknown	25 (7.8)	45 (2,6)	
Mean time to surgery (days)	2.5 ± 0.76	3.3 ± 0.93	< 0.001
Walking ability n (%)			0.025
Independent	154 (48)	881 (52)	
Single aid	80 (24.9)	439 (26)	
Two aids/Frame	67 (20.9)	289 (17.1)	
Wheelchair	2 (0.6)	34 (2)	
Unknown	18 (5.6)	49 (2.9)	
Living alone *n* (%)	171 (53.3)	186 (10.9)	< 0.001
Discharge destination n (%)			0.302
Own home	135 (42.2)	812 (48.1)	
Rehabilitation unit	160 (50)	735 (43.4)	
Nursing home	24 (7.2)	136 (8)	
Died as inpatient	2 (0.6)	9 (0.5)	
Mean length of stay (days)	10.5 ± 2.34	11.2 ± 2.03	0.009
Mortality *n* (%)	139 (43.3)	135 (7.97)	< 0.001

IC intracapsular, *Hb* hemoglobin, *WCC* white cell count, *INR* international normalized ratio

Moreover, the average length of hospital stay was 10.5 days and 11.2 days for the first and the second subgroup, respectively (Table 1).

Patients with a contralateral second hip fracture were more likely to be older, female, with a higher hemoglobin value on hospital admission, a higher platelet count and lower serum sodium, potassium, creatinine and INR levels (Table 1). Furthermore, there was a statistically significant difference in relation to walking ability, the mean time to surgery, the average length of hospital stay, the admission source, the living status and especially the mortality. Moreover, patients with a second contralateral hip fracture were more likely to suffer from concurrent chest and urinary tract infection, dementia, peripheral vascular disease, chronic heart failure and hemiplegia (Table 3). Also, we observed that denosumab was the most commonly used anti-osteoporotic treatment in both groups (Table 4).

Table 2 List of causes of death by sex in patients with and without a second hip fracture

Causes of mortality	With 2nd hip fracture ($n=139$)							Without 2nd hip fracture ($n=135$)						
	Men ($n=53$),%				Women ($n=86$),%				Men ($n=34$), %				Women ($n=101$), %			
	6 months	12 months	24 months	Total	6 months	12 months	24 months	Total	6 months	12 months	24 months	Total	6 months	12 months	24 months	Total
Cardio-vascular disease, *n*%	6 (11.3)	4 (7.5)	2 (3.8)	12 (22.6)	11 (12.8)	9 (10.4)	3 (3.5)	23 (26.7)	5 (14.7)	3 (8.8)	1 (2.9)	9 (26.5)	13 (12.9)	10 (9.9)	4 (3.9)	27 (26.7)
Pulmonary disease, *n*%	7 (13.2)	5 (9.4)	1 (1.9)	13 (24.5)	8 (9.4)	7 (8.1)	7 (8.1)	22 (25.6)	5 (14.7)	4 (11.8)	1 (2.9)	10 (29.5)	12 (11.9)	11 (10.9)	3 (3)	26 (25.7)
Diabetes *n* %	2 (3.8)	1 (1.9)	2 (3.8)	5 (9.5)	2 (2.3)	3 (3.5)	3 (3.5)	8 (9.3)	0	1 (2.9)	0	1 (2.9)	2 (2)	4 (3.9)	3 (3)	9 (8.9)
Malignancy *n*%	3 (5.6)	7 (13.2)	9 (17)	19 (35.8)	5 (5.8)	11 (12.8)	13 (15.1)	29 (33.7)	2 (5.9)	5 (14.7)	6 (17.6)	13 (38.2)	5 (4.9)	14 (13.9)	15 (14.9)	34 (33.7)
Other *n* %	1 (1.9)	2 (3.8)	1 (1.9)	4 (7.6)	1 (1.1)	1 (1.1)	2 (2.5)	4 (4.7)	0	0	1 (2.9)	1 (2.9)	1 (1)	3 (3)	1 (1)	5 (5)
Total *n* %	19 (35.8)	19 (35.8)	15 (28.4)	53	27 (31.4)	31 (36)	28 (32.6)	86	12 (35.3)	13 (38.2)	9 (26.5)	34	33 (32.7)	42 (41.6)	26 (25.7)	101

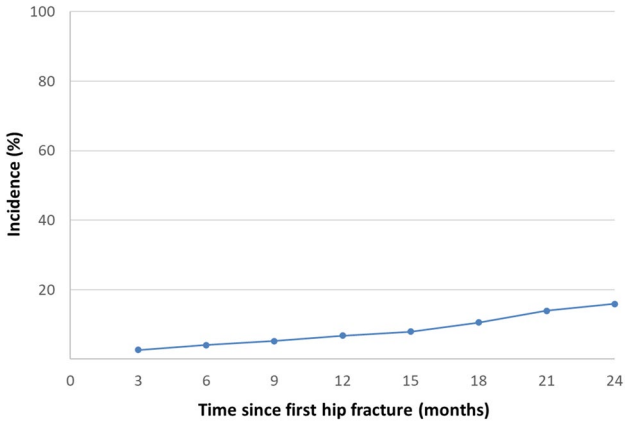

Fig. 2 Incidence rate of subsequent second hip fracture. Timescale is in months after first fracture

Discussion

The main outcome of our study is that patients who are at increased risk for a second contralateral hip fracture within two years are very likely to suffer from dementia, peripheral vascular disease, chest and urinary tract infection and chronic heart failure in comparison to patients who did not. Furthermore, there was a statistically significant difference between the two subgroups regarding age and the female gender. Findings from prior studies have supported that advanced age and female gender are risk factors that are related to a second contralateral hip fracture [8, 18].

One of the strengths of our study is the use of data from patients who were treated at local level in contrast to the data of the national patient register, which are susceptible to errors. Thus, we are convinced of the reliability of our findings. Periprosthetic and pathological fractures of the contralateral hip as well as at the same time bilateral hip fractures were excluded. Our data stemming from a large Greek tertiary hospital in North Greece, with treatment practices which are in accordance with national guidelines. Thereafter, we are convinced that our findings are proper for the broader Greek context as well as at international level. The most important is that the risk factors have been identified and can be modified accordingly to minimize the risk of a second contralateral hip fracture.

We note that our study has some limitations. First, the present data come from a single-center and as a result there are no recorded numbers in the national data register. However, the design of our study allowed the collection of multiple data including medical comorbidities, blood tests and data related to surgery (e.g., time to operative treatment from the admission). We also chose to limit to two-year follow-up, since most of the second hip fracture occurs within 4 years after the initial fracture [17]. It is important to emphasize that the results of our study

Table 3 List of comorbidities of patients with and without a second hip fracture

	With 2nd hip fracture $N=321$ n (%)	Without 2nd hip fracture $N=1692$ n (%)	P value
Alcohol excess	10 (3.1)	56 (3.3)	0.890
Hypertension	17 (5.3)	134 (7.9)	0.141
Concurrent chest infection	67 (20.1)	190 (11.2)	< 0.001
Concurrent UTI	80 (24.9)	250 (14.8)	< 0.001
Previous myocardial infarction	11 (3.4)	49 (2.9)	0.434
Chronic heart failure	147 (45.8)	13 (0.8)	< 0.001
PVD	0 (0)	30 (1.8)	0.016
Cerebrovascular disease	16 (5)	65 (3.8)	0.326
DM	27 (8.4)	180 (10.6)	0.213
Chronic kidney disease	30 (9.3)	78 (4.6)	0.001
Dementia	55 (17.1)	144 (8.5)	< 0.001
COPD	42 (13.1)	255 (15.1)	0.439
Hemiplegia	11 (3.4)	25 (1.5)	0.017
Solid organ malignancy	35 (10.9)	162 (9.6)	0.727
Liver disease	3 (0.9)	15 (0.9)	0.943

UTI urinary tract infection, *PVD* peripheral vascular disease, *DM* diabetes mellitus, *COPD* chronic obstructive pulmonary disease

Table 4 Treatment of osteoporosis in the study groups by sex

Osteoporosis treatment	With 2nd hip fracture ($n=321$)			Without 2nd hip fracture ($n=1692$)		
	Men ($n=122$)	Women ($n=199$)	Total	Men ($n=435$)	Women ($n=1257$)	Total
Bisphosphonates, *n*%	6 (4.9)	14 (8.0)	20 (6.3)	28 (6.4)	133 (10.6)	161 (9.5)
Denosumab, *n*%	5 (4.0)	16 (8.1)	21 (6.5)	36 (8.3)	168 (13.4)	204 (12.1)
None, *n* %	111 (90.1)	169 (84.9)	280 (87.2)	371 (85.3)	956 (76.0)	1327 (78.4)
Total	122	199	321	435	1257	1692

represent only the Greek population, and may not be generalized to the other countries populations. Furthermore, the study did not focus exclusively on mortality and morbidity after the second hip fracture, as this knowledge is well documented in the literature [12].

The majority of second hip fractures were located in the same anatomical region as the first fracture, which is in line with previous published studies [7, 19]. Theoretically, it has been contended, that this may be due to the anatomic shape of the femoral neck and/or the walking pattern in gait; however, it is not demonstrated by evidence or argument to be accurate or existing [20, 21]. The findings of our study showed that the walking ability after the first facture was deteriorated approximately in the half of the patients. The reduced walking ability after the initial hip fracture is a significant risk factor for a second one and there is a high correlation with reduced levels of independence after hospital discharge [15, 22, 23]. Despite this, the Framingham Heart Study concluded that there was a relationship between higher level of functionality and an increased risk of second hip fracture [18]. A possible explanation is that patients with increased independence have an increased risk of falls and, therefore higher risk of second hip fracture.

It has been reported in the literature for different populations that the risk of the second hip fracture in the first year may vary between 2 and 15% [6, 15]. In our study, the frequency of the second hip fracture was 6.8% and 15.9% the first and the second year, respectively, lower than data from Denmark and Ireland, but higher than data from the Finland and USA [8, 15, 21, 22]. This is probably due to the local differences in life expectancies and healthcare provision. It has been well documented that the average time between the two hip fractures is two years following the initial one [2]. Dretakis et al. argued that 75% of the second hip fractures occur within 4 years after the first one [19]. Moreover, Mitani et al. concluded that in one study from Japan, 85.7% of the patients suffered from a second hip fracture three years after the first one [24]. The findings of our study are comparable with reliable literature data. Despite this, these data could be useful to improve and to identify risk factors that should be amended to reduce the frequency of second

hip fracture. To the best of our knowledge, our study is one of the few studies that referred to the risk factors for the second hip fracture in a Greek population.

In our study, one of the most important risk factors for the second contralateral hip fracture is dementia, which is consistent with previous studies [15, 24, 25]. Dementia is a well-recognized risk factor for the initial and the second hip fracture [26]. Therefore, it could be argued that patients who struggle with dementia may require further more care in order to improve their functional status and as a result it would be better to continue their care in an inpatient rehabilitation unit with complete and detached care. In spite of this, our study's findings did not show a significant correlation between the discharge destination and a second hip fracture.

A study from Japan argued that chronic respiratory diseases (especially asthma and chronic obstructive pulmonary disease) are strongly correlated with the second hip fracture [24]. It is very possibly that these patients have impaired mobility, have been treated systematically with long-term use of corticosteroids, consequently, both of these two factors predispose to decreased bone mineral density and increased risk of fragility fractures. Our results were focused on concurrent acute chest infection separately from chronic obstructive airways disease and concurrent acute urinary tract infection and found a correlation with the second hip fracture. We hypothesize that acute chest and urinary infections can increase the risk of falls by affecting the posture balance. Furthermore, the second hip fracture is strongly correlated with various comorbidities. Consequently, patients who suffer from these diseases should receive full medical attention and falls risk assessment before hospital discharge.

Previous studies have supported that the use of bisphosphonates has many advantages in decreasing the risk of second hip fracture [9, 27]. All patients admitted with hip fractures in our department start anti-osteoporotic treatment upon the hospital admission. Despite this, the compliance is low after hospital discharge [16]. In order to improve patient's compliance with this, new therapeutic strategies should be adopted, such as intravenous administration of zoledronic acid once yearly or subcutaneous administration of denosumab once every 6 months.

Having a second contralateral hip fracture does not change the usual therapeutic strategy; there was a statistically significant difference in the mortality between the two groups. According to our results, in the first subgroup the mortality was 43.4% highlighting the significant aggravation of the functionality that patients experience after the second hip fracture. Therefore, this explains the economic and social actions that health systems must adopt [2].

In conclusion, we found that patients who suffer from dementia, respiratory or urinary tract infection, peripheral vascular disease and chronic heart failure, are more prone to sustain a second contralateral hip fracture. In the future this information could be used to predict second hip fracture risk in older adults as part of their health risk assessment. Prevention strategies should be formulated. Therapeutic recommendations include detailed medical performance and assessment of the prevention of falls before leaving, to provide guidelines for determining the appropriate destination of patients, in order to decrease the risk of second contralateral hip fracture.

Declarations

Conflict of interest The authors declare no conflict of interest.

References

1. Leal J, Gray AM, Prieto-Alhambra D, Arden NK, Cooper C, Javaid MK, Judge A (2016) Impact of hip fracture on hospital care costs: a population-based study. Osteoporos Int 27(2):549–558. https://doi.org/10.1007/s00198-015-3277-9
2. Larrainzar-Garijo R, Diez-Perez A, Fernandez-Tormos E, Prieto-Alhambra D (2021) Risk factors for a second nonsimultaneous hip fracture in a prospective cohort study. Arch Orthop Trauma Surg. https://doi.org/10.1007/s00402-021-03991-0.10.1007/s00402-021-03991-0
3. Pioli G, Bendini C, Pignedoli P et al (2018) Orthogeriatric co-management – managing frailty as well as fragility. Injury 49:1398–1402. https://doi.org/10.1016/j.injury.2018.04.014
4. Sabharwal S, Wilson H (2015) Orthogeriatrics in the management of frail older patients with a fragility fracture. Osteoporos Int 26:2387–2399. https://doi.org/10.1007/s00198-015-3166-2
5. Folbert EC, Hegeman JH, Vermeer M et al (2017) Improved 1-year mortality in elderly patients with a hip fracture following integrated orthogeriatric treatment. Osteoporos Int 28:269–277. https://doi.org/10.1007/s00198-016-3711-7
6. Omsland TK, Emaus N, Tell GS, Ahmed LA, Center JR, Nguyen ND, Gjesdal CG, Forsmo S, Schei B, Sgaard AJ (2013) Ten-year risk of second hip fracture. A NOREPOS Study Bone 52(1):493–497. https://doi.org/10.1016/j.bone.2012.09.009
7. Sawalha S, Parker M (2012) Characteristics and outcome in patients sustaining a second contralateral fracture of the hip. J Bone Joint Surg Br 94(1):102–106. https://doi.org/10.1302/0301-620X.94B1.27983
8. Ryg J, Rejnmark L, Overgaard S, Brixen K, Vestergaard P (2009) Hip fracture patients at risk of second hip fracture: a nationwide population-based cohort study of 169,145 cases during 1977–2001. J Bone Miner Res 24(7):1299–1307. https://doi.org/10.1359/jbmr.090207
9. Shen S-H, Huang K-C, Tsai Y-H, Yang T-Y, Lee MS, Ueng SW, Hsu RW (2014) Risk analysis for second hip fracture in patients after hip fracture surgery: a nationwide population-based study. J Am Med Dir Assoc 15(10):725–731. https://doi.org/10.1016/j.jamda.2014.05.010
10. Hagino H, Sawaguchi T, Endo N, Ito Y, Nakano T, Watanabe Y (2012) The risk of a second hip fracture in patients after their first hip fracture. Calcif Tissue Int 90(1):14–21. https://doi.org/10.1007/s00223-011-9545-6

11. Chapurlat R, Bauer D, Nevitt M, Stone K, Cummings SR (2003) Incidence and risk factors for a second hip fracture in elderly women. The study of osteoporotic fractures. Osteoporos Int 14(2):130–136. https://doi.org/10.1007/s00198-002-1327-6
12. Sheikh H, Hossain F, Khan S, Usman M, Kapoor H, Aqil A (2019) Short-term risk factors for a second hip fracture in a UK population. Eur J Orthop Surg Traumatol 29:1055–1060. https://doi.org/10.1007/s00590-019-02412-8
13. Korall AMB, Feldman F, Yang Y, Cameron ID, Leung PM, Sims-Gould J, Rabinovitch SN (2019) Effectiveness of hip protectors to reduce risk for hip fracture from falls in long-term care. J Am Med Dir Assoc 20(11):1397–1403. https://doi.org/10.1016/j.jamda.2019.07.010
14. Birks YF, Hildreth R, Campbell P, Sharpe C, Torgerson DJ, Watt I (2003) Randomized controlled trial of hip protectors for the prevention of second hip fractures. Age Ageing 32(4):442–444. https://doi.org/10.1093/ageing/32.4.442
15. Egan M, Jaglal S, Byrne K, Wells J, Stolee P (2008) Factors associated with a second hip fracture: a systematic review. Clin Rehabil 22(3):272–282. https://doi.org/10.1177/0269215507081573
16. Soong Y-K, Tsai K-S, Huang H-Y, Yang R-S, Chen J-F, Wu P-H, Huang K-E (2013) Risk of refracture associated with compliance and persistence with bisphosphonate therapy in Taiwan. Osteoporos Int 24(2):511–521. https://doi.org/10.1007/s00198-012-1984-z
17. Nymark T, Lauritsen JM, Ovesen O, Rock ND, Jeune B (2006) Short time-frame from first to second hip fracture in the Funen County hip fracture study. Osteoporos Int 17(9):1353–1357. https://doi.org/10.1007/s00198-006-0125-y
18. Berry SD, Samelson EJ, Hannan MT, McLean RR, Lu M, Cupples LA, Shaffer ML, Beiser AL, Kelly-Hayes M, Kiel DP (2007) Second hip fracture in older men and women: the Framingham study. Arch Intern Med 167(18):1971–1976. https://doi.org/10.1001/archinte.167.18.1971
19. Dretakis KE, Dretakis EK, Papakitsou EF, Psarakis S, Steriopoulos K (1998) Possible predisposing factors for the second hip fracture. Calcif Tissue Int 62(4):366–369. https://doi.org/10.1007/s002239900446
20. Shabat S, Gepstein R, Mann G, Kish B, Fredman B, Nyska M (2003) The second hip fracture–an analysis of 84 elderly patients. J Orthop Trauma 17(9):613–617. https://doi.org/10.1097/00005131-200310000-00003
21. Lonnroos E, Kautiainen H, Karppi P, Hartikainen S, Kiviranta I, Sulkava R (2007) Incidence of second hip fractures. A population-based study. Osteoporos Int 18(9):1279–1285. https://doi.org/10.1007/s00198-007-0375-3
22. Nolan P, Tiedt L, Ellanti P, McCarthy T, Hogan N (2020) Incidence of non-simultaneous contralateral second hip fractures: a single-center Irish study. Cureus 12(10):e11154. https://doi.org/10.7759/cureus.11154
23. Pearse E, Redfern D, Sinha M, Edge A (2003) Outcome following a second hip fracture. Injury 34(7):518–521. https://doi.org/10.1016/s00201383(02)00282-6
24. Mitani S, Shimizu M, Abo M, Hagino H, Kurozawa Y (2010) Risk factors for second hip fractures among elderly patients. J Orthop Sci 15(2):192–197. https://doi.org/10.1007/s00776-009-1440-x
25. Fujita T, Takegami Y, Ando K et al (2022) Risk factors for second hip fracture in elderly patients: an age, sex, and fracture type matched case-control study. Eur J Orthop Surg Traumatol 32(3):437–442. https://doi.org/10.1007/s00590-021-02996-0
26. Wang HK, Hung CM, Lin SH, Tai YC, Lu K, Liliang PC, Lin CW, Lee YC, Fang PH, Chang LC, Li YC (2014) Increased risk of hip fractures in patients with dementia: a nationwide population-based study. BMC Neurol 14:175. https://doi.org/10.1186/s12883-014-0175-2
27. Lee Y-K, Ha Y-C, Yoon B-H, Koo K-H (2013) Incidence of second hip fracture and compliant use of bisphosphonate. Osteoporos Int 24(7):2099–2104. https://doi.org/10.1007/s00198-012-2250-0