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Retrospective analysis of sequential bilateral hip fractures in elderly patients: A nested case-control study

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Abstract
Aim: The aim of the present nested case- control study was to compare the results and mortality rates of patients with consecutive bilateral hip fractures with those of patients with unilateral hip fractures selected from patients with similar characteristics.
Material and Methods: Patients diagnosed with acute hip fracture, age >65 years, with a minimum of 1-year follow-up (for surviving patients), low-energy fractures, and available demographics and medical records were included in this study. A total of 46 patients with consecutive hip fractures who met the evaluation criteria for the study were included (Group 1). A control group of 138 patients was selected based on their age, sex and type of fractures (Group 2). Demographic data, comorbidities and mortality rates were compared between the two groups.
Results: When comparing 2 groups in terms of age, gender distribution, ASA score, time to surgery, length of hospitalization stay, and time from fracture to surgery, no statistically significant difference was noted ($p>0.05$). No significant differences were noted between the groups in terms of fracture type and treatment modality ($p>0.05$). There was an obvious relationship between the bilateral hip fracture and a lower Singh Index (SI) (grade ≤3) ($p<0.001$). Neurological diseases rate was 30.4% (n=14) in Group 1 and 15.2% (n=21) in Group 2. There was a significant difference between the 2 groups ($p=0.023$). No difference was noted in the 1-year death rates between the groups ($p=0.059$).
Discussion: In our nested case- control study, an increased risk of secondary hip fracture was associated with lower SI and neurological diseases.

Keywords
Hip fracture; Mortality; Comorbidity

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Introduction

Hip fracture is an important health concern, especially in terms of its increasing rate among the elderly population. Hip fractures are an important healthcare issue throughout the world due to the high incidence, associated mortality, and health care expenditure [1]. Non-simultaneous bilateral hip fractures have been reported with increasing frequency in elderly patients [2]. The cumulative incidence of contralateral hip fracture after the first hip fracture is 9% after one year and 20% after 5 years [3]. A history of hip fracture has been well-established as a risk factor for subsequent contralateral hip fracture [4,5]. Several factors, such as female gender, older age, dementia, Parkinson's disease, a history of falls, low vision, osteoporosis, cardio-respiratory disease, and institutionalization have been found to increase the risk of a second hip fracture [6–8]. These second hip fractures have been associated with poorer postoperative outcomes, including complications and mortality [9,10].

Although there are several studies on the frequency and causes of the development of a second hip fracture after the first hip fracture in elderly patients, it seems insufficient. The aim of the present nested case-control study was to compare the results and mortality rates of patients with consecutive bilateral hip fractures with those of patients with unilateral hip fractures selected from patients with similar characteristics.

Material and Methods

The design and protocol of this study were approved by the Institutional Review Board (IRB) of Istanbul Education and Research Hospital (IRB number; 2693/01.2021). This retrospective nested case-control study was conducted by evaluating the records of 724 patients operated for hip fractures at the mentioned hospital between January 2014 and December 2019.

Patients diagnosed with an acute hip fracture (e.g., femoral neck and perthrochanteric fractures), aged over 65 years, with a minimum of 1-year follow-up (for surviving patients), low-energy fractures, and available demographics and medical records were included in this study. Patients with a fracture due to high-energy trauma or with a pathological fracture, isolated fractures of the greater or lesser trochanter, and fractures of the sub-trochanteric region were excluded.

A total of 46 patients with consecutive hip fractures who met the inclusion criteria for the study were included (Group 1). A nested case-control design was used to compare the outcomes of patients with contralateral hip fractures to those without them. A control group of 138 patients was selected from the remaining 724 patients, based on their age, sex, and type of fractures (1:3 ratio of cases to control; Group 2).

The overall information and complete health history were obtained from the medical history. Data on comorbid medical conditions were based on the presence of the following conditions: hypertension, diabetes mellitus, neurological diseases (such as dementia, Parkinson's disease), heart diseases (such as heart failure), renal diseases, and respiratory diseases (such as chronic obstructive pulmonary disease).

The demographic data comprised of age, gender distribution, fracture type, ASA score (11), treatment modality type (e.g., proximal femoral nailing, hemi-arthroplasty, and dynamic hip screw), time to surgery, length of hospitalization stay, and time between death and last hip fracture. The structure of the bony trabeculae in the proximal femur changes with the effect of osteoporosis. Osteoporosis is classified in 6 different degrees according to the trabecular structure in proximal femur radiographs in the index defined by Singh et al [12]. Finally, radiographs (anteroposterior-lateral hip and pelvis) at the first fracture occurrence were assessed for the degree of osteoporosis with Singh-Index (SI).

The Social Security Administration Death Master File (Social Security Death Index) was used to determine the mortality and expiration date of the patients. The 1-month, 1-year, and overall survival of the patients were also assessed. Patient characteristics included in the analysis of risk factors for contralateral hip fracture were as follows: age, sex, medical comorbidities, fracture type, and SI. The data obtained were compared between the two groups.

Statistical Analysis

All analyses were performed using the Statistical Package of the Social Sciences version 26.0 (SPSS Inc., Chicago, IL, USA). Mean, standard deviation, median, minimum value, maximum value, frequency and percentage were used for descriptive statistics. The distribution of variables was checked with the Kolmogorov-Smirnov test. The Mann-Whitney U test was used for the comparison of quantitative data. The Kaplan-Meier method was used for survival analysis. A p- value of less than 0.05 was considered statistically significant.

Results

Contralateral hip fractures were observed in 46 out of 724 patients (6.3%). The demographic and clinical features of these 2 groups are summarized in Table 1.

The mean age at admission for the first hip fracture was 82.3 ± 7.0 years. The median interval between both hip fractures in 46 patients who suffered from a contralateral hip fracture during the follow-up was 28.8 ± 16.2 months. The mean age of the patients at the time of the contralateral hip fracture was 84.2 ± 7.2 years, which was greater than the mean age of 80.1 ± 8.1 years in the group of 138 patients unilateral hip fracture, although the difference was not statistically significant ($p > 0.05$).

When 2 groups unilateral hip fracture in terms of age, gender distribution, ASA score, time to surgery, length of hospitalization stay, and time from fracture to surgery, no statistically significant difference was noted ($p > 0.05$; Table 1).

The fracture type and treatment modality type in the two groups are cited in Table 2. No significant differences were noted between the groups in terms of fracture type and treatment modality ($p > 0.05$).

The SI was categorized into 2 degrees: grade 1-3 and grade 4-6. While the rate of patients with grade 1-3 in Group 1 was 69.6 (n = 32), and the rate of patients with grade 4-6 was 30.4% (n = 14); in Group 2, the corresponding numbers were 37.7 (n = 52) and 62.3 (n = 86), respectively. There was an obvious relationship between the bilateral hip fracture and a lower SI (grade ≤3) ($p < 0.001$; Table 1).

Comparison of comorbid medical conditions between the two groups is given in Table 3. The comorbidities observed in the

Table 1. Demographic Characteristics and Clinical Outcomes

	Group 1 (n = 46)		Group 2 (n = 138)		p-value
	Mean±SD	Min-Max	Mean±SD	Min-Max	
Age, years	82,3±7,0	68-96	80,1 ± 8,1	65-98	n.s
Gender, F/M	34/12		93/45		n.s
Mortality:					
in first month, n, (%)	4 (8,7)		11 (8,0)		n.s
in first year, n, (%)	18 (39,1)		34 (24,6)		0,059
Overall, n, (%)	33 (71,7)		73 (52,9)		0,025
Survive, months	26,5 ± 20,7	0-58	27,9 ±16,4	0-49	n.s
Time to surgery, day	3,9 ± 2,1	1-10	4,2 ± 2,5	1-21	n.s
Length of hospital-ization stay, day	7,6 ± 2,3	4-13	8,6 ± 4,5	3-35	n.s
ASA Score					
ASA 1-2, n, (%)	20 (43,5)		57 (41,3)		n.s
ASA 3-4, n, (%)	26 (56,5)		81 (58,7)		
Singh index (SI)					
SI 1-2-3, n (%)	32 (69,6)		52 (37,7)		0.000
SI 4-5-6, n (%)	14 (30,4)		86 (62,3)		

SD: Standard deviation; Min: Minimum; Max: Maximum; n.s: no significant

Table 2. Comparison of the type of fracture and treatment method in both groups

	Group 1 (n = 46)		Group 2 (n = 138)
	First hip fracture	Contralateral hip fracture	
Type of Fracture			
Pertroc	14	17	73
Collum	32	29	65
Treatment method			
IMN	13	16	69
HA	28	27	56
THA	4	2	11
DHA	1	1	2
Type of anesthesia			
R	39	41	112
G	7	5	26

Pertroc: Pertrochanteric fracture; Collum: Collum fracture; IMN: Intramedullary nailing; HA: Hemiarthroplasty; THA: Total Hip Arthroplasty; DHS: Dynamic Hip Screw; R: Regional anesthesia; G: General anesthesia

Table 3. Comparison of comorbid medical conditions of both groups

	Group 1 (n = 46)	Group 2 (n = 138)	P-value
Hypertension	32 (69,6)	93 (67,4)	0.78
D. Mellitus	13 (28,3)	37 (26,8)	0.86
Neurological Disease	14 (30,4)	21 (15,2)	0.023
Heart Disease	12 (26,1)	48 (34,8)	0.27
Respiratory Disease	8 (17,4)	15 (10,9)	0.24
Renal Disease	6 (13,0)	20 (14,5)	0.80

Values are presented as number (%).

two groups were not significantly different for hypertension, diabetes mellitus, heart disease, renal disease, and respiratory disease (p > 0.05). Among the comorbid medical conditions, neurological diseases (such as dementia or Alzheimer) rate was 30.4% (n = 14) in Group 1 and 15.2% (n = 21) in Group 2. There was a significant difference between the two groups (p = 0.023; Table 3).

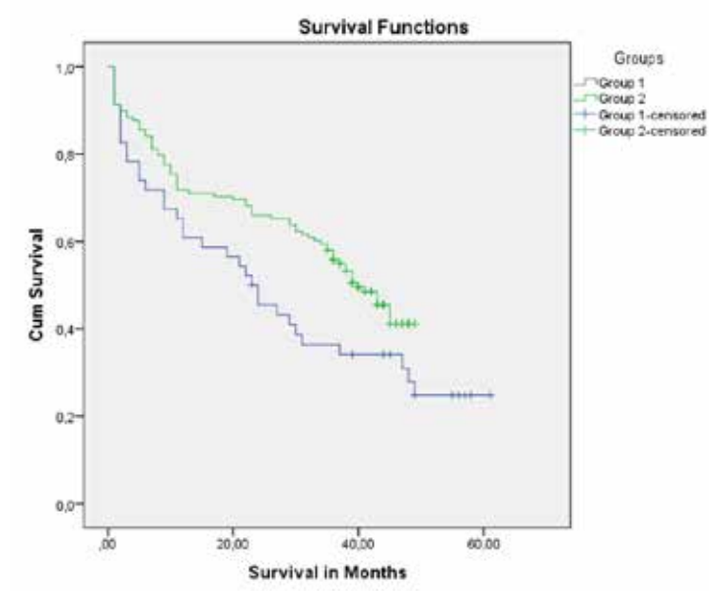

Figure 1. Survival analysis graph with the Kaplan-Meier method

The mean survival durations after surgery were 26.5 months (range: 1–58 months) in Group 1 and 27.9 months (range: 1–49 months) in Group 2 (p > 0.05). Among the 184 patients, 106 (57.6%) eventually died, while 78 (42.4%) survived. The overall death rates in the respective groups were 71.7% (n = 33) and 52.9% (n = 73) in Groups 1 and 2, respectively. The overall survival rates were significantly different between the groups (p = 0.025) (Figure 1).

The death rates at 1-month were 8.7% (n = 4) and 8.0% (n = 11) in the Groups 1 and 2, respectively. No difference was noted in the 1-month death rates between the groups (p = 0.87). The death rates at 1-year were 39.1% (n = 18) in Group 1 and 24.6% (n = 34) in Group 2. No difference was noted in the 1-year death rates between the groups (p = 0.059; Table 1).

Discussion

In this retrospective nested case-control study, the rate of contralateral hip fracture development in patients after the first hip fracture was 6.3%. When compared with the control group with unilateral hip fracture, it was found that the SI value, which indicates the degree of osteoporosis in the hip roentgenogram, was statistically significantly lower in patients with consecutive bilateral hip fractures. We believe that it should be considered a risk factor for contralateral hip fracture in patients with low SI. When the two groups were compared in terms of comorbid medical conditions, the presence of neurological diseases was found to be statistically significantly higher in Group 1.

There appears to be an increased risk for contralateral hip fracture in patients with neurological diseases. Although there was no statistically significant difference in the 1-month and 1-year mortality rates between the groups, it was found to be nearly significant for the 1-year mortality rate comparison (p = 0.059). However, the overall survival rates were significantly different between the groups (p = 0.025).

For patients who suffered from a hip fracture, the contralateral hip fracture development rates have been reported to be 3.4–10% [2,13-15]. In the present study, 46 patients had a contralateral hip fracture among 724 hip fracture patients

(approximate rate 6.3%), which is consistent with the reports of other studies.

Egan et al. [16] stated that older age is one of the risk factors for a second contralateral hip fracture after the first one, while Yamanashi et al. [18] demonstrated no significant difference in the incidence of second hip fracture in relation to age in the elderly. In our study, no statistically significant difference was noted in the comparison of mean age between the groups ($p > 0.05$).

Female gender is considered a risk factor for a second hip fracture [6]. In our study, no statistically significant difference was found in terms of gender distribution during the comparison between the two groups ($p > 0.05$).

Some studies have focused on factors affecting the development of contralateral hip fractures. Several risk factors including neurological diseases, falls, poor perceived health, low weight gain, absence of walking for exercise, dizziness, and osteomalacia have been reported to be associated with an increased risk for a second hip fracture [4,17]. Senile dementia and Parkinson's disease are also major risk factors for second hip fractures [18]. In this study, in the comparison of comorbidities between the groups, it was found that the presence of neurological diseases was significantly higher in patients with contralateral hip fracture. No significant difference was noted in the comparison of other common comorbidities studied (such as hypertension and diabetes mellitus). Neurological diseases can thus be considered a risk factor for contralateral hip fracture.

Singh et al. [12] described that there is a break in the continuity of the principal tensile group of trabeculae that can be clearly seen in grade ≤3. According to some studies, lower SI grades are not clearly related to osteoporosis [18,19].

Yamanashi et al. [18] reported no significant difference between the first and second hip fractures with regard to the SI, which was divided into 6 grades. On the other hand, in their prospective study, Gluer [20] reported that low SI was a risk factor for hip fracture. According to our study, when compared with the control group with unilateral hip fracture, it was found that the SI value, which indicates the degree of osteoporosis in the hip roentgenogram, was statistically significantly lower in patients with consecutive bilateral hip fractures.

Ryg et al. [3] performed a nationwide population-based cohort study on 169 patients, 145 of whom had their first hip fracture. The authors reported that patients with a second hip fracture had substantial mortality rates of 27% and 64% in men and 21% and 58% in women after 1-year and 5-years, respectively. In our study, the death rates at 1-month were 8.7% and 8.0% in Groups 1 and 2, respectively. No difference was noted in the 1-month death rates between the groups ($p = 0.87$). The death rates after 1 year were 39.1% and 24.6% in Groups 1 and 2, respectively. No difference was noted in the 1-year death rates between the groups. However, it was found to be close to statistically significant difference ($p = 0.059$).

The limitation of our nested case control study is that it is a retrospective cohort review that only included patients with surgically treated hip fracture. The nonsurgically treated hip fracture patients were excluded, as they were usually medically unfit for surgery, which potentially underestimated the overall incident and mortality. The exclusion criteria from the study were the presence of osteoporosis and whether the patients took antiosteoporosis medications. Another limitation was that the mobility status of the patients was not assessed before hip fracture. In addition, complications such as infection and implant failure can be seen after hip fracture surgery [21]. In our study, no evaluation was made in this respect.

Conclusion

The incidence of contralateral hip fractures in this nested case-control study was 6.3%. There was no significant difference between the groups in terms of 1-month and 1-year mortality rates. However, overall survival rates varied significantly between the groups. There was no significant difference between the groups in terms of fracture type and treatment modalities. The comorbidities observed in the two groups were not significantly different for hypertension, diabetes mellitus, heart disease, renal disease, and respiratory disease. There appears to be an increased risk for contralateral hip fracture in patients with neurological diseases (such as dementia or Alzheimer's). We thus recommend that these risk factors be identified and corrected properly in patients who sustain their first hip fracture.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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