

# Risk Factors and Characteristics of Falls Resulting in Hip Fracture in the Elderly

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## Abstract

**Background:** Risk factors for injurious falls among elderly people differ from those for falls in general. The characteristics of falls play an important role in determining the risk of hip fracture.

**Objective:** To investigate the risk factors associated with the fall characteristics known to be associated with the majority of hip fractures, e.g., a lateral fall and a subsequent impact on the greater trochanter.

**Methods:** In this 6 month prospective observational case-control study, 101 individuals aged 65 years and over hospitalized following a hip fracture were interviewed 7–14 days after the accident. Data were also obtained from medical records, focusing on known predisposing and situational risk factors for the fall. We compared the risk factors between two groups: patients who suffered a lateral fall and subsequent impact on the greater trochanter of the femur, and patients who suffered other types of falls.

**Results:** Only 51.5% of the hip fracture patients reported that they had fallen directly to the side. Apart from age, there were no significant differences between the groups in other factors studied. When considering both fall direction and the area that took the main impact, we found that the majority of patients (85%) reported having fallen onto the posterolateral aspect and/or a fall with an impact on the greater trochanter.

**Conclusion:** Our findings did not show differences (except for age) in the factors studied between the groups. This study suggests that both fall direction and the area that takes the main impact should be considered in the characteristics of falls that might cause a hip fracture. Characteristics associated with greatest fracture risk include a fall onto the posterolateral aspect and/or a fall with an impact on the greater trochanter. More studies are needed to evaluate potential risk factors associated with this type of injury.

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Among the elderly, only 15% of falls cause serious injuries, approximately 5–10% cause fractures, and only 1–2% result in hip fracture [1–3]. Determining whether risk factors for injurious falls are different from risk factors for falls in general might have important implications for preventive interventions, such as muscle strengthening, gait/balance training, and aerobic exercise. A few studies that examined this question found that the risk factors for falls with more severe injury differed from those for non-injurious falls and for minor injury falls. The factors associated with serious injury include: recurrent falling, impaired vision, disabling stroke, neuromuscular and balance impairments, impaired protective responses, cognitive impairment, and use of long-acting sedatives, especially benzodiazepines [3–10].

The characteristics of falls play an important role in determining the risk of hip fracture. While considerable research has focused on factors affecting the strength of bone, little attention has been paid to the characteristics of falls. Several case-control studies of persons who fall found that those who suffered a hip fracture as a result of a fall were much more likely to have fallen sideways on the hip than were controls who fell and did not sustain a fracture [11–14]. In a recent prospective controlled study, Parkkari et al. [15] demonstrated that most hip fractures are the result of a fall and the subsequent impact on the greater trochanter of the proximal femur. No research has been done on risk factors for this type of fall.

The present prospective case-control study investigated a patient population that sustained the injury mechanism known to cause the majority of hip fractures, i.e., a lateral impact on the trochanteric area of the hip. Using data from patients hospitalized for rehabilitation following a hip fracture due to a fall, the present analyses were designed to assess risk factors associated with different types of falls. In this context, the analyses focus on the risk factors for the fall characteristics known to be associated with the majority of hip fractures, e.g., a fall and the subsequent impact on the greater trochanter.

## Patients and Methods

We identified all non-institutionalized individuals aged 65 years and over who were hospitalized in the Fliman Rehabilitation Geriatric Hospital (a 210 bed public geriatric facility affiliated with the Technion Faculty of Medicine and located in Haifa, Israel) for rehabilitation after a hip fracture operation between 1 December 2000 and 31 May 2001. Patients who suffered from dementia, delirium or other definite age-related memory impairment during the interview were excluded (diagnosed according to the DSM-IV criteria). Patients with postoperative delirium were also excluded. Of the 215 elderly people identified, 150 eligible individuals were randomly selected for interview, and of these, 101 were interviewed, giving a response rate of 67.3%. Among the 84 women and 17 men in the study group, 23 were aged 65–74, and 78 were 75 years old and over. All other medical relevant characteristics of the patients were obtained from the medical records.

## Interview questionnaire

All interviewed patients were capable of answering the questions accurately themselves. Persons who witnessed the fall also gave interview answers. One of the authors (N.D.) interviewed all the study subjects during their stay in the hospital, 7–14 days after the

accident. Each subject was interviewed with a structured questionnaire.

Characteristics of the accident were determined by the first part of the interview. The activity at the time of the fall was divided into five categories: sitting or lying down, standing, changing position, walking, or running. The direction of the fall was divided into six categories: forward, oblique forward, directly sideways, oblique backwards, on buttock, or on back. The part of the body that took the main impact during the fall was recorded as: hand, forearm, elbow, shoulder, ribs, knee, hip (greater trochanter), buttocks, back, side, or head. Breaking of the fall was categorized as "yes" or "no."

The patients were analyzed into two subgroups. The first group included those who suffered a hip fracture as a result of a fall from a standing height and the subsequent impact on the greater trochanter of the femur (trochanter group). The second group included all other fall patterns (diverse group). Data regarding risk factors for falls were obtained using the patient's medical records and from the second part of the interview questionnaire.

Demographic characteristics, a history of falling in the past, and the type of fracture were recorded for each participant. Risk factors for falls were classified into situational and predisposing risk factors [5]. Situational risk factors included acute host, risk-taking activities (behavioral), and the environmental factors present at the time of the reported fall. Predisposing factors identified were the medical, sensory, neuralgic, musculoskeletal, and medication-related measures known to be associated with an increased risk of falls among the elderly [5].

Recorded acute host-related factors were acute diseases (pneumonia and urinary tract infections), new medications ingested in a temporal relationship to the fall, delirium (DSM-IV criteria), dizziness, syncope, and cardiovascular events during the fall. Diagnostic criteria for cardiovascular diseases were those listed by Lipsitz et al. [16]. Acute behavior factors were behavior disturbances involving risk-taking activities. Environmental risk factors, obtained through subject report, were environmental hazards that caused the fall, such as poor stairway design, inadequate lighting, and slippery floor.

Recorded musculoskeletal risk factors were: arthritis, spinal disease, foot and ankle problems, and state post-orthopedic surgery of the hip severe enough to cause functional impairment (dependent on at least two functions in the Katz Index of Activities of Daily Living) [17]. Neurologic predisposing factors including Parkinson's disease, state post-stroke, tactile-proprioceptive sensation disturbance and vestibular impairment were diagnosed according to the criteria of Sudarsky and Ronthal [18]. Depression was assessed by means of the Geriatric Depression Scale [19]. Recorded medical conditions were heart and lung disease severe enough to cause functional impairment (dependent on at least two functions in the Katz Index of ADL) [17]. Categories of medications considered to increase the risk of falling were sedatives, anti-depressants and neuroleptics.

### Statistical methods

The group of people who fell on the greater trochanter (trochanter group) was analyzed in relation to the other group (diverse group).

All the variables (risk factors) obtained were compared by the Pearson chi-square test and the *t*-test to identify factors that distinguished these two groups of subjects. A *P* value less than 0.05 was assumed to indicate statistical significance.

## Results

In all of our hip fracture patients the fracture was the result of a fall. In 52 patients (51.5%), the fracture was the result of a lateral fall and subsequent impact on the greater trochanter of the proximal femur (trochanter group). The remaining 49 patients (48.5%) who suffered a different type of fall comprised the diverse group.

### Characteristics of fallers and fractures

As shown in Table 1, except for age, the basic characteristics of both the trochanter group patients and the diverse patients did not differ from each other. There was no significant difference in the fracture type between the two groups.

### Fall characteristics

The fall characteristics of the two groups of patients are presented in Table 2. Only one fall characteristic significantly distinguished the two groups of fallers. In the diverse group, the main impact during the fall was directed on the buttocks in 20%, whereas in the trochanter group this occurred only in 2% (*P* = 0.003).

We found that when both the fall direction and the area that

**Table 1.** Subjects' characteristics and fracture type

	Trochanter group (%) (n=52)	Diverse group (%) (n=49)	<i>P</i> value
Age (years ± SD)	77.3 ± 8.4	80.4 ± 6.7	0.0482
<b>Gender</b>			
Male	10 (14%)	7 (19%)	0.5081
Female	42 (86%)	42 (81%)	
<b>Fracture</b>			
Femoral neck	28 (53.8%)	22 (44.9%)	0.3684
Impacted	2 (7.1%)	3 (13.6%)	0.46
Non-displaced	3 (10.7%)	2 (9.1%)	0.915
Displaced	23 (82.1%)	17 (77.3%)	0.323
Intertrochanteric	24 (46.2%)	27 (55.1%)	0.3684

**Table 2.** Fall characteristics of the two groups

	Trochanter group (%) (n=52)	Diverse group (%) (n=49)	<i>P</i> value
Fall from standing height	41 (78.8%)	45 (91.8%)	0.025
<b>Fall direction</b>			
Directly to the side	21 (40.3%)	12 (24.4%)	0.14
Oblique backwards	7 (13.2%)	7 (14.2%)	0.91
Direct or obliquely forwards	21 (40.3%)	14 (29.1%)	0.05
On buttocks	1 (1.9%)	10 (20.4%)	0.003
On back	2 (3.8%)	5 (10.2%)	0.25
Managed to break the fall	12 (23.1%)	16 (33%)	0.27

**Table 3.** Comparison of selected variables (risk factors) in trochanter group and diverse group

<b>Risk factors</b>	<b>Trochanter group (%) (n=52)</b>	<b>Diverse group (%) (n=49)</b>	<b>P value</b>
<b>Acute host factors</b>			
Acute disease	9 (17.3%)	11 (22.4%)	0.268
Medication	5 (9.6%)	2 (4%)	0.577
Mental change	3 (5.7%)	8 (6.3%)	0.532
Dizziness, syncope	1 (1.5%)	1 (2%)	0.867
<b>Risky activities</b>	21 (40.3%)	25 (51%)	0.7653
<b>Environmental risk</b>	23 (42.3%)	19 (38.7%)	0.847
<b>Sensory factors</b>			
Tactile-proprioceptive	1 (1.9%)	3 (6.1%)	0.353
Vestibular impairment	21 (40.4%)	21 (42.9%)	0.842
<b>Musculoskeletal</b>			
Arthritis	10 (19.2%)	15 (30.6%)	0.188
Foot and ankle	6 (11.5%)	11 (22.4%)	0.141
Spinal disease	10 (15.2%)	14 (28.6%)	0.293
S/P Orthopedic surgery	16 (30.8%)	20 (40.8%)	0.273
<b>Neurologic factors</b>			
CNS disease	14 (26.9%)	17 (34.7%)	0.398
Depression, anxiety	4 (7.7%)	3 (6.1%)	0.756
<b>Medical conditions</b>			
Heart disease	37 (71.2%)	37 (75.5%)	0.62
Lung disease	5 (9.6%)	4 (8.2%)	0.798
<b>Medication variables</b>			
Sedative	22 (71.2%)	24 (49%)	0.5
Neuroleptic	1 (1.9%)	0	0.781
Antidepressant	6 (11.5%)	8 (16.3%)	0.488
<b>Recurrent falling</b>	<b>39 (75%)</b>	<b>30 (61.2%)</b>	<b>0.139</b>

took the main impact were considered, 85% of all patients either fell posterolaterally or fell with the main impact on the greater trochanter. This group of fallers comprised all subjects from the trochanter group as well as those subjects from the diverse group who fell on their posteriolateral aspect.

### Risk factors for different types of falls

In most subjects there were multiple abnormalities that could have played a role in predisposing to the fall. To identify the conditions that characterize the trochanter group fallers, we compared the selected variables for the trochanter group vs. the diverse group. Table 3 shows the results of a variable analysis for these variables. Among all classes of risk factors, we did not find any variable that was significantly more common among either of these groups of fallers.

### Discussion

This study reports the most common characteristics of falls known to result in hip fracture in the elderly, as well as the characteristics of these fallers. The present findings add to earlier analyses [11–15] and clarify, in particular, the issues of fall characteristics and risk factors for different types of falls. Each of these issues will be considered in turn.

### Fall characteristics

Eighty-five percent of our hip fracture patients fell from a standing height, and most of them (72.3%) did not manage to break the fall, e.g., with an outstretched arm. Only 51.5% of the hip fracture patients reported that when they fell they suffered a lateral impact on the greater trochanter. Sixty-four percent of the patients fell posterolaterally (directly to the side, on buttocks, oblique, and direct backwards). Another 21 patients of the 37 who fell forwards reported that they landed on the greater trochanter of the femur. When both fall direction and the area that took the main impact were considered, the type of fall associated with greatest fracture risk was a fall onto the posterolateral aspect and/or a fall with an impact on the greater trochanter. Eighty-five percent of our hip fracture patients reported these fall characteristics.

These proportions are not in line with the results of most previous studies, which found that most hip fracture patients fell directly to the side [11–15]. When we considered both fall direction and the area that took the main impact, our results compare favorably with previous results. We believe that this description of fall characteristics improves our understanding of the loading conditions under which the femur is the most likely to fracture. Our findings concur with the results of the study by Keyak et al. [20], who quantified, using a finite element model of the proximal femur, the effect of force direction on fracture load, a factor inherently associated with fracture load. When both fall and atraumatic configurations were considered, the type of loading associated with greater fracture risk was impact from a fall onto the posterolateral aspect of the greater trochanter [20]. Another study that investigated the role of impact direction in hip fracture in a finite element model of the proximal femur [21] suggested that a greater hip fracture risk exists with a posterolateral impact. The results of this study indicated that a change in the angle between the line of action of the applied force and the axis of the femoral neck from 0 degrees (representing a direct lateral impact) to 45 degrees (representing a posterolateral impact) reduced the structural capacity of the femur by 26%.

A fall from a standing height has 400–500 joules of potential energy, which is more than required to fracture the hip of an elderly woman [22]. A fall directed to the greater trochanter generates femoral impact forces that are 30–50% greater than needed to fracture the proximal femur of older women [23]. Yet, only approximately 1–2% of falls result in hip fractures [1–3]. Differences within the older population in the strength of bone, resistance of the body through inertial forces, and elastic capacity of tissues cannot explain why only some falls result in a hip fracture. The forces generated in falls are affected by a tremendous diversity of circumstances and human characteristics [12,13].

The forces generated on impact play a very important role in risk of fracture, and the mechanics of the fall play a major role in determining those forces. Recent studies support the view that the characteristics of a fall are the most important determinants of whether it will result in a hip fracture [14,15,24]. Our case-control study suggests that both the fall direction and the area that takes the main impact should be considered in the fall characteristics, and that most hip fractures are related to a fall onto the

posterolateral aspect and/or a fall with an impact on the greater trochanter.

### Risk factors for different types of falls

Comparing the selected variables (the abnormalities present that could have played a role in predisposing to the fall) for the trochanter group versus the diverse group, we did not find any variable that was significantly more common among fallers in either group. This finding emphasizes our stand that most hip fractures are related to posterolateral falls and/or an impact on the greater trochanter.

There are a number of features that may affect the findings of this study. Given the 7–14 days interval between the fall and the interview, some patients may not have remembered exactly the characteristics and circumstances of their fall. To deal with this problem we excluded all patients who suffered any cognitive decline (permanent or acute) or any age-related memory impairment. In the case of patients not capable of answering themselves, the questions were given to a person who witnessed the fall. Since the subjects were unaware of any *a priori* hypotheses, there is no reason to expect biased responses. Subjects were asked both open-ended and close-ended questions with fixed responses. Furthermore, since all the subjects were hospitalized in a rehabilitation facility, our findings may not apply to all elderly persons with a hip fracture. Nevertheless, to the best of our knowledge, most elderly hip-fractured patients (except for the severely demented) in this area are hospitalized for rehabilitation. Finally, more detailed neurologic or musculoskeletal examinations might contribute additional information on the risk factors.

In conclusion, our results suggest that both the direction of the fall and the area that takes the main impact should be considered among the fall characteristics that might cause a hip fracture. Most hip fractures are related to a fall onto the posterolateral aspect of the femur and/or a fall with an impact on the greater trochanter. We believe that a more extensive and precise evaluation of hip fracture risk should focus on this high risk type of fall.

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