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Subsequent Fracture in Nursing Home Residents with a Hip Fracture: A Competing Risks Approach

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Abstract

OBJECTIVES—To determine the incidence and predictors of subsequent fracture in nursing home residents with a hip fracture, accounting for the competing risk of death.

DESIGN—Dynamic cohort study.

SETTING—Hebrew Rehabilitation Center, a 725-bed, long-term care facility in Boston, Massachusetts.

PARTICIPANTS—Long-term care residents with a surgically repaired hip fracture (1999–2006) followed through June 30, 2007, for the occurrence of subsequent fracture at any skeletal site.

MEASUREMENTS—Information on age, sex, anatomic location, type of repair, body mass index (BMI), comorbidities, functional status, cognitive status, and medication use were evaluated as potential risk factors for subsequent fracture.

RESULTS—The study included 184 residents with a baseline hip fracture. Thirty-nine residents (7 men, 32 women) experienced a subsequent fracture over a median follow-up of 1.1 years. After the baseline hip fracture, 6% of residents experienced a subsequent fracture within 6 months, 12% within 1 year, and 21% within 5 years. In addition, 23% of residents died within 6 months, 31% within 1 year, and 60% within 5 years. High functional status was associated with a five times greater risk of subsequent fracture (high vs low functional status, hazard ratio = 5.10, $P < .005$). Age, sex, BMI, comorbidities, cognitive status, and medication use were not associated with subsequent fracture.

CONCLUSION—Hip fractures are a sentinel event in nursing home residents, with a high incidence of subsequent fracture and death occurring within 1 year. Identification of prefracture characteristics and postfracture complications associated with mortality should help guide secondary prevention efforts in nursing home residents.

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Keywords

hip fracture; nursing home; mortality; second fracture

Incidence rates of hip fracture in nursing home residents are more than five times as great as rates in community dwellers of the same age and sex.^{1,2} In nursing home residents, hip fractures are associated with high morbidity, mortality, and costs.^{3,4} It is well recognized that community dwellers with a hip fracture are at greater risk of subsequent fracture.^{5,6} However, mortality after a hip fracture is greater in nursing home residents than in community dwellers,^{3,7} and thus, it remains unclear whether nursing home residents with a hip fracture also have a greater risk of subsequent fracture. To help inform clinical decision-making in this highly vulnerable population, the incidence, timing, and predictors of subsequent fracture were determined in nursing home residents with a hip fracture. Moreover, a competing risk approach was used to account for the high mortality in this frail population.

METHODS

Study Design

A dynamic cohort study of nursing home residents with a hip fracture who were followed for the occurrence of subsequent fracture at any site or until death, loss to follow-up, or the end of follow-up (June 30, 2007). The Hebrew SeniorLife institutional review board approved this research.

Study Population

Participants included all long-term care residents who experienced a baseline hip fracture between January 1, 1999, and December 31, 2006, while living at Hebrew Rehabilitation Center, a 725-bed, long-term care facility within the Hebrew SeniorLife care network (Boston, MA).

Baseline Hip Fracture Ascertainment

Hip fractures were identified according to a review of federally mandated injury files. Fractures were confirmed with medical records including radiographic reports, operative notes, and discharge summaries. In cases of uncertainty, a physician (SB) adjudicated fractures. Fractures associated with Paget's disease, periprosthetic fractures, and pathological fractures were excluded ($n = 5$). Individuals who did not undergo surgical repair of their hip fracture ($n = 21$) were also excluded, given their limited life expectancy.

Subsequent Fracture Ascertainment

Subsequent fractures were defined as a clinically diagnosed fracture at any skeletal site (e.g., leg, arm, second hip), excluding toes and hands, that occurred during follow-up. Subsequent fractures were confirmed according to medical records.

Death Ascertainment

Vital status was ascertained through the facility's administrative database, with confirmation of deaths according to medical records.

Other Measurement

Information on age, sex, body mass index (BMI), comorbidities, functional status, and cognitive status were obtained from the Minimum Data Set (MDS) assessment closest to and preceding the baseline hip fracture. The MDS is a federally mandated needs assessment system

performed on all nursing home residents at admission and every 3 months thereafter.⁸ Nursing staff measured weight to the nearest pound and height to the nearest inch and used this to calculate BMI (kg/m^2). Active illnesses (anemia, cancer, emphysema, congestive heart failure, and diabetes mellitus) were determined (yes/no). Cognitive status was measured using a validated Cognitive Performance Scale⁹ and defined as intact (score 0–1), mild to moderate impairment (score 2–4), or severe impairment (score 5–6). Functional status was assessed using the validated activities of daily living (ADL) short scale,^{10,11} which designates independence (score = 0) or dependence (score = 1) for seven items: bed mobility, transfers, locomotion, dressing, eating, toileting, and personal hygiene.¹² Functional status was defined as high with a score of 0 to 1, moderate 2 to 3, and low 4 to 7. In addition to baseline (prefracture) characteristics, functional status was also assessed within 3 months after the fracture.

Information on anatomic location and type of repair were obtained from chart review. Medication use in the month after the baseline hip fracture was determined from administration logs and included supplemental calcium, vitamin D, and osteoporosis medications (oral estrogen, selective estrogen-receptor modulators, bisphosphonates, or calcitonin). Supplemental calcium was categorized as greater than 1,000 mg/d versus 1,000 mg/d or less and supplemental vitamin D as 600 IU/d or greater versus less than 600 IU/d. A reliability test was performed for all variables with a physician (SB) and research assistant (MB) each independently reviewing a random sample of 10 charts. The interrater agreement was 94%, and the intrarater reliability was 98%.

Statistical Analysis

The incidence rate of subsequent fracture was determined as the total number of subsequent fractures divided by the total person-years of follow-up. The incidence of subsequent fracture was calculated accounting for the occurrence of death as a competing risk using a Cumulative Incidence Competing Risk (CICR) curve.^{13,14} Similarly, the incidence of death was calculated accounting for the occurrence of subsequent fracture using a CICR curve.^{13,14}

Participant characteristics were compared according to three discrete time-to-event outcomes: occurrence of subsequent fracture, death before a subsequent fracture, or censorship (alive without a subsequent fracture). Four subjects transferred facilities and thus were censored in the analyses.

Age, sex, anatomic location, type of repair, BMI, individual comorbidities, functional status, cognitive status, and medication use were evaluated as potential risk factors for subsequent fracture. To determine predictors of subsequent fracture, the subhazard function was modeled using competing risk regression to obtain estimates of the relative hazards and corresponding 95% confidence intervals.^{15–17} Because of the limited number of subsequent fractures, age- and sex-adjusted analyses were performed individually accounting for the competing risk of death. Variables associated with subsequent fracture in the age- and sex-adjusted analyses ($P \leq .10$) were included in the multivariable, competing risk regression model. SAS (version 9.1, SAS Institute, Inc., Cary, NC) was used for data management and R (version 2.5.1, <http://www.r-project.org>) for analyses.

RESULTS

Study participants included 184 residents (38 men, 146 women) with a baseline hip fracture. The mean age $\pm$ standard deviation of participants was 89.0 ± 6.1 (Table 1). The intertrochanter was the most common site of the fracture (52.2%), and 72.3% of the fractures were repaired using internal fixation. Fifteen percent of subjects were cognitively intact, and 25.4% were high functioning at the time of the hip fracture. Ninety-five percent of hip fractures were related

to a fall. The duration of follow-up ranged from 2 days to 8.5 years, with a median follow-up of 1.1 years.

Of the 184 residents with a baseline hip fracture, by the end of follow-up, 21.2% (7 men, 32 women) had experienced a subsequent fracture, 57.1% (23 men, 82 women) had died without a subsequent fracture, and 21.7% (8 men, 32 women) were alive without subsequent fracture (Table 1). The most frequent site for a subsequent fracture was the hip ($n = 18$), followed by arm ($n = 5$), leg ($n = 5$), pelvis ($n = 4$), ankle ($n = 2$), vertebra ($n = 2$), patella ($n = 1$), clavicle ($n = 1$), and rib ($n = 1$). Eighty percent of subsequent fractures were related to a fall. Of residents with a subsequent fracture, four experienced an additional fracture (2 second hip, 1 leg, 1 rib), and one resident experienced two additional fractures (vertebra and second hip).

The incidence rate of subsequent fracture in nursing home residents with a baseline hip fracture was 11.2 cases per 100 person-years. The highest risk of subsequent fracture was found in the first year (Figure 1). The cumulative incidence of subsequent fracture increased 1% per month during the first year such that 6.0% of participants experienced a subsequent fracture by 6 months and 12.1% by 1 year. The cumulative incidence of subsequent fracture continued to rise after 1 year such that 15.8% of participants experienced a subsequent fracture within 2 years and 21.1% within 5 years.

The cumulative incidence of death after a baseline hip fracture was greater than the cumulative incidence of subsequent fracture, and the magnitude of this difference increased with time (Figure 1). Twenty-three percent of nursing home residents with a hip fracture died within 6 months of the fracture, 31.4% within 1 year, 42.2% within 2 years, and 60.1% within 5 years.

In multivariable analyses, subsequent fracture risk was not greater with age (hazard ratio (HR) per year = 0.97, $P = .18$) or female sex (HR = 1.20, $P = .72$) (Table 2). Higher BMI decreased the risk of subsequent fracture, although the results were not statistically significant (HR per $\text{kg}/\text{m}^2 = 0.92$, $P = .11$). Residents with baseline moderate or high functional status were more likely to experience a subsequent fracture than those with low functional status (HR moderate vs low = 2.16, $P = .17$; HR high vs low = 5.10, $P < .005$). High supplemental vitamin D intake was associated with a nonstatistically significantly greater risk of subsequent fracture (HR = 1.79, $P = .10$). Individual comorbidities, cognitive status, anatomic location, type of repair, supplemental calcium, and osteoporosis medications were not predictive of subsequent fracture (results not shown).

DISCUSSION

To the authors' knowledge, this is the first study to describe the incidence of subsequent fracture in nursing home residents with a hip fracture. It was found that the cumulative incidence of subsequent fracture was 12.1% by 1 year and 21.1% by 5 years. Mortality was even greater, with 31.4% of participants dying within 1 year and 60.1% within 5 years of a baseline hip fracture. High functional status was associated with a five times greater risk of subsequent fracture, whereas characteristics such as age, sex, cognitive status, and medication use did not predict subsequent fracture.

Prior studies from a sample of U.S. nursing homes estimated the incidence rate of osteoporotic fracture in men and women as 3.5 to 6.0 cases per 100 person-years.^{18,19} In studies of female nursing home residents, the incidence rate of fracture was even higher (10.9–11.5 cases/100 person years).^{4,20} Despite the high mortality observed after a hip fracture in the current study, a similarly high incidence rate of subsequent fracture was found in male and female nursing home residents (11.2 cases/100 person-years). This highlights the importance of addressing primary and secondary osteoporotic fracture prevention in the nursing home setting.

The incidence of subsequent fracture of all types was found to be greatest in the first year after a hip fracture (12.1%). In contrast, community-based studies have shown a low occurrence of second hip fracture within 1 year of a baseline hip fracture (1.0–2.5%).^{21,22} The fact that all subsequent fracture types were considered rather than second hip fracture alone may in part explain the differences in these results. Given that hip fractures accounted for nearly half of all subsequent fracture types, this is unlikely to completely explain these findings. An alternative explanation is that participants in the current study were older than community-based subjects, with a greater prevalence of dementia and functional impairment. As a result, study participants may have been at greater risk for delirium and functional decline than community dwellers, resulting in greater opportunities for subsequent falls and fracture in the months immediately after a hip fracture.

Mortality after a hip fracture was found to be greater than the incidence of subsequent fracture throughout follow-up. Six-month (23.0%) and 1-year (31.4%) mortality in nursing home residents with a hip fracture was 1.6 times as great as mortality in community-dwellers.^{7,23} This is consistent with at least one other cohort study in which 26% of residents with a hip fracture died within 6 months.³ Because risk of mortality is higher than the risk of subsequent fracture, identifying nursing home residents who are likely to survive will help target secondary prevention to residents most likely to benefit from interventions.

Risk factors for fracture in nursing home residents are similar to those reported for community dwellers and include older age, female sex, dementia, a prior history of falls or fracture, psychotropic medications, urinary continence, and low bone mineral density.^{19,24,25} Given the high morbidity and mortality associated with hip fractures in the nursing home, it is unclear whether these traditional risk factors for fracture are also predictive of subsequent fracture in frail nursing home residents.

Consistent with community-based studies of second hip fracture, the current study found that nursing home residents with high baseline functional status were more likely to experience a subsequent fracture than residents with low functional status.²¹ This may not be surprising, given that high-functioning individuals are more likely to engage in activities that increase the opportunity for falls. Because a measure of physical activity was not available, it was not possible to test the hypothesis that the greater risk of subsequent fracture in high-functioning persons was mediated through physical activity. At the same time, low-functioning individuals may be more likely to become immobile or die after a hip fracture, resulting in fewer opportunities for future falls and fractures. In the current study, low functional status was associated with 60% greater mortality than high functional status (results not shown). The association between high functional status and the risk of subsequent fracture persisted even after controlling for the competing risk of death. Thus, in nursing home residents, high functional status appears to predict subsequent fracture independent of survival.

Functional status may deteriorate after a hip fracture. Thus, the present analysis may not accurately represent the association between functional status and subsequent fracture in persons who experience functional decline. For example, a high-functioning resident who becomes bed-bound after a hip fracture may no longer be at greater risk for falls and subsequent fracture. A sensitivity analysis using information on functional status obtained after the fracture supports this hypothesis, because the association between high functional status and subsequent fracture was unchanged.

It is therefore recommended that all high-functioning residents with a hip fracture should be assessed for modifiable risk factors for falls. Although prescribing calcium and vitamin D is a reasonable first step in an effort to reduce subsequent fractures, the role of pharmacological agents in nursing home residents for the secondary prevention of fracture is not well defined.

Older age, female sex, anatomic site, type of repair, low BMI, comorbidities, or cognitive impairment were not found to increase the risk of subsequent fracture. In community dwellers, older age, dementia, and weight loss have been associated with a greater risk of subsequent fracture.^{21,26,27} In the current study, higher BMI tended to be protective against subsequent fracture, but these results were not statistically significant. These null findings may reflect an inability to detect a statistically significant association because of the small sample size and possibly because of the relative homogeneity in the distribution of baseline characteristics in study participants compared with community dwellers.^{6,21}

Supplemental calcium, vitamin D, and osteoporosis medication use were not predictive of subsequent fracture in this study. No prior studies have specifically addressed the role of calcium and vitamin D in the secondary prevention of fractures, but supplementation with calcium and vitamin D has been associated with a 33% lower risk of nonvertebral fractures in ambulatory nursing home residents.²⁸ It is likely that the small sample size explains the null findings, with even fewer subjects receiving osteoporosis treatment. It is also possible that calcium, vitamin D, and osteoporosis medications may not affect bone fragility soon enough to prevent subsequent fractures that occur during the first year, particularly in frail nursing home residents. Another explanation is that these treatments may have preferentially been given to individuals at highest risk of subsequent fracture.

A unique aspect of this study is that it used the CICR estimate to determine the incidence of subsequent fracture.^{13,14,29} Most prior studies of subsequent fracture have relied on Kaplan-Meier estimates, which assume that persons who are lost to follow-up for any reason are censored and that censored subjects remain at risk for the outcome for the duration of the study.¹³ However, subjects who are censored because of death are no longer capable of experiencing a subsequent fracture. By failing to account for the competing risk of death, traditional methodological approaches can overestimate the frequency of events in the remaining population.²⁹ It is important to describe the incidence and timing of subsequent fracture in nursing home residents accurately because this has clinical implications for secondary fracture prevention efforts. Using a CICR approach, the cumulative incidence of subsequent fracture was calculated as 12.1% by 1 year, 15.8% by 2 years, and 21.1% by 5 years. If a Kaplan-Meier estimate had instead been used, the incidence of subsequent fracture would have been calculated as 15.5% at 1 year, 21.5% at 2 years, and 35.5% at 5 years. A CICR approach more closely reflects the true risk of subsequent fracture in nursing home residents with a hip fracture.

This study has several limitations. First, the sample size was small. Nonetheless, there are few studies in nursing home residents with hip fracture and none that describe the incidence of subsequent fracture in this highly vulnerable population. Second, it was not possible to ascertain hip fractures that occurred before 1999 or fractures that occurred at other nursing home facilities for residents who may have transferred. Transfers from other facilities are not common, and it is unlikely that this would have influenced the results greatly. Third, information on most potential predictors were collected from administrative data sets (MDS). All clinical staff at Hebrew Rehabilitation Center responsible for MDS data entry undergo annual training specific to the MDS, making the quality of the data better than at most nursing homes. Finally, this study was conducted at a single nursing home. No major administrative or nursing changes in the care of residents with hip fracture occurred during the study, but the results may not be generalizable to all nursing home populations. Compared with nursing homes nationwide, HRC has a similar sex distribution (75% women), although the residents of HRC are older (88 vs 84), and a greater proportion are white (98% vs 88%).³⁰

Despite these limitations, this study is important because it is the first to describe the incidence, timing, and predictors of subsequent fracture after a hip fracture in nursing home residents. All hip fractures were confirmed through medical record review. In addition, the study used a CICR

approach to describe the incidence and measures of association of subsequent fracture, which is a more-valid time-to-event approach in the presence of competing risks.

In conclusion, this study demonstrates that hip fractures are a sentinel event in nursing home residents, with a high incidence of subsequent fracture and death occurring within 1 year. Because the risk of death is greater than the risk of subsequent fracture, identifying prefracture characteristics and postfracture complications associated with mortality is greatly needed. Establishing these risk factors should lead to better recognition of nursing home residents with sufficient life expectancy to benefit from osteoporosis medications.

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Figure 1. Cumulative incidence of subsequent fracture and death in nursing home residents after a hip fracture. The incidence of subsequent fracture accounts for the occurrence of death as a competing risk using a Cumulative Incidence Competing Risk (CICR) curve. The incidence of death also accounts for the occurrence of subsequent fracture using a CICR curve.

Table 1

Baseline Characteristics of 184 Nursing Home Residents with a Hip Fracture Between 1999 and 2006 According to Their Outcome

Characteristic	Total N = 184	Experienced a Second Fracture n = 39 (21.2%)	Died without a Second Fracture n = 105 (57.1%)	Alive without a Second Fracture n = 40 (21.7%)
Female, %	79.3	82.1	78.1	80.0
Age, mean $\pm$ SD	89.0 $\pm$ 6.1	87.9 $\pm$ 4.9	90.0 $\pm$ 5.8	87.4 $\pm$ 7.4
Body mass index, kg/m ² , mean $\pm$ SD	25.2 $\pm$ 5.4	23.5 $\pm$ 5.5	25.3 $\pm$ 5.0	26.5 $\pm$ 5.0
Type of fracture, %				
Femoral neck	37.5	30.8	39.1	40.0
Intertrochanteric	52.2	61.5	52.4	42.5
Other	6.0	5.1	4.8	10.0
Unknown	4.4	2.6	3.8	7.5
Type of repair, %				
Internal fixation	72.3	74.4	73.3	67.5
Arthroplasty	27.2	25.6	26.7	30.0
Unknown	0.5	F	F	2.5
Cognitive Performance Scale score, %				
0–1 (intact)	15.5	20.5	12.5	18.4
2–3 (mild to moderate impairment)	68.5	71.8	66.4	71.1
4–7 (severe impairment)	16.0	7.7	21.2	10.5
Comorbidities, %				
Anemia	21.0	16.2	22.9	20.5
Cancer	9.9	8.1	8.6	15.4
Congestive heart failure	11.5	2.6	16.2	7.7
Diabetes mellitus	17.7	8.1	21.0	18.0
Emphysema	6.6	2.7	6.7	10.3
Activity of daily living scale score (functional status), %				
0–1 (high)	25.4	38.5	17.3	34.2
2–3 (moderate)	51.9	48.7	54.8	47.4
4–7 (low)	22.7	12.8	27.9	18.4
Supplements and medications, % [*]				
Supplemental calcium, mg/d				
$\leq$ 1,000	67.1	65.8	74.5	48.6
>1,000	33.0	34.2	25.5	51.4
Supplemental vitamin D, IU/d				
<600	73.4	63.2	81.6	62.2
$\geq$ 600	26.6	36.8	18.4	37.8
Other osteoporosis medications, %				
None	86.1	84.2	88.8	81.1
Oral bisphosphonate	7.5	7.9	6.1	10.8
Calcitonin	4.6	5.3	3.1	8.1

Characteristic	Total N = 184	Experienced a Second Fracture n = 39 (21.2%)	Died without a Second Fracture n = 105 (57.1%)	Alive without a Second Fracture n = 40 (21.7%)
Estrogen or selective estrogen- receptor modulator	1.7	2.6	2.0	F

* Medications administered within 1 month after the hip fracture.

SD = standard deviation.

Table 2

Risk Factors for Subsequent Fracture in Nursing Home Residents with a Hip Fracture, Accounting for the Competing Risk of Death

Risk Factor	Age and Sex Adjusted	Multivariate Adjusted
	Hazard Ratio (95% Confidence Interval) <i>P</i> -Value	
Age (per year)	0.97 (0.93–1.01) .14	0.97 (0.92–1.01) .18
Female sex	1.21 (0.52–2.83) .66	1.20 (0.53–3.87) .72
Body mass index, per kg/m ²	0.92 (0.84–1.01) .09	0.92 (0.83–1.02) .11
Activity of daily living scale score (functional status)		
0–1 (high) versus 4–7 (low)	3.45 (1.24–9.55) .02	5.10 (1.65–16.06) .005
2–3 (moderate) versus 4–7 (low)	2.00 (0.74–2.71) .17	2.16 (0.71–6.57) .17
High vitamin D intake (≥600 IU/d)	1.80 (0.94–3.46) .08	1.79 (0.90–3.56) .10