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Original Article

Femoral Neck and Intertrochanteric Fractures Have Different Risk Factors: A Prospective Study

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Abstract. The aim of this study was to determine whether both types of hip fracture, femoral neck and intertrochanteric, have similar risk factors. A prospective cohort study was carried out on community-dwelling elderly women in four areas of the United States: Baltimore, MD; Pittsburgh, PA; Minneapolis, MN and Portland, OR. The participants were 9704 Caucasian women, 65 years and older, of whom 279 had fractured their femoral neck and 222 had fractured their trochanteric region of the proximal femur. The predictors used were the bone mass of the calcaneus and proximal femur, anthropometry, history of fracture (family and personal), medication use, functional status, physical activity and visual function. The main outcome measures were femoral neck and intertrochanteric fractures occurring during an average of 8 years of follow-up. In multivariate proportional hazards models, several risk factors increased the risk of both types of hip fracture; including femoral neck bone density and increased functional difficulty. In hazard regression models that directly compared risk factors for the two types of hip fracture, calcaneal bone mineral density (BMD) predicted femoral neck fractures more strongly than intertrochanteric fractures (OR = 1.16; 95% CI = 1.02–1.31). Steroid use and impaired functional status also predicted femoral neck fractures instead of intertrochanteric fractures. Poor health status (OR = 0.74; 95% CI = 0.55–1.00) predicted intertrochanteric fractures more strongly than femoral neck fractures. We conclude that femoral neck fractures are largely predicted by BMD and poor functional ability while aging and poor health status predispose to intertrochanteric fractures.

Keywords: Femoral neck; Hip fractures; Intertrochanteric; Risk factors

Introduction

Most studies have treated hip fractures as a homogeneous condition [1–2], although they include two major anatomic types: fractures of the intertrochanteric region and fractures of the femoral neck. The composition of bone in the two regions differs, so the etiology of each fracture type may also differ. The trochanteric region has a greater proportion of trabecular bone than the femoral neck (50% vs 25%) [3]. Moreover, most investigators have found significantly lower femoral bone mineral density (BMD) among women with intertrochanteric fractures than femoral neck fractures [4–9]. Additionally, Uitewaal and colleagues [10] found significantly lower trabecular bone volume and surface density in patients with intertrochanteric fractures than patients with cervical hip fractures. However, others have found no difference in BMD between these fracture types [3,11,12].

The evidence about risk factors for different types of hip fracture is sparse and conflicting. Greenspan [5] found no association between fall characteristics, body habitus, gender and age and type of hip fracture. Yet, Vega and others [7,13] reported that women with intertrochanteric fractures were older, thinner and had more concomitant vertebral fractures than women with

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femoral neck fractures. The present community-based study was undertaken to determine prospectively whether risk factors differ between fracture types. The risk factors for intertrochanteric and femoral neck fractures were independently compared with a non-fracture group and then compared with each other.

Subjects and Methods

Subjects

From September 1986 through October 1988, 9704 women who were 65 years of age and older were recruited for the Study of Osteoporotic Fractures in four areas of the United States: Baltimore, Maryland; Monongahela Valley near Pittsburgh, Pennsylvania; Minneapolis, Minnesota; and Portland, Oregon. Age-eligible women were recruited from population-based membership lists from several sources [14]. Black women were excluded because of their low incidence of hip fracture [15]. Women who were unable to walk without the assistance of another person and those who had bilateral hip replacements were excluded. The study protocol was approved by the institutional review committee and all subjects gave written informed consent.

Measurement of Bone Mass

Calcaneal BMD (g/cm^2) was measured using single-photon absorptiometry (OsteoAnalyzer, Siemens-Osteon, Wahiawa, Hawaii). The protocol for the bone mass measurements and quality control procedures has been described elsewhere [14,16]. The average coefficient of variation in these older women was 1.3%. Inter-scanner reproducibility was 1.2% for the os calcis. All measurements were conducted on the right side except in women who had suffered a fracture, stroke or severe injury involving that limb; in these instances, measurements were made on the left side.

Between November 1988 and December 1990, the women were invited for a follow-up examination which included a dual-energy X-ray absorptiometry scan of the proximal femur (Hologic, Waltham, MA). Of the 9704 subjects originally enrolled, 87% of the surviving women returned for this second examination. The right hip was scanned in all cases except in the event of hip replacement or severe degenerative change. Areal BMD was determined for the femoral neck, trochanter, intertrochanteric region, Ward's triangle and total hip. The in vivo coefficient of variation between centers was 1.2% for the femoral neck and the inter-scanner coefficient of variation was 0.9% for an anthropometric hip phantom [16].

Assessment of Fractures

To ascertain fractures, participants were asked to notify the local clinical center as soon as possible after any fracture. In addition, we contacted participants every 4 months by letter or telephone to ask whether they had sustained a fracture. These contacts were 99% complete. As soon as possible after a reported fracture, we interviewed participants about the type of fracture and how it occurred. Copies of radiology reports were obtained for all reported fractures and copies of preoperative radiographs were obtained for all reported hip fractures. Radiology reports were reviewed by physicians at the coordinating center to confirm and classify fractures. We excluded any fractures that resulted from major trauma, such as a motor vehicle accident; a total of 8 hip fractures were excluded because of major trauma. Women who fractured their hip between the baseline and the second examination were not included in the analyses that examined hip BMD (n = 59 femoral neck; n = 76 intertrochanteric fractures).

Predictor Variables

At the second examination, subjects completed a self-administered questionnaire and were examined at the clinical centers. Information obtained included past medical history, family history and reproductive history. Subjects were asked to bring all prescription and non-prescription medications for verification and determination of doses and duration of use. A detailed history was obtained concerning lifetime smoking history, alcohol use and caffeine intake. Calcium intake was assessed using the method developed from the NHANES II survey [19]. Physical activity was estimated using a modified Paffenbarger scale that assesses participation in a wide variety of activities [20]. Weight was measured in indoor clothing with shoes removed using a balance beam scale. Knee height was measured as the distance from the floor to the anterior tibial plateau. Body mass index (BMI) was computed using knee height instead of current height so that the measurement was not confounded by vertebral height loss and scoliosis. Maximal triceps extension and hip abduction strength were measured with a hand-held dynamometer (Sparks Instruments and Academics, Coralville, IA). Grip strength was assessed as the average of two attempts with a Preston dynamometer (Sammons-Preston, Burridge, IL). We measured corrected visual acuity [21] and contrast sensitivity for low and high spatial frequency [22]. Contrast sensitivity assessed whether the women could differentiate different degrees of gray according to Ginsburg's test.

Statistical Analyses

Predictor variables were chosen based upon their association with hip fracture from previous studies and included age, calcaneal BMD, femoral BMD, height, weight, body mass index, history of osteoporosis or fracture, age and duration of menopause, hip abduction strength, change in height or weight since age 25 years, falls in the past year, medication use, calcium intake, use of calcium supplements, alcohol intake, smoking status, functional status, visual function (contrast sensitivity), triceps strength and grip strength [14,17,18]. To detect potential associations between predictor variables and type of hip fracture, the data were first analyzed using age-adjusted models. Cox proportional hazards models were computed to examine the effect of individual and multiple predictor variables on risk of femoral neck and intertrochanteric fractures separately. For all variables that were measured at more than one visit (i.e., BMI, walking speed, steroid use, fracture history, weight loss, back pain and caffeine), the most recent measurement for each individual was used in the analyses. Variables associated in age-adjusted analyses at a significance level of $p < 0.05$ were included in multivariate models. Where more than one variable within a broad category of interest (e.g., weight, physical activity, functional status, estrogen exposure) was significantly associated with fracture type, one variable which best explained the variability in hip fracture risk was selected for the multivariate models. Cox proportional hazards regression models were then computed to examine the effect of independent predictor variables on the risk of intertrochanteric fractures compared with femoral neck fractures. Individual risk factor models were computed and adjusted for age. Subjects with no hip fractures were excluded from the models. Hazard ratios greater than 1 indicated that femoral neck fractures are more likely than intertrochanteric fractures in the presence of the risk factor. Hazard ratios less than 1 indicated that an intertrochanteric fracture was more likely than a femoral neck fracture.

Results

Participants were followed for an average of 8 years (range 6–10 years) for the occurrence of hip fractures. During this time, 279 participants suffered a femoral neck fracture and 222 suffered an intertrochanteric fracture. Characteristics of the hip fracture participants are shown in Table 1. Intertrochanteric fracture patients were significantly older and had lower BMD at all measured skeletal sites.

Risk Factors for Femoral Neck Fractures

Two separate multivariable Cox proportional hazards models were run: one without BMD, the other with femoral neck BMD. From the model without BMD, a history of maternal hip fracture almost doubled the risk of femoral neck fracture (Table 2). Current use of steroids more than doubled the risk, and a history of fractures after age 50 years and being on one's feet for less than 4 h a day increased the risk of a femoral neck fracture by more than 50%. An increase in pulse rate while lying raised the risk of femoral neck fracture. For each 4.7 kg/cm^3 decrease in BMI, the risk of femoral neck fracture increased by one-third. Impaired contrast sensitivity (inablity to detect varying shades of gray) and slower walking speed were associated with an increased risk of femoral neck fracture.

With the addition of femoral neck BMD to the model, the same relationships were found between risk of femoral neck fractures and maternal hip fracture, history of fracture, being on one's feet for less than 4 hours/day, current steroid use and walking speed. The association was slightly strengthened and remained statistically significant for each predictor except age, pulse, contrast sensitivity and BMI. The risk of femoral neck fractures

Table 1. Characteristics of elderly women with femoral neck and intertrochanteric hip fractures

Characteristics	No fractures	Femoral neck fracture	Intertrochanteric fracture
No. of subjects	9190	279	222
Age, mean years (SD)	71.5 (5.2)	74.2 (5.7)*	76.8 (6.2)*
Education, mean years (SD)	12.6 (2.8)	12.5 (3.0)	12.3 (3.2)
Self-rated health (% excellent/good)	83.7	80.3	77.9*
Marital status (% married)	49.5	38.7*	34.2*
Maternal hip fracture (%)	13.1	22.8*	14.9
History of osteoporosis or vertebral fracture (%)	17.6	26.5*	32.2*
Height at age 25, mean cm (SD)	162.6 (5.9)	163.1 (6.1)	162.9 (6.3)
Weight, mean kg (SD)	67.3 (12.5)	63.1 (11.5)*	62.4 (11.6)*
Back pain (%)	68.0	69.9	73.9
Current steroid use (%)	1.9	5.0*	1.8
Calcium supplement use (%)	42.3	46.6	50.5*
Surgical menopause (%)	12.6	10.6	6.6*
Falls in past year (%)	29.8	34.9	37.4*
Calcaneal BMD (g/cm^2), mean (SD)	0.407 (0.094)	0.370 (0.098)*	0.321 (0.085)*
Total hip BMD (g/cm^2), mean (SD)	0.762 (0.130)	0.672 (0.108)*	0.637 (0.110)*
Femoral neck BMD (g/cm^2), mean (SD)	0.653 (0.110)	0.569 (0.088)*	0.557 (0.089)*
Intertrochanteric BMD (g/cm^2), mean (SD)	0.889 (0.159)	0.781 (0.133)*	0.742 (0.136)*
Grip strength (kg)	21.0 (4.3)	19.2 (4.8)*	18.9 (4.3)*
Triceps extension force (kg)	10.6 (2.7)	9.7 (2.6)*	9.7 (2.5)*

*p <0.05; test of significance of each fracture type vs no fractures.

increased by 49% for each standard deviation decrease in femoral neck BMD (Table 2).

The following variables were not significantly associated with the risk of femoral neck fractures in the multivariate model: alcohol intake, smoking status, fall in past year, ability to complete 5 chair stands and health status.

Risk Factors for Intertrochanteric Fractures

As before, two separate models were run with and without femoral neck BMD. For every 5 year increase in age, the risk of intertrochanteric fracture increased by 57% (Table 3). Current use of calcium supplements and a 20% weight loss increased the risk of intertrochanteric fractures by 47% and 53% respectively. Having a fracture after age 50 years, lying pulse and height at age 25 years also increased the risk of intertrochanteric fractures. Having undergone a surgical menopause and drinking alcohol in the past 12 months, taking walks for exercise and walking speed were found to be protective against intertrochanteric fractures.

When femoral neck BMD was added, older age, height at age 25 years and weight loss since age 25 years remained significant predictors of intertrochanteric fractures, with a slight reduction in the strength of the association. Low femoral neck BMD also significantly increased the risk of intertrochanteric fractures (RR = 0.44; 95% CI 0.29–0.66). Pulse rate, surgical menopause, alcohol use, walks for exercise, calcium use and fractures after age 50 years were no longer independent predictors.

The following variables were not significantly associated with the risk of intertrochanteric fractures in the multivariate model: smoking status, maternal history of hip fracture, maternal dowager's hump, fall in past year, history of hyperthyroidism, frequency or severity of back pain, being off one's feet for 12+ hours/day, total kilocalories per week burned in physical activity, functional status difficulty, contrast sensitivity, and muscle strength.

Femoral Neck Versus Intertrochanteric Fractures: Risk Factors

The regression models comparing risk factors for femoral neck and intertrochanteric fracture risk factors were adjusted for age (Table 4). All risk factors that were significant predictors in the individual fracture type analyses were tested. Current steroid use, calcaneal

Table 2. Cox relative hazards for risk factors for femoral neck fractures

Risk factors	Units	Relative hazards from age-adjusted model	Relative hazards without BMD	Relative hazards with BMD
Age	5 years	1.62*	1.36*	1.18
Maternal hip fracture	Yes/no	1.99*	1.79*	1.92*
Pulse lying down (mmHg)	10.14 (SD)	1.17*	1.17*	1.15
Contrast sensitivity at low spatial frequencies	35.62 (SD)	0.74*	0.81*	0.83
Body mass index	4.67 (SD)	0.69*	0.67*	0.88
Walking speed (m/s)	0.22 (SD)	0.75*	0.72*	0.75*
Steroid use	Yes/no	2.82*	2.10*	2.16*
On feet <4 h/day	Yes/no	1.80*	1.56*	1.74*
History of fracture after age 50 years	Yes/no	2.00*	1.79*	1.69*
Femoral neck BMD (g/cm^2)	0.111 (SD)	0.41*		0.51*

*p <0.05.

Table 3. Cox relative hazards for risk factors for intertrochanteric fractures

Risk factors	Units	Relative hazards from age-adjusted model	Relative hazards without BMD	Relative hazards with BMD
Age	5 years	2.21*	1.58*	1.40*
Pulse lying down (mmHg)	10.14 (SD)	1.25*	1.19*	1.16
Surgical menopause	Yes/no	0.59	0.47*	0.50
Drank alcohol in past 12 months	Yes/no	0.58*	0.65*	0.73
Height at age 25 years	6 cm	1.13	1.19*	1.23*
Take walks for exercise	Yes/no	0.66*	0.67*	0.70
Current calcium use	Yes/no	1.46*	1.52*	1.44*
Weight loss from age 25 years	20%	1.39*	1.53*	1.25*
Walking speed (m/s)	0.22 (SD)	0.71*	0.61*	0.59*
Caffeine use (mg/day)	190	1.10	1.28*	1.24*
History of fracture after age 50 years	Yes/no	1.64*	1.63*	1.14
Femoral neck BMD (g/cm^2)	0.111 (SD)	0.43*		0.44*

*p <0.05.

Table 4. Cox relative hazards for risk factors for femoral neck fractures versus intertrochanteric fractures

Risk factors	Units	Relative hazards (95% CI)	*p*-value
Age	5 years	0.91 (0.82–1.00)	0.057
Maternal hip fracture	Yes/no	1.17 (0.85–1.61)	0.330
Pulse lying down (mmHg)	10.14 (SD)	1.05 (0.94–1.18)	0.398
Contrast sensitivity at low spatial frequencies	35.6 (SD)	1.00 (0.86–1.15)	0.972
Body mass index	4.67 (SD)	0.99 (0.87–1.13)	0.861
Height at age 25 years (cm)	6	1.06 (0.94–1.20)	0.324
Weight loss from age 25 years	20%	1.08 (0.95–1.22)	0.242
Walking speed (m/s)	0.22 (SD)	0.99 (0.87–1.14)	0.936
Steroid use	Yes/no	1.87 (1.09–3.20)	0.024
On feet < 4 h/day	Yes/no	1.27 (0.93–1.73)	0.133
Take walks for exercise	Yes/no	0.95 (0.75–1.20)	0.657
History of fracture after age 50 years	Yes/no	1.09 (0.86–1.38)	0.467
Surgical menopause	Yes/no	1.32 (0.89–1.96)	0.161
Drank alcohol in past 12 months	Yes/no	1.08 (0.84–1.37)	0.562
Current calcium use	Yes/no	1.06 (0.84–1.34)	0.635
Health status (excellent/good)	Yes/no	0.74 (0.55–1.00)	0.050
Functional status sum	3	1.41 (1.12–1.79)	0.004
Degree of difficulty with functional status	3	1.16 (1.03–1.30)	0.013
Calcaneal BMD (g/cm^2)	0.095	1.16 (1.02–1.31)	0.022
Femoral neck BMD (g/cm^2)	0.111 (SD)	0.93 (0.78–1.1)	0.414
Total hip BMD (g/cm^2)	0.131 (SD)	1.07 (0.90–1.27)	0.461

BMD and functional status predicted femoral neck fractures more strongly than intertrochanteric fractures. Poor health status was the only independent predictor for intertrochanteric fractures. Maternal hip fracture, body composition (BMI, height, weight loss) and history of fractures after age 50 years were not significantly associated with one fracture type instead of the other.

Discussion

We found that femoral neck and intertrochanteric fractures have different risk factors and therefore may be caused by different physiopathologic processes. Aging and thin body habitus appear to predispose to intertrochanteric fractures. Recent studies have shown that the incidence of intertrochanteric fractures increases steeply with age [23–25]. Steroid use and impaired functional ability strongly increased the risk of femoral neck but not intertrochanteric fractures. Steroids cause osteocyte apoptosis and decreased bone formation, so they may increase the accumulation of unrepaired microdamage in the femoral neck.

The association between calcium supplement use and risk of intertrochanteric fractures was unexpected and may be due to the fact that women who have osteoporosis are more likely to take calcium supplements; thus use of calcium supplements may be a proxy for osteoporosis, especially since the association was attenuated with BMD in the model. Additionally, dietary calcium intake was not a significant risk factor for either fracture type, further indicating that the supplement use was a proxy for osteoporosis. A protective effect of surgical menopause in the risk of intertrochanteric fractures was also unexpected. This association might have been due to the fact that women who have an early menopause are more likely to be taking estrogen replacement therapy. However, adjusting for hormone replacement therapy did not alter the association between surgical menopause and risk of intertrochanteric fractures.

Our findings confirm previous investigations that found lower BMD among women with intertrochanteric fractures [4–9]. We also found an association with concomitant fractures and both fracture types. Yet, low calcaneal BMD predicted femoral neck fractures rather than intertrochanteric fractures. We hypothesize that low BMD might protect against femoral neck fractures if fractures of the intertrochanteric region dissipated the energy of a direct impact on the hip. The intertrochanteric region must be strong enough to stay intact while transmitting sufficient energy to fracture the neck. Vega [7] reported that vertebral fractures were twice as frequent among intertrochanteric fracture patients compared with femoral neck fracture patients. In contrast, in our comparison of femoral neck with intertrochanteric fractures, a history of osteoporosis or vertebral fractures or fractures after age 50 years were not independent predictors of one fracture type over the other. Vega [7] also found that on average intertrochanteric fracture patients weighed 6 kg less than femoral neck fracture patients, while our investigation confirmed a weight factor, with weight loss increasing the risk of intertrochanteric fractures. Weight or weight loss, however, did not significantly predict one type of fracture when comparing intertrochanteric with femoral neck fractures simultaneously.

This is the first prospective study comparing risk factors for the two major types of hip fracture. Previous studies have been either retrospective analyses or limited by small sample sizes limiting their power to detect differences [5–10,26]. This is also the first study to evaluate all potential risk factors simultaneously to determine the independent association of each variable with that type of fracture and between the two types of hip fracture. However, our subjects were likely to be healthier than the general population because they were volunteers and because we excluded women who were unable to walk without assistance. Participants were women over age 65 years and almost all white, so these findings may not generalize to men, younger women and women of other races.

These data may have implications for hip fracture prevention. Pharmacologic agents may have differential effects on the hip sites depending on the amount of trabecular versus cortical bone. Femoral neck fractures may be best prevented by careful screening for family history and instituting early preventive measures. Intertrochanteric fractures may be best prevented by increasing bone density. Overall, the differences in the physiopathologic processes of these two types of hip fracture need to be recognized in future studies of risk factors for hip fracture.

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