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FOOT AND ANKLE FRACTURES IN ELDERLY WHITE WOMEN

INCIDENCE AND RISK FACTORS

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Background: Although foot and ankle fractures are among the most common nonspinal fractures occurring in older women, little is known about their epidemiology. This study was designed to determine the incidence of and risk factors for foot and ankle fractures in a cohort of 9704 elderly, nonblack women enrolled in the multicenter Study of Osteoporotic Fractures.

Methods: At their first clinic visit, between 1986 and 1988, the women provided information regarding lifestyle, subjective health, and function. Bone mineral density was measured in the proximal and distal parts of the radius and in the calcaneus. The women were followed for a mean of 10.2 years, during which time 301 of them had a foot fracture and 291 had an ankle fracture. The fractures were classified with use of a modification of the Orthopaedic Trauma Association's guidelines.

Results: The incidence of foot fractures was 3.1 per 1000 woman-years, and the incidence of ankle fractures was 3.0 per 1000 woman-years. The most common ankle fracture was an isolated fibular fracture (prevalence, 57.6%), and the most common foot fracture was a fracture of the fifth metatarsal (56.9%). Women who sustained an ankle fracture had been slightly younger at the time of study enrollment than the women who did not sustain such a fracture (71.0 compared with 71.7 years), they had a higher body mass index (27.6 compared with 26.5), and they were more likely to have fallen within the twelve months prior to filling out the original questionnaire (38.1% compared with 29.7%). The appendicular bone mineral density was not significantly different between these two groups of subjects.

Women who sustained a foot fracture had a lower bone mineral density in the distal part of the radius (0.345 g/cm^2 compared with 0.363 g/cm^2) and a lower calcaneal bone mineral density (0.394 g/cm^2 compared with 0.404 g/cm^2) than the women without a foot fracture, they were less likely to be physically active (62.3% compared with 67.8%), and they were more likely to have had a previous fracture after the age of fifty (45.5% compared with 36.8%) and to be using either long or short-acting benzodiazepines.

Conclusions: Overall, foot fractures appeared to be typical osteoporotic fractures, whereas ankle fractures occurred in younger women with a relatively high body mass index.

Level of Evidence: Prognostic study, Level I-1 (prospective study). See Instructions to Authors for a complete description of levels of evidence.

Fractures are common in older women, and the numbers of fractures will most likely continue to increase as the size of the older population continues to increase. Most fractures in older women are considered to be osteoporotic fractures, especially if they are the result of minimal trauma. In fact, osteoporosis is believed to account for 1.5 million fractures in the United States each year[1,2].

However, little is known about the epidemiology of foot and ankle fractures in older women. This is surprising when one considers that foot and ankle fractures are among the most common nonspinal fractures in older women, that they often have a poor prognosis, and that they can have a substantial impact on lifestyle in this population[1,2]. In addition, since many elderly patients have coexisting medical conditions, the treatment of lower-extremity fractures is often challenging. Therefore, a major public health goal should be to identify specific risk factors and methods to prevent the occurrence of foot and ankle fractures in older women.

The traditional belief has been that both foot and ankle fractures in elderly people are osteoporotic or insufficiency

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fractures[3,4]. However, a previous study of a cohort of older women enrolled in the Study of Osteoporotic Fractures suggested that these fractures are not associated with a low bone mass in the foot but are related to other factors such as activity level and a low bone mass in the distal part of the radius[5]. Female gender, obesity, and diabetes have also been reported to be risk factors for ankle fractures[5]. In this study, we attempted to further clarify and define the risk factors associated with foot and ankle fractures in a large population of older, nonblack women enrolled in the Study of Osteoporotic Fractures and followed over an approximately ten-year period.

Materials and Methods

A total of 9704 nonblack women, sixty-five years of age or older, who were able to walk were recruited during 1986 through 1988 at four clinical sites: Baltimore, Maryland; Minneapolis, Minnesota; Monongahela Valley, Pennsylvania; and Portland, Oregon. A complete description of the study recruitment process was published previously[6]. Because the original focus of this study was hip fractures, men and black women were excluded because of the low incidence of hip fractures in those populations. Women with bilateral total hip replacement were also excluded. The study was approved by the Institutional Review Board at each clinic site, and all participants signed a consent form prior to the initial clinic visit.

Initially, a comprehensive history was recorded for each patient and a thorough physical examination was performed. The participants completed a questionnaire regarding age, education, living status, personal habits, exercise, smoking, alcohol consumption, medical history, family history, medication history, and reproductive history. (This questionnaire is available from the one of the authors [S.F.C.].) During the initial interview, patients rated their functional status by describing their ability to perform six activities of daily living: (1) walking two to three blocks outside on level ground, (2) ascending ten steps without stopping, (3) descending ten steps, (4) preparing meals, (5) doing strenuous housework, and (6) shopping for food and clothes[7]. Cognitive function was assessed with the Modified Mini-Mental State examination[8]. Height and weight were measured, and the body mass index was calculated as weight divided by height (kg/m^2). The circumferences of the waist and hips were measured and were expressed as the waist-to-hip ratio.

At the initial visit, the bone mineral density was measured at the distal part of the radius, the proximal part of the radius, and the calcaneus with use of single photon absorptiometry (OsteoAnalyzer; Siemens-Osteon, Wahiawa, Hawaii). Mean coefficients of variation for bone mineral density among the centers were 0.4%, 0.5%, and 1.2% for the distal part of the radius, proximal part of the radius, and calcaneus, respectively. The technique for determining bone mineral density at these sites has been previously described[6].

Study participants were instructed to contact the regional clinic site as soon as possible after sustaining any fracture. In addition, participants were contacted by mail or telephone every four months to see if they had sustained a fracture[5,9]. The rate of follow-up to determine whether a fracture had occurred was >99% (9636 women). If a participant had died, her primary care physician or someone who had had a close relationship with her was interviewed to determine if a fracture had occurred since the last follow-up contact. During the follow-up period, the women in this cohort sustained 578 hip fractures, 282 clinically identified vertebral fractures, and 2756 other fractures not related to major trauma. The radiographic report on each fracture was obtained and confirmed by the principal investigator at the clinic as well as by an investigator at the coordinating center.

TABLE I Ankle Fractures Occurring During the Period of Follow-up in Elderly Women Enrolled in the Study of Osteoporotic Fractures*

Ankle fracture	276
Isolated fibular	159 (57.6%)
Bimalleolar	53 (19.2%)
Trimalleolar	56 (20.3%)
Isolated medial malleolar	8 (2.9%)

*The values are given as the number of fractures with the percentage of the total number of ankle fractures in parentheses. The fractures in fifteen women were not characterized because of a lack of detail in the radiology reports.

The radiographic report on each ankle and foot fracture was reviewed by one of us (C.T.H.), and the fracture was classified with a modification of the system adopted by the Orthopaedic Trauma Association Committee for Coding and Classification (see Appendix)[10,11]. The modifications of this system allowed us to classify the fractures on the basis of their location without addressing specific fracture patterns, which were not usually described in the radiology reports. Of the 592 women who had an ankle or foot fracture, 553 (268 with an ankle fracture and 285 with a foot fracture) had radiology reports with sufficient detail for fracture classification.

The women who had sustained a foot or ankle fracture were compared with the women who had not sustained a fracture. Chi-square tests were used for categorical variables, and t tests were used for continuous variables. Multivariate Cox proportional hazards models were constructed to identify the baseline characteristics that were independently predictive of ankle and foot fractures.

Results

Usable data were obtained from 9659 participants who were followed for an average (and standard deviation) of 10.18 ± 3.03 years. During this time, 301 women sustained a fracture of one or more bones in the foot and 291 women sustained a fracture of the ankle; the overall incidence of foot fractures was 3.1 per 1000 woman-years, and the overall incidence of ankle fractures was 3.0 per 1000 woman-years.

Of the ankle fractures, 57.6% were isolated fibular frac-

TABLE II Independent Predictors of Ankle and Foot Fractures Occurring in Elderly Women Enrolled in the Study of Osteoporotic Fractures*

	Ankle Fracture	Foot Fracture
Age (per 5 years)	0.94 (0.84, 1.06)	1.13 (1.00, 1.28)
Body mass index (per standard deviation)	1.17 (1.05, 1.30)	—
Distal radial bone mineral density (per standard deviation)	—	1.23 (1.16, 1.32)
Falls in previous year		
0	1.0	—
1	1.26 (0.94, 1.69)	—
≥2	1.65 (1.18, 2.32)	—
Other fracture since age of 50 yr	—	1.41 (1.10, 1.79)
Currently taking short-acting benzodiazepines	—	1.62 (1.09, 2.40)
Currently taking long-acting benzodiazepines	—	1.72 (1.24, 2.40)

*The values are given as the relative risk for fracture, with the 95% confidence interval shown in parentheses.

tures. Of the isolated fibular fractures, 76% involved the shaft or metaphysis and 24% were avulsion or "chip" fractures. Bimalleolar and trimalleolar fractures accounted for 19.2% and 20.3%, respectively, of the ankle fractures. Isolated medial malleolar fractures accounted for only 2.9% of the ankle fractures (Table I).

The majority (88.5%) of the foot fractures involved the metatarsals, and 56.9% involved the fifth metatarsal (see Appendix). Fractures of the second, third, and fourth metatarsals each accounted for approximately 10% of the foot fractures. Only 2% of the foot fractures involved the first metatarsal. Four percent of the foot fractures were phalangeal, with most occurring in the proximal phalanx. Fractures of the calcaneus, talus, and tarsal bones each accounted for approximately 1% of the foot fractures. Of the fractures of the fifth metatarsal, 56% were located at the base of the bone, 41% were within the diaphysis, and 2% were at the head. In contrast, >70% of the fractures of the second, third, and fourth metatarsals were within the diaphysis and most of the others were located at the base.

The appendicular bone mineral density of the women who sustained a fracture of the ankle was not significantly different ($p > 0.05$) from that of the women who did not sustain a fracture (see Appendix). In contrast, the women who sustained a foot fracture had a 5% lower bone mineral density in the distal part of the radius (0.345 g/cm^2 compared with 0.363 g/cm^2) and a 2.5% lower calcaneal bone mineral density (0.394 g/cm^2 compared with 0.404 g/cm^2) than the women who did not have a fracture. Bone mineral density in the proximal part of the radius was not significantly different between these two groups. Adjustment of these data for age and body mass index did not substantially affect the results.

The women who had an ankle fracture were slightly younger (71.0 compared with 71.7 years, $p < 0.05$) and had a higher body mass index (27.6 compared with 26.5, $p < 0.05$) than the women without an ankle fracture, and more had fallen in the twelve months prior to filling out the original questionnaire (38.1% compared with 29.7%, $p < 0.05$). Women who had a foot fracture were less likely to have been physically active (62.3% compared with 67.8%, $p < 0.05$) and were more likely to have had a previous fracture of any bone after the age of fifty years (45.5% compared with 36.8%, $p < 0.05$) than women without a foot fracture. Use of estrogen replacement therapy did not vary by fracture status. No data were available on the use of bisphosphonates or selective estrogen receptor modulators in this cohort of women.

The baseline characteristics that independently increased the likelihood of sustaining an ankle fracture during the follow-up period were a high body mass index and a history of recurrent falls (two or more falls during the year prior to the initial clinic visit). Increased age, a previous fracture after the age of fifty years, decreased bone mineral density in the distal part of the radius, and use of benzodiazepines were predictive of foot fractures (Table II).

Discussion

The results of this study suggest that the risk factors for foot and ankle fractures differ. Foot fractures appear to be more typically osteoporotic fractures, whereas ankle fractures occur in younger, more active women with a higher body mass index.

A previous study of the same women showed no correlation between calcaneal bone mineral density and fractures of the foot or ankle[5]. In that study, the women were followed for 5.9 years and a total of 395 with a foot or ankle fracture were evaluated. In our study, these women were followed for a mean of more than ten years and a total of 592 with a fracture were evaluated. Although the previous study did not demonstrate a significant difference in calcaneal bone mineral density, women with a foot fracture did have a lower bone

mineral density in the distal part of the radius compared with those without a fracture. In our study, fractures of the foot were independently associated with a lower bone mineral density in both the distal part of the radius and the calcaneus. However, it should be noted that, in general, the ability of bone mineral density to predict the occurrence of fractures is approximately the same regardless of the site at which it is measured (the hip, spine, radius, or calcaneus) or the technique used for measurement[12,13].

In addition, women with a foot fracture were more likely to have had a previous fracture during their postmenopausal years. Such a medical history is considered to be a major predictor of future osteoporotic fractures.

Previous reports have suggested that fractures of both the foot and the ankle in elderly people are the result of osteoporosis[3]. Other studies have suggested that foot and ankle fractures are not related to bone mineral density[4,5]. Our study suggested that, although ankle fractures are independent of bone mineral density, foot fractures seem to be a type of osteoporotic fracture. Several studies have suggested that fractures of the metatarsal shaft in elderly individuals are associated with osteoporosis[2,3], and about 50% of the foot fractures in our current study involved the metatarsal shaft.

The majority of the ankle fractures in this study were isolated fibular fractures, a finding that is in agreement with those of previous studies[5,14]. Obesity was highly associated with ankle fractures in both the present study and the previous studies. More recently, it was found that the risk of ankle fractures was 40% lower among women in the lowest quartile of weight gain since the age of twenty-five than it was in those in the highest quartile[15]. Since ankle fractures usually result from rotation of the talus within the mortise, it is possible that accidental twisting of the ankle leads to higher torques in obese patients. These women also had a higher percentage of falls, suggesting that the increased weight predisposed them to falling.

Although diabetes mellitus is known to be associated with a variety of skeletal abnormalities, most research to date has not indicated that patients with diabetes have a greater tendency to sustain peripheral osteoporotic fractures. Neither our study nor a previous study of the same women[5] demonstrated an association between diabetes and ankle fractures. However, Daly et al.[14] found diabetes to be associated with an increased rate of ankle fractures. Schwartz et al.[16] analyzed the data from the Study of Osteoporotic Fractures and reported that the 106 participants who had insulin-treated Type-II diabetes had a two to three times higher risk of foot fractures than did persons without diabetes. However, although these findings were significant, they were based on only seven fractures. In our study, there was a trend for persons with diabetes to have a higher percentage of foot and ankle fractures than those without diabetes, but the difference between the groups was not significant.

The use of both long and short-acting benzodiazepines (as reported at the initial clinic visit) significantly increased the risk for foot fractures in this population. Patients who used benzodiazepines did not have more falls, suggesting a different reason for the increased risk of foot fracture. Future work should focus on the possible role of benzodiazepines in foot fractures.

The great majority of the foot fractures in these elderly women occurred in the fifth metatarsal rather than in the other bones of the foot. Why this bone is predisposed to fracture is not clear.

Future research on this cohort of elderly women will focus on the characteristics of the fall associated with the fracture. Furthermore, we plan to compare measures of mobility and function before the fracture to those after the fracture in order to determine the impact of the fractures on the lives of elderly women.

Appendix

eA Tables presenting the fracture classification system that was used, the anatomic distribution of the fractures, and the demographic and selected clinical characteristics of all of the patients in the study (with and without fractures) are available with the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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In support of their research or preparation of this manuscript, one or more of the authors received grants or outside funding from the National Institutes of Health. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

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