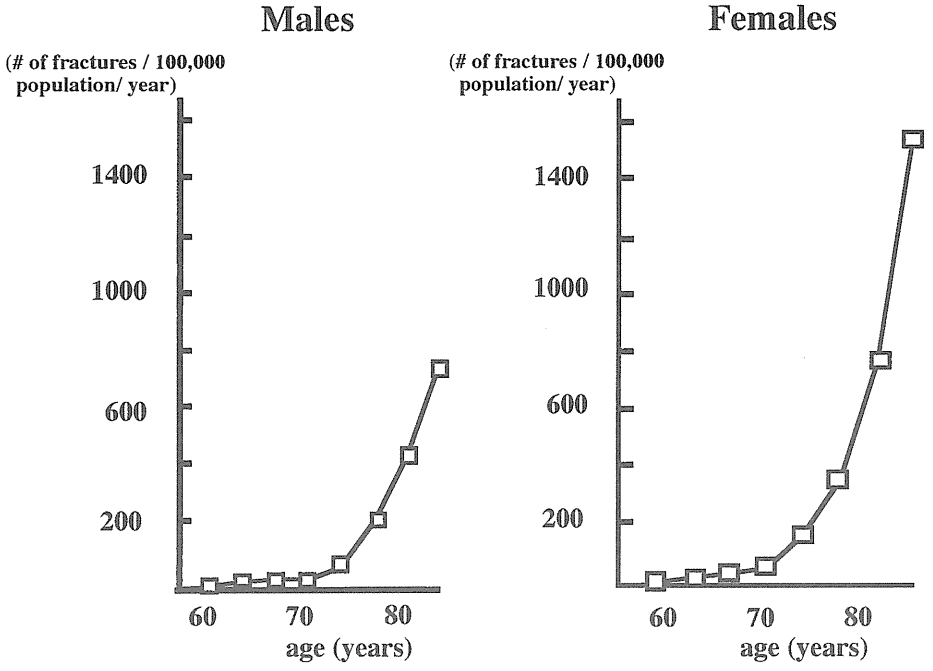

Fig. 2. Age-related incidence of cervical and trochanteric fractures of the proximal femur in males(*left*) and females (*right*) in Niigata Prefecture in 1994

Table 4. Change in the incidence of cervical and trochanteric fractures of the proximal femur in Niigata over the 4 study years

	1985	1987	1989	1994
Total number of fractures	677	773	996	1468
Male-to-female ratio	1:2.7	1:2.4	1:2.8	1:2.9
Average age (years)				
Males	67.5	70.4	71.4	74.4
Females	76.2	76.9	77.7	80.9
Raw incidence (number of fractures/100 000 population/year)	27.3	31.2	40.1	59.1

the patients with cervical fractures ($P < 0.05$). The average age of females with either type of fracture was significantly higher than the age of males ($P < 0.05$).

Change in incidence of hip fractures from 1985 to 1994

The total number of cervical and trochanteric fractures in Niigata Prefecture increased in every study year from 1985 to 1994 (Table 4) [2,13]. However, some minor differences existed among the population distributions by age and sex during the study years (Table 1). The number and percentage of those over 65 years of age increased each year, from 12.9% in 1985 to 17.3% in 1994.

Based on a reference year of 1985, the difference (or change) among the population by age and sex was adjusted. The expected number of the fractures in a age class was obtained by multiplying the incidence of the age class in 1984 by the population of that age class in 1994. The summation of the expected number of all classes was the total expected number in 1994, based on the number of fractures in 1985. If the incidence did not change from 1985 to 1994, the expected number of the fractures in 1994 would be the same as that in 1985. The total expected number of the fractures in 1994 was 936, and the expected number of fractures in 1994 was 220 for males and 716 for females (Table 5). However, the actual observed total number was 1468, 378 in malesand 1090 in females (Table 2). The expected number of the fractures in 1994 was significantly less than the actual observed numbers ($P < 0.001$) (Fig. 3). Therefore, the incidence of patients with these fractures significantly increased from 1985 to 1994.

In addition, there was the tendency that the actual observed number of fractures increased more in older age classes (especially in age classes over 75 years) than in younger classes (Table 5).

Discussion

In this study, we determined the number of cervical and trochanteric fractures of the proximal femur in Niigata in 1994 by visiting all the hospitals with an orthopedic surgery department. However, some patients with hip fractures may have presented at other medical facilities without an orthopedic department, such as nursing homes or mental hospitals. To estimate the number of patients with hip fractures treated at these other institutions lacking an orthopedic department, questionnaires

Table 5. The number of fractures in 1985 and 1994 and the expected number in 1994

Age class (years)	Fractures in 1985	Population in 1985	Incidence in 1985 (In)	Fractures in 1994	Population in 1994 (Pn)	Incidence in 1994	Expected no. in 1994[a] (En = In × Pn ÷ 100000)
Male							
Under 60	46	1014251	4.5	57	953396	5.9	42.9
60–65	13	59464	21.9	23	77930	29.5	17.1
65–70	16	45379	35.3	35	68167	51.3	24.1
70–75	38	38231	99.4	41	43274	94.7	43.0
75–80	33	26673	123.7	63	31059	199.6	38.4
80–85	16	13243	120.8	91	19743	455.8	23.8
Over 85	17	5726	296.9	68	10545	635.4	31.3
Total	179	1202967	14.9	378	1204114	31.1	220.6
Female							
Under 60	34	1005077	3.4	48	936085	5.1	31.8
60–65	16	77113	20.7	39	86273	45.2	17.9
65–70	40	61258	65.3	62	80908	76.6	52.8
70–75	89	53227	167.2	132	65786	200.7	110.0
75–80	112	40320	277.8	191	48693	394.3	135.3
80–85	103	23042	447.0	289	36600	792.4	163.6
Over 85	104	12206	852.0	329	24020	1373.9	204.7
total	498	1272243	39.1	1090	1278365	85.5	716.1
Both sexes							
Total	677	2475210	27.4	1468	2482479	59.1	936.7

[a] Expected number of hip fractures with adjustments for 1994 population composition

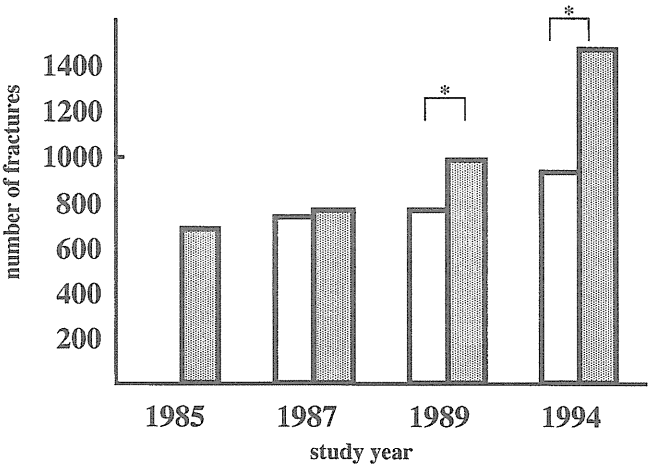

Fig. 3. Comparison of the expected (*open columns*) and observed (*shaded columns*) numbers of cervical and trochanteric hip fractures in the 4 study years.*, Statistically significant, $P < 0.05$

were sent in 1989 to 50 nursing homes and 23 mental hospitals in Niigata Prefecture in which patients with hip fractures may have been seen. According to this study, these possible "neglected" hip fractures corresponded to only about 2% of the total number of the fractures in Niigata Prefecture [3]. Because the present study was carried out using the same methodology as in 1989, it is believed that nearly all cases of hip fractures in Niigata Prefecture in 1994 were reliably included in this study, with similarly low numbers of "neglected" patients.

The overall incidence of cervical and trochanteric fractures in Niigata Prefecture in 1994 was 59.1 fractures per 100000 population per year (31.4 for malesand 85.2 for females). The fracture incidence increased with age in the 5-year age groups. Because the incidence of hip fractures has been shown to be high in the elderly population, it has been reported that the incidence of these fractures is most likely related to senile osteoporosis [14]. Our data support the idea that the increasing incidence of hip fractures with aging is caused by the progression of senile osteoporosis.

The overall incidence of cervical fractures in this study was 21.3 (9.1 for malesand 32.7 for females), and the overall incidence of trochanteric fractures was 37.8 (22.3 for malesand 52.5 for females). It is well known that osteoporosis more commonly occurs in females than in men, and is more closely related to trochanteric fractures than to cervical fractures. In the present study, the incidence of the combined number of cervical and trochanter fractures was greater in females than in men, and the number of trochanteric fractures was greater than the number of cervical fractures. It would appear that these differences result from the different frequency or degree of osteoporosis. However, we have no direct evidence to prove this.

When comparing the number of cervical and trochanteric hip fractures in 1994 with the numbers reported in Niigata Prefecture in 1985, 1987, and 1989 [2,3], it is evident that the overall number and incidence of these fractures have been increasing during the study period. After computing the expected number of cervical or

trochanteric fractures in 1994, adjusted with the age-related population in 1985, we compared the observed number of hip fractures in 1994 with the expected number. Although the total expected number of fractures in 1994 was 936.7, the observed number was 1468 (see Table 5). The observed number of fractures was significantly higher than the expected number, indicating that the incidence of these fractures has been increasing from 1985 to 1994. This increase was evident in the total number of the fractures, in both sexes, and in both types of fractures.

Many possible factors may be responsible for this increase in incidence of hip fractures [3,5,10,14–21]. In Niigata Prefecture, the age-related distribution of the population changed during the 9 years of the study period. The percentage of the elderly population (those over 65 years of age) within the overall population increased from 12.9% in 1985 to 17.3% in 1994. The incidence of cervical and trochanteric fractures was higher in the elderly group than in the younger age groups. This increase in the elderly population may be one of the factors responsible for the increase in the incidence of hip fractures in Niigata.

We compared the expected numbers of cervical and trochanteric hip fractures with the actual observed numbers, adjusting for the age-related distribution of the population. The differences between the expected and the observed numbers were significant, suggesting that factors other than the increase in the elderly population are responsible for the increase in the fracture incidence.

Sernbo and Johnell compared the Singh index of patients in the 1950s and 1980s, and suggested that the increase in the incidence of hip fractures was caused by a decrease in bone quality [22]. Some changes in the degree (seriousness) of osteoporosis of the patients and some changes in the number of patients of the study group could be important factors. We confirmed the tendency that the increase of the actual observed number of fractures was more in older classes (especially in those over 75 years of age) than in younger groups. Our hypothesis is that not only the increase of elderly population, but also the weak (easy-to-break-the-hip) elderly population can increase and can influence the increase of the number of the fractures. It can be seen that the numbers of old people who lived in 1940–1950, the period of insufficient food during World War II and the postwar period, increased. As they were growing up through the age of puberty during this period, their bone density or quality may be less than those of other age groups. In other words, each age group may have a particular bone strength. Making bone stronger during the younger years and maintaining the strength during older age may be important prevention measures against the fractures.

Epidemiological studies of cervical and trochanteric hip fractures were performed recently in other areas of Japan [10–12]. The age-specific incidence of the fractures in Nagasaki and Tottori, Japan, were at nearly the same level as in Niigata Prefecture [2,3]. In addition, the incidence of fractures in Japan was lower than the incidence reported in Europe and the United States [23,24]. Hinton et al. [25] studied the geographic and sex- and age-related variations in the incidence of hip fractures from 1984 to 1987 in the United States. The regional variations in the incidence of hip fractures in the United States were greater than the regional differences in Japan [10–12,26,27].

Some epidemiological studies have reported differences in the incidence of hip fractures among countries and races [21,24,28–33]. The age-specific incidence of hip fractures in various countries are compared in Fig. 4. The incidence of cervical and trochanteric hip fractures was lower in Japan than in other countries. Kawashima [2] and Dohmae et al. [3] pointed out that the age-specific hip fracture incidence curve for Niigata, Japan, was shifted to the right by more than 10 years, compared to the incidence curve from Uppsala, Sweden (see Fig. 4). Although the incidence of cervical and trochanteric fractures in Niigata increased between 1985 and 1994, the increase was not so great as that detected in Uppsala in 1991. Possible explanations for the difference in the incidence of hip fractures among various countries or races that have been proposed

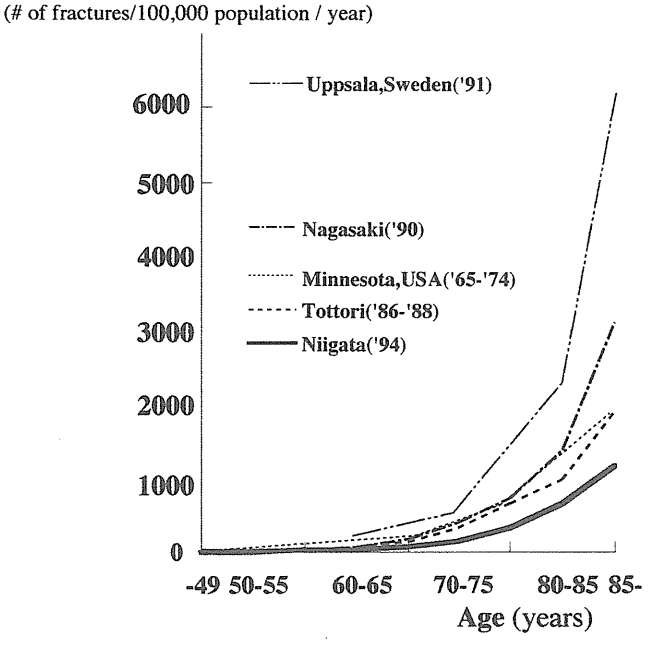

Fig. 4. Comparison of the age-related incidence of cervical and trochanteric hip fractures in several regions of Japan and in other countries

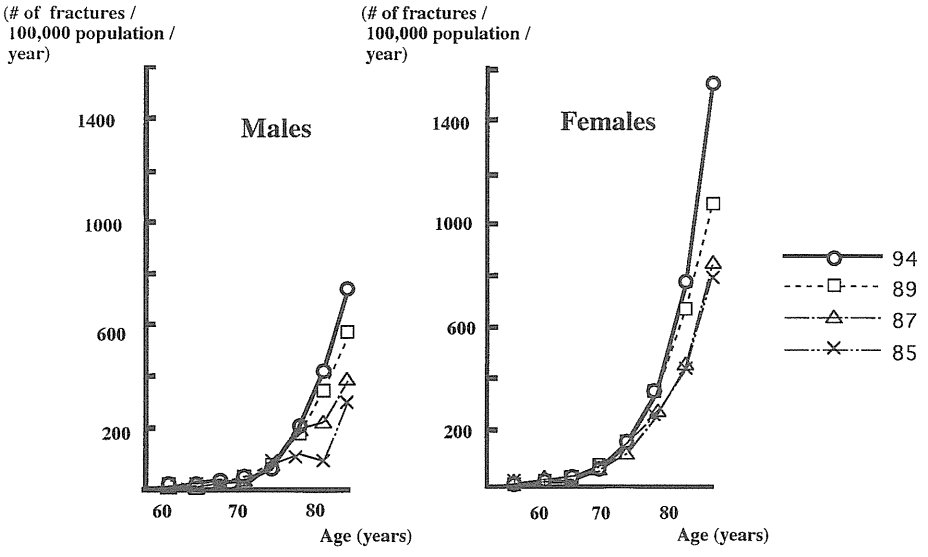

Fig. 5. Change in the incidences of cervical and trochanteric hip fractures in Niigata, Japan, from 1985 to 1994

include genetic differences between races and differences in the level of physical activity [5,28,29].

Some previous studies compared the bone mineral density of the Japanese and Caucasians and reported that the degree of osteoporosis in the Japanese was more severe [8,9]. It was also reported that the incidence of spinal fractures was higher in the Japanese than in Caucasians. Other authors reported that the incidence of hip fractures was related not only to osteoporosis but also to variation in the morphology of the proximal femur among races [23,34,35].

Brody projected future trends in the population of the United States, and predicted that the number of hip fractures would increase as the percentage of elderly people in the population increased [16]. The incidence of cervical and trochanteric hip fractures has increased in Niigata Prefecture from 1985 to 1994 (see Fig. 5). This increase, and possible future increases, may also reflect the growth in the elderly population in Niigata Prefecture and in Japan in general. The increase in the incidence of hip fractures is and will continue to be a very serious problem for our society.

Conclusions

The incidence of cervical and trochanteric fractures of the proximal femur was studied in 1994 in Niigata Prefecture, Japan. The incidence of these fractures detected in 1994 was compared to the incidence previously reported from 1985 to 1989. The number of cervical and trochanteric hip fractures increased in this 9-year study period, from 677 in 1985 to 1468 in 1994. The age-related incidence of these fractures also increased. The reasons for this increase in the incidence of hip fractures remain unknown, although many factors are undoubtedly involved. We have a hypothesis that the weak (easy-to-break-the-hip) elderly population may increase and that this increase can influence the increase in the number of fractures, but we have no evidence to prove this. The clarification of the causes of increase of the fractures and the prevention of hip fractures are important goals to attain in following studies.

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The incidence of cervical and trochanteric fractures of the proximal femur in 1999 in Niigata Prefecture, Japan

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Abstract The purpose of this study was to determine the incidence of cervical and trochanteric fractures of the proximal femur in 1999 in Niigata Prefecture, Japan, and to compare this incidence with those previously reported in Niigata in 1985, 1987, 1989, and 1994. The authors visited all hospitals within Niigata Prefecture having an orthopedic department and reviewed the medical records and radiographs of all patients who sustained such fractures in 1999. The population of Niigata Prefecture was determined in 1999 to be 2486999 (1208195 males and 1278804 females). The population over 65 years of age was 515290 (210564 males and 304726 females), representing 20.7% of the total population. In 1999, there were 1697 cervical or trochanteric fractures, in 400 males and 1297 females, with a male-to-female ratio of 1:3.2. The incidence of these fractures in persons over 65 years of age was 308.7 fractures per 100000 per year. This incidence increased from 1985 to 1989 and from 1989 to 1994, but after that, the rate of increase in incidence from 1994 to 1999 slowed down slightly. This suggests that the prevention of fractures in the elderly population in Niigata Prefecture influenced the lower ratio.

Key words epidemiology · cervical and trochanteric femoral fracture · hip fracture · Niigata · Japan

Introduction

Hip fractures are related to senile osteoporosis and result in impaired physical activity [1]. Previous studies have shown that the incidence of hip fractures differs from country to country and among different races [2–5].

Asian and Africans are thought to have a lower incidence of hip fractures, compared with Caucasians [5–8]. However, several studies of the prevalence of osteoporosis reported that the Japanese tend to have lower bone mineral content and a higher incidence of postmenopausal spinal osteoporosis than Caucasians [9–10]. Kawashima [2] carried out the first study of the incidence of hip fractures in Niigata Prefecture, Japan, in 1985. He found that the incidence of hip fractures in Niigata was lower than the incidence reported for Caucasians. Recently, similar studies in Japan have also reported that the incidence of hip fractures was lower than that in Caucasians [3,11–13].

The goals of this study were to determine the incidence of cervical and trochanteric fractures of the proximal femur that occurred in 1999 in Niigata Prefecture, Japan, and to document the secular change in the incidence of these fractures from 1985 to 1999.

Subjects and methods

Niigata Prefecture: location, races, and population

This study was carried out in Niigata Prefecture, which is located in the middle of the main island of Japan. The center of the region is located at 38° north latitude and 139° east longitude. The area of Niigata Prefecture is approximately 12580 square kilometers. The racial composition of the people in Niigata Prefecture is almost exclusively Japanese. Because the region is bounded by the mountains and sea, most residents are treated in medical institutions within Niigata Prefecture.

The prefectural office in Niigata collects census data each year. As of December 1999, the population of Niigata Prefecture was 2486999 (1208195 males and

Offprint requests to: N. Endo
Data presented in the *Journal of Bone and Mineral Metabolism* (references 2–4) are included in some Figures and Tables in this article, to examine secular change from 1985.
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Table 1. Relevant population in Niigata Prefecture during the 5 study years

Year	Total population	Population over 65 years of age	Percentage of population over 65 years of age (%)
1985	2476383	319305	12.9
1987	2480846	340944	13.7
1989	2482223	352003	14.2
1994	2483879	428795	17.3
1999	2486999	515290	20.7

1278804 females). The population of residents over 65 years of age was 515290 (210564 men and 304726 women), or 20.7% of the total population. The total population of Niigata Prefecture in each study year, as well as the elderly population over 65 years of age, is shown in Table 1.

Number of hip fractures in 1999

The medical records and radiographs of all residents of Niigata Prefecture who were diagnosed as having a hip fracture from January 1 to December 31, 1999, were collected by the authors from 62 hospitals in the prefecture.

The present study was carried out using the same methodology as in 1989 [3]. Basic demographic information on sex, age, and the type of hip fracture was recorded. Patients with isolated fractures of the greater trochanter, subtrochanteric fractures, and pathological fractures were excluded from the study.

Patients from other prefectures were also excluded, as well as those under 20 years of age. All hip fractures were classified as being either cervical or trochanteric. Fractures at the level of the base of the neck were included in the trochanteric category. The residents of Niigata Prefecture who sustained cervical or trochanteric fractures in 1999 were included in the study.

Secular change in the incidence of fractures from 1985 to 1999

All patients with fractures in this study were classified according to the patient's age (5-year intervals), sex (male or female), and type of fracture (cervical or trochanteric). The incidence of cervical or trochanteric fractures in each 5-year age interval in each study year was calculated as the number of fractures per 100000 population per year.

Studies of the incidence of hip fractures in Niigata Prefecture have been performed previously, in 1985, 1987, 1989, and 1994 [2–4]. We collected these data to compare the results with those in 1999. To compare the incidence of cervical or trochanteric fractures in the individual and combined 5-year age groups among the 5 study years, a standard (reference) study year was chosen, which was 1985 in this study.

The number of fractures "expected" to occur in each age group in a "particular" study year, for example 1999, was compared with the number that was actually "observed" in 1999. The expected number of fractures (En) was computed by taking the product of the incidence of fractures in the reference study year, 1985 (In), and the population in the particular study year, 1999 (Pn), and then dividing by 100000:

$$En = In1985/*Pn1999/100000$$
$$E\ total\ 1999 = \Sigma En1999$$

E total : the expected total number of fractures

The expected total number of fractures (E total) refers to the number of fractures that would be expected to occur in 1999, based on the incidence previously recorded in 1985 and the current population in 1999. In other words, the expected number of fractures refers to the number expected to occur, assuming that the incidence is the same in the reference year and the particular study year, with the differences in the age-related population pyramid between the 2 years being taken into account. If the expected total number of fractures (E total) in the particular study year was higher than the observed number, the incidence in the particular study year would be lower than the incidence in the reference year. Also, if the expected number of fractures in the particular study year was lower than the observed number, the incidence in that particular year would be higher than that in the reference year.

This indicates the secular change (decrease or increase) in the incidence of hip fractures regardless of the age composition of the population. The expected number of males and females with cervical or trochanteric fractures in each of the age intervals was calculated using these procedures.

Comparisons were made using different combinations of reference and particular study years. The differences between the expected and observed numbers of fractures were compared using χ^2 analysis. An alpha level of 0.05 was considered significant. The expected number of fractures in an age class was obtained by multiplying the incidence of the age class in 1985 by the

population of that age class in 1999. Summation of the expected number of all classes was the expected total number in 1999, based on the number of fractures in 1985. If the incidence did not change from 1985 to 1999, the expected number of fractures in 1999 would be the same as the observed number in 1999.

Results

Number of hip fractures in 1999

A total of 1697 cervical or trochanteric fractures of the proximal femur occurred in 1999 (400 males and 1297 females), with a male-to-female ratio of 1:3.24 (Tables 2 and 3; Fig. 1). Ninety-four percent (1599) of all cervical or trochanteric fractures occurred in "the elderly population", who were more than 65 years of age, and 78% (1324) of all fractures occurred in the "advanced age group", over 75 years of age.

Table 2. Summary of cervical and trochanteric fractures in the proximal femur for people living in Niigata Prefecture, Japan, in 1999

	Number	Incidence[a]
Total number of fractures	1697	68.2
Sex		
Male	400	33.1
Female	1297	101.4
Male-to-female ratio	1:3.24	
Type of fracture		
Cervical	622	25.1
Trochanteric	1075	43.2
Cervical-to-trochanteric ratio	1:1.73	

[a]Number of fractures/100000 population per year

The overall incidence of the combined number of cervical and trochanteric fractures was 68.2 per 100000 population per year, with 33.1 for males, and 101.4 for females (Tables 2 and 3). The incidence of the combined number of cervical and trochanteric fractures in those over 65 years of age was 168.6 for men and 405.6 for women. The incidence in those more than 85 years of age increased to 628.4 for men and 1299.8 for women. There were 1075 trochanteric fractures (63.4%) and 622 cervical fractures (36.6%) (Table 2).

The average age of patients with cervical fractures was 75.5 years for men and 80.5 years for women. The average age of the patients with trochanteric fractures was 89.5 years for men and 82.2 years for women. The average age of the patients of both sexes with trochanteric fractures was significantly higher than the age of the patients with cervical fractures (Tables 2–4).

Secular change in the incidence of hip fractures from 1985 to 1999

The total number of cervical and trochanteric fractures (observed number) in Niigata Prefecture increased in every study year from 1985 to 1999 (Table 4) [2–4]. The number and percentage of those over 65 years of age increased each year, from 12.9% in 1985 to 20.7% in 1999 (Table 1).

Based on a reference year of 1985, the population was adjusted by age and sex. The expected total number of fractures in 1999 was 1200.2, with 269.3 for males and 930.9 for females (Table 5). The actual observed number of fractures was 1697, with 400 for men and 1297 for women (Table 2). The expected number of fractures in 1999 was significantly less than the actual numbers observed ($P < 0.05$) (Fig. 2). This indicates that the

Table 3. Age-specific number and incidence of cervical and trochanteric fractures of the proximal femur in 1999

	Males		Females		Total	
Age (years)	Number	Incidence	Number	Incidence	Number	Incidence
Incidence						
0–49	11	1.5	12	1.7	23	1.6
50–54	5	5.2	7	7.6	12	6.4
55–59	8	10	11	13.4	19	11.7
60–64	21	28.3	31	38.2	52	33.5
65–69	35	48.5	57	68.5	92	59.2
70–74	54	86.0	125	159.4	179	126.8
75–79	64	169.4	231	367.7	295	293.2
80–84	105	469.4	321	770.3	426	665.2
85+	97	628.4	502	1299.8	599	1108.0
Total	400	33.1	1297	101.4	1697	68.2
Over 65	358	168.6	1241	405.6	1599	308.8
Percentage	89.5		95.7		94.2	
Over 75	267	351.9	1057	736.4	1324	613.6
Percentage	66.8		81.5		78.0	

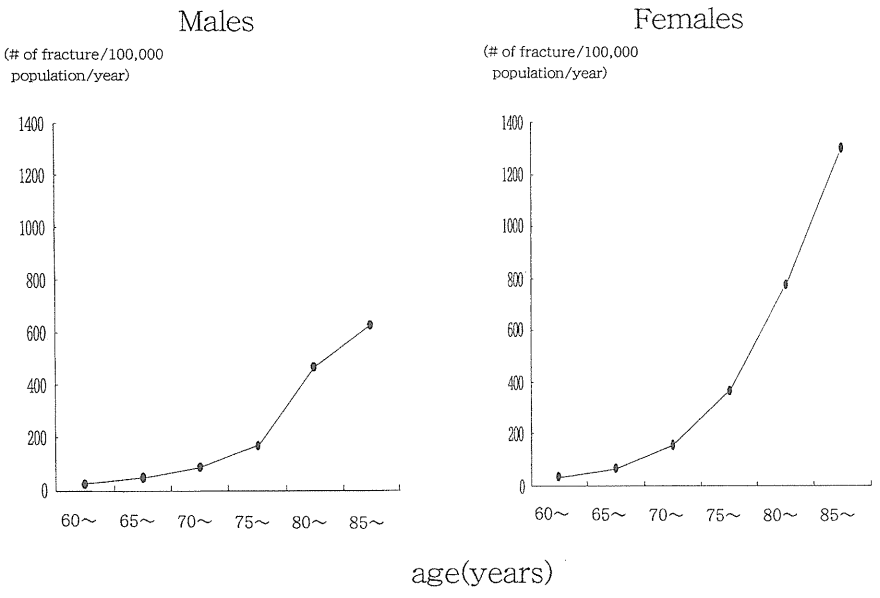

Fig. 1. Age-related incidence (/100000 population/year) of cervical and trochanteric fractures of the proximal femur

Table 4. Changes in the incidence of cervical and trochanteric fractures of the proximal femur in Niigata over the 5 study years

	1985	1987	1989	1994	1999
Total number of fractures	677	773	996	1468	1697
Male-to-female ratio	1:2.7	1:2.4	1:2.8	1:2.9	1:3.24
Average age (years)					
Males	67.5	70.4	71.4	74.4	75.5
Females	76.2	76.9	77.7	80.9	80.5
Raw incidence[a]	27.3	31.2	40.1	59.1	68.2

[a] Number of fractures/100000 population/year

Table 5. The number of fractures in 1985 and 1999 and expected number in 1999

Age class (years)	Fractures in 1985	Population in 1985	Incidence in 1985 (In)	Fractures in 1999	Population in 1999 (Pn)	Incidence in 1999	Expected no. (En) in 1999 (En = In*Pn/100000)
Male							
Under 60	46	1014251	4.6	24	923399	2.4	42.5
60–65	13	59464	21.9	21	74232	26.9	16.3
65–70	16	45379	35.3	35	72196	49.9	25.5
70–75	38	38231	102	54	62777	87.6	64
75–80	33	26673	127.5	64	37783	172.0	48.2
80–85	16	13243	120.8	105	22371	469.4	27.0
Over 85	17	5726	296.9	97	15437	628.4	45.8
Total	179	1202967	15.1	400	1208195	33.1	269.3
Female							
Under 60	34	1005077	3.5	30	892967	2.9	30.3
60–65	16	77113	20.8	31	81111	37.0	16.9
65–70	40	61258	65.3	57	83188	69.7	54.3
70–75	89	53227	167.2	125	78416	160.7	131.1
75–80	112	40320	280.3	231	62826	369.3	176.1
80–85	103	23042	451.4	321	41674	772.7	188.1
Over 85	104	12206	860.2	502	38622	1302.4	332.1
Total	498	1272243	39.5	1297	1278804	101.4	930.9
Both sexes							
Total	677	2475210	27.4	1697	2486999	68.2	1200.2

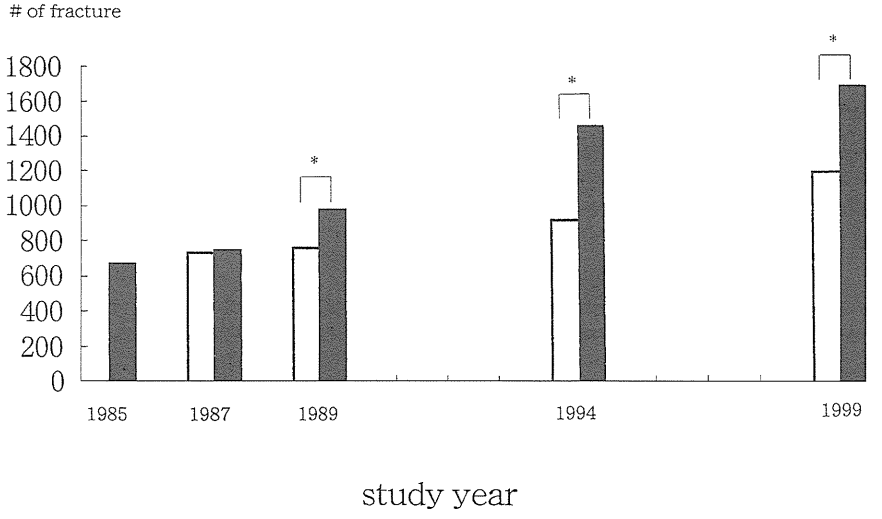

Fig. 2. The expected (*open columns*) and observed (*shaded columns*) numbers of cervical and trochanteric fractures in the 5 study years. $*P < 0.05$

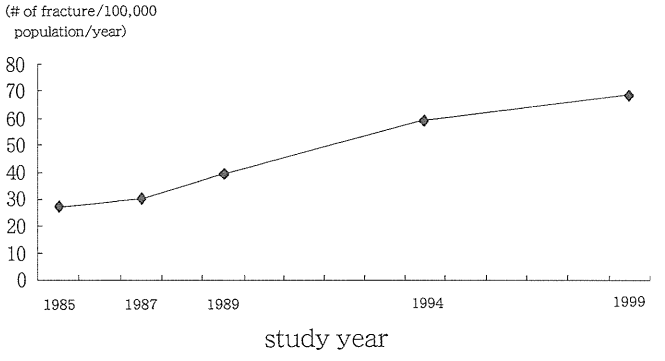

Fig. 3. Total incidence (/100000 population/year) of hip fractures in the 5 study years

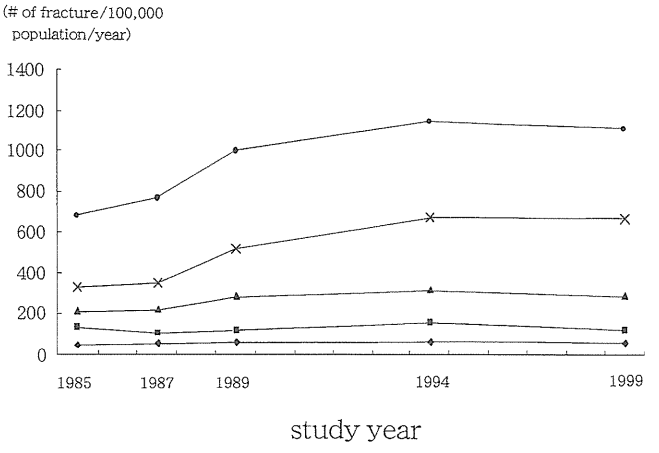

Fig. 4. The incidence (/100000 population/year) of hip fractures in patients over 65 years of age. *Closed circles*, Age 85 or more; *crosses*, age 80–84; *closed triangles*, age 75–79; *closed squares*, age 70–74; *closed diamonds*, age 65–69

incidence of patients with these fractures increased significantly from 1985 to 1999, on the basis of adjustment of the population composition.

The secular change of incidence was examined. There was a significant difference between 1985 and 1999, 1987 and 1999, and 1989 and 1999, but no significant difference was observed between 1994 and 1999. The rate increased from 1985 to 1989 and from 1989 to 1994, whereas, after that, the increasing rate of incidence from 1984 to 1994 went down slightly. In other words, the raw incidence of hip fractures increased from 1985 to 1999, while from 1994 to 1999, the increasing rate of incidence slowed down (Fig. 3). The incidence of hip fractures in people over 65 years of age slowed down, and in any age class of people over 65 years of age (elderly population) the incidence of hip fractures flattened or slightly decreased from 1994 to 1999 (Fig. 4).

Discussion

In this study, we determined the number of cervical and trochanteric fractures of the proximal femur in Niigata in 1999 by visiting all the hospitals with an orthopedic surgery department. However, some patients with hip fractures may have presented at other medical facilities without an orthopedic department, such as nursing homes or mental hospitals. Dohmae et al. [3] reported that patients with "neglected" hip fractures corresponded to only about 2% of the total number of fractures in Niigata Prefecture in the previous study. Because the present study was carried out using the same methodology as in 1989, it is believed that nearly all cases of hip fractures in Niigata Prefecture in 1999 were reliably included in this study, with low numbers of "neglected" patients.

The overall incidence of cervical and trochanteric fractures in Niigata prefecture in 1999 was 68.2 fractures per 100 000 population per year (33.1 for men and 101.4 for women). The fracture incidence increased with age in the 5-year age groups. Because the incidence of hip fractures has been shown to be high in the elderly population, it has been reported that the incidence of these fractures is most likely related to senile osteoporosis [14] in the elderly population.

The use of long-acting sleeping drugs, visual difficulties, impaired physical capacity, altered cognitive function (failing muscle strength and poor balance) were risk factors for hip fractures [15,16].

The overall incidence of cervical fractures in this study was 25.1 (11.1 for men and 38.1 for women), and the overall incidence of trochanteric fractures was 43.2 (21.9 for men and 63.3 for women). It is well known that osteoporosis occurs more commonly in women than in men, and is more closely related to trochanteric fractures than to cervical fractures.

In the present study, the incidence of the combined number of cervical and trochanter fractures was greater in women than in men, and the number of trochanteric fractures was greater than the number of cervical fractures. It would appear that these differences result from the different frequencies or degrees of osteoporosis.

When comparing the number of cervical and trochanteric hip fractures in 1999 with the numbers reported in Niigata Prefecture in 1985, 1987, 1989, and 1994 [2–4], it is evident that the overall number and incidence of these fractures increased during the study period (1985–1994).

After computing the expected number of cervical or trochanteric fractures in 1999, adjusted with the age-related population in 1985, we compared this number with the observed number. Although the total expected number of fractures in 1999 was 1200.2, the observed number was 1697 (see Table 5). The observed number of fractures was higher than the expected number, indicating that the incidence of these fractures had been increasing from 1985 to 1999. This increase was evident in the total number of fractures, in both sexes, and in both types of fractures.

We also compared the secular change of incidence, between 1987 and 1999, 1989 and 1999, and 1994 and 1999, in the same manner. There was a significant difference between 1987 and 1999, and between 1989 and 1999, whereas between 1994 and 1999, there was no significant difference, in males only.

Kannus et al. [17] reported that the worldwide trend is for increasing incidence. Rogmark et al. [18] reported that the incidence of hip fractures increased. On the other hand, Levi [19] noted an incidence that was unchanged in Copenhagen, Denmark. Because of the decrease in the incidence of hip fractures in "the elderly population," the overall incidence of hip fractures has slowed down year by year. This suggests that the prevention of fractures for the elderly population (public information, including prevention and treatment for osteoporosis, etc) may be related to the above-mentioned results.

Many possible factors are responsible for the increase in the incidence of hip fractures [3,6,11,14,20–26]. In Niigata Prefecture, the age-related distribution of the population changed during the 14 years of the study period. The percentage of the elderly population (those over 65 years of age) within the overall population increased from 12.9% in 1985 to 20.7% in 1999. The incidence of cervical and trochanteric fractures was higher in the elderly group than in the younger age group. This increase in the elderly population may be one of the factors responsible for the increase in the incidence of hip fractures in Niigata.

Sernbo and Johnell [27] compared the Singh index of patients in the 1950s and 1980s, and suggested that the increase in the incidence of hip fractures was caused by a decrease in bone quality. Some changes in the degree (seriousness) of osteoporosis in the patients and some changes in the number of patients in the study group could be important factors.

We confirmed the tendency that an increase in the actual observed number of fractures was greater in older age groups (especially in those over 75 years of age) than in younger groups. Our hypothesis is that not only is there an increase in the elderly population but also there could be an increase in the weak (fragile) elderly population, and this can influence the increase in the number of fractures. It can be seen that the number of old people who lived in the 1940s increased (at the time, the elderly population, of over 75 years of age, were adolescents, during the period of insufficient food during World War II and the postwar period). As they were growing up through the age of puberty during this period, their bone density or quality may have been less than that of other age groups. Reid et al. [28] reported that nutrition in childhood played some part in the hip axis length and affected the incidence of hip fractures. Baker et al. [29] reported that the nutritional needs of children and adolescents for calcium influenced the development of osteoporosis in adulthood. In other words, each age group may have a particular bone strength. Making bones stronger during the early years and maintaining this strength in older age may be important measures in preventing fractures.

Epidemiological studies of cervical and trochanteric hip fractures were performed recently in other areas of Japan [11,12]. The age-specific incidences of fractures in Nagasaki and Tottori, Japan, were at nearly the same level as that in Niigata Prefecture [2–4]. In addition, the incidence of fractures in Japan was lower than the inci-

dence reported in Europe and the United States [30,31]. Hinton et al. [32] studied the geographic and sex- and age-related variations in the incidence of hip fractures from 1985 to 1987 in the United States. The regional variations in the incidence of hip fractures in the United States were greater than the regional difference in Japan [10–12,33,34].

Some previous studies have compared the bone mineral density of Japanese and Caucasians and reported that the degree of osteoporosis in Japanese was lower [9,10]. It was also reported that the incidence of spinal fractures was higher in Japanese than in Caucasians. Other authors reported that the incidence of hip fractures was related not only to osteoporosis but also to variations in the morphology of the proximal femur among races [30,35,36].

Brondy projected future trends in the population of the United States, and predicted that the number of hip fractures would increase as the percentage of elderly people in the population increased [21]. Recently, the ratio of the elderly population has been increasing year by year, and hip fractures have become a serious problem for our society [37–40].

The overall number of hip fractures in Niigata Prefecture increased from 1985 to 1999, but the ratio of increase in incidence slowed down from 1994 to 1999.

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ORIGINAL ARTICLE

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Incidence and outcome of osteoporotic fractures in 2004 in Sado City, Niigata Prefecture, Japan

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Abstract Osteoporotic fracture in elderly populations is increasing worldwide, but there are few data on the incidence and outcome of osteoporotic fractures, including upper extremity and vertebral fracture, during a certain period in a defined geographic area. The purpose of this study was to determine the incidence of osteoporotic fractures in a particular area: Sado City, Niigata Prefecture, Japan. From January to December 2004, osteoporotic fractures of the vertebra, hip, distal radius, and proximal humerus in Sado City were recorded. The incidence, age, gender, type of fracture (for hip fracture), right or left side (for distal radius, proximal humerus, and hip fracture), place of injury, cause of injury, outcome, hospitalization period, and patient status regarding taking of drugs for osteoporosis treatment were checked for each fracture. The incidence was calculated based on the whole population of Sado City. The incidence per 100000 population was 232.8, 121.4, 108.6, and 37.1 for fractures of the vertebra, hip, distal radius, and proximal humerus, respectively. The total incidence of these four kinds of fracture was 499.9 per 100000 persons per year. The average age at the time of injury was 81.4, 77.7, 75.7, and 60.2 years old for fractures of the hip, vertebra, proximal humerus, and distal radius, respectively. As the average age increased, the percentage of fractures that occurred indoors also increased; that is, a higher percentage of hip fractures occurred indoors, followed by fractures of the vertebra, proximal humerus, and distal radius. Most patients were not taking anti-osteoporosis drugs before fractures of the hip or vertebra. We determined the incidence of major osteoporotic fractures in 1 year in a defined geographic area. Our data showed that 81% of hip fracture patients also had a vertebral fracture and that the average age at the time of injury was higher for hip fractures than for vertebral fractures. Therefore, these results suggest that vertebral fracture leads to hip fracture, indicating that early fracture prevention and continuous prevention strategies through positive treatment are of importance in osteoporotic elderly people.

Key words vertebral fracture · hip fracture · proximal humerus fracture · distal radius fracture · incidence

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Introduction

Osteoporotic fractures, and especially vertebral and hip fractures, reduce quality of life (QOL) in elderly people because of associated pain, malposture, movement disability, and mental anxiety [1–4]. Knowledge of the descriptive epidemiology of the incidence and outcome of these fractures is important for prevention or reduction of such fractures. The aim of this study was to identify the incidence of fractures of the vertebra, hip, distal radius, and proximal humerus over a certain period in a population in a defined geographic area: Sado City, Niigata Prefecture, Japan.

Patients and methods

Study site

The study was carried out in Sado City, Japan. Sado City is located on Sado Island, and the population of the city and the island are equivalent. Sado Island is located in Niigata Prefecture on the Sea of Japan, at latitude 37°47′ N to 38°20′ N and longitude 138°12′ E to 138°34 E, situated north of the main Japanese island of Honshu. Sado Island has an area of 855 km^2, and the population of the island was 70011

(33418 males and 36593 females) as of June 30, 2004, of which 23787 (9603 males and 14184 females) (34%) were 65 years old and older. Tourism, fishing, and agriculture are the chief industries, and access to the island is only possible by sea or air. Immigration and emigration among the elderly people of the island are extremely low.

Subjects

We examined the occurrences of osteoporotic fractures of the vertebra, hip, distal radius, and proximal humerus on Sado Island from January to December 2004. Almost all patients with hip fractures visited one general hospital, where all cases of this type are concentrated and surgery for hip fractures is carried out. To obtain information on fractures of the vertebra, distal radius, and proximal humerus, we distributed questionnaires to four hospitals and five doctors' offices on the island, including the main orthopedics facility. Answers were obtained from three hospitals and three doctors' offices, comprising 94% of the number of beds allocated for orthopedics cases. Fractures that occurred in tourists were excluded from the data, and pathological fractures resulting from malignant tumor or other bone metabolic diseases were also excluded.

Methods

All fractures were examined by X-ray. For vertebral fractures, lateral spinal radiographs were examined and the fractures were defined as wedge, biconcave, and compound (Fig. 1) based on the dimensions of the vertebral body and diagnostic criteria issued by the Ministry of Health and Welfare and widely used in Japan [5,6]. It was not necessarily easy to identify a new vertebral fracture, but patients who visited the hospital for symptoms such as back pain for the first time and were judged to have a vertebral fracture by the orthopedic doctor based on X-ray and physical examination were considered to be new fracture cases (an incident of fracture: clinical fracture). Asymptomatic older fractures (prevalent fracture) discovered accidentally by X-ray were excluded from the data. The incidence, age, gender, type of fracture (for hip fracture), right or left side (for distal radius, proximal humerus, and hip fracture), place of injury, cause of injury, outcome, hospitalization period, and patient status regarding taking of anti-osteoporosis drugs were checked for each fracture. The incidence rates were calculated based on the whole population of Sado City. Incidence rates adjusted to the entire population of Japan in 2005 were also calculated.

Statistical analysis

A chi-square test for goodness of fit was used to evaluate the difference in numbers of right and left side fractures (for distal radius and proximal humerus fractures). The analysis was performed using Microsoft Excel for Windows.

Results

Vertebral fracture

There were 163 cases of vertebral fracture (45 males and 118 females), a male-to-female ratio of 1:2.6 (Table 1). The overall incidence was 232.8 per 100000 population per year, which was the highest incidence among the four kinds of fractures. With adjustment for the Japanese population, the incidence was 138.4. The average age at the time of injury was 77.7 years old, with a range of 18 to 97 years old.

Hip fracture

There were 85 cases of hip fracture (20 males and 65 females), a male-to-female ratio of 1:3.3. The overall incidence was 121.4 per 100000 population per year. Adjusted for the Japanese population, the incidence was 69.8. The

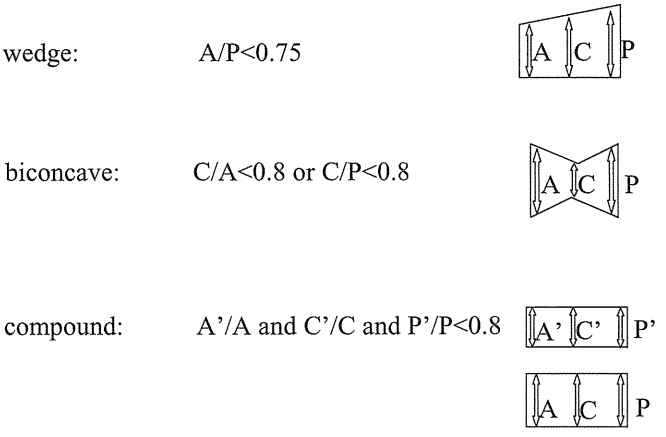

Fig. 1. Diagnostic criteria for vertebral fracture. (From [5, 6])

Table 1. Number and incidence of each fracture in Sado City in 2004

Site	Number of fractures (male, female)	Male-to-female ratio	Mean age (years)	Incidence (per 100000 person-year)	Adjusted for Japanese population (2005)
Vertebra	163 (45, 118)	1:2.6	77.7 ± 11.8 (18–97)	232.8	138.4
Hip	85 (20, 65)	1:3.3	81.4 ± 11.0 (42–104)	121.4	69.8
Distal radius	76[a] (18, 57)	1:3.2	60.2 ± 24.6 (8–91)	108.6	76.9
Proximal humerus	26 (3, 23)	1:7.7	75.7 ± 16.2 (15–92)	37.1	37.3
Total	350 (86, 263)	1:3.1	—	499.9	322.4

[a] One patient of unknown gender

cervical-to-trochanteric ratio was 1:1.30 [7]. The right hip was fractured in 47 patients and the left hip in 38 patients. The average age was 81.4 years old, which was the highest among the four kinds of fractures, with a range of 18 to 97 years old. Of 44 random hip fracture patients for whom we were able to examine a spinal X-ray, 81.8% (36 of 44) also had a vertebral fracture [7].

Distal radius fracture

There were 76 cases of fracture of the distal radius (18 males and 57 females, with 1 case of unknown gender): a male-to-female ratio of 1:3.2. The incidence per 100000 population per year was 108.6 [8]. Adjusted for the Japanese population, the incidence was 76.9. Thirty-four fractures occurred on the right side and 42 on the left side. The average age at the time of injury was 60.2 years old, with a range of 8 to 91 years old.

Proximal humerus fracture

There were 26 cases of fracture of the proximal humerus (3 males and 23 females), a male-to-female ratio of 1:7.7. The incidence per 100000 population per year was 37.1 [8]. Adjusted for the Japanese population, the incidence was 37.3. Nine fractures occurred on the right side, 16 on the left, and 1 occurred bilaterally. The average age at the time of injury was 75.7 years old, with a range of 15 to 92 years old.

Overall incidence of fracture

Incidences for the four kinds of fractures are shown in Table 1. We identified 350 fractures, including the vertebra, hip, distal radius, and proximal humerus, giving a total incidence of these fractures of 499.9 per 100000 population per year. The average age at the time of injury was highest for fractures of the hip (81.4 years old), followed by the vertebra (77.7 years old), proximal humerus (75.7 years old), and distal radius (60.2 years old). The incidence of each fracture by age is shown in Fig. 2: fractures of the vertebra, hip, and proximal humerus steeply increased in the seventies or eighties. A similar increase in incidence for fractures of the distal radius was not observed. The incidence of each fracture and the average age for males and females are also shown in Table 2: both the incidence and age at the time of injury were higher in females for all fractures.

The incidences of each fracture by age in males and females are shown in Fig. 3. These data show a peak in fractures of the distal radius in the male teens, whereas the incidence of fracture gradually rose in females with age and then decreased after the seventies. Very few fractures of the proximal humerus occurred in males, whereas a peak was present in the nineties in women. For vertebral fractures, the incidence gradually increased from the sixties and reached a peak in the nineties, without a large gender difference. The incidence of hip fractures began to increase from the seventies, with an exponential increase in women.

Place and cause of injury

The location in which each fracture occurred is shown in Fig. 4. Outdoor injuries were most common for fractures of the distal radius, followed by the proximal humerus, vertebra, and hip. Based on data for each kind of fracture, as the average age at the time of injury increased a greater percentage of injuries occurred indoors (Fig. 4). As shown in Fig. 5, the most common cause of injury was a fall, but there were many divergent causes of vertebral fracture.

Hospitalization and outcome after discharge

The average period of hospitalization and the places to which hospitalized patients were discharged are shown in

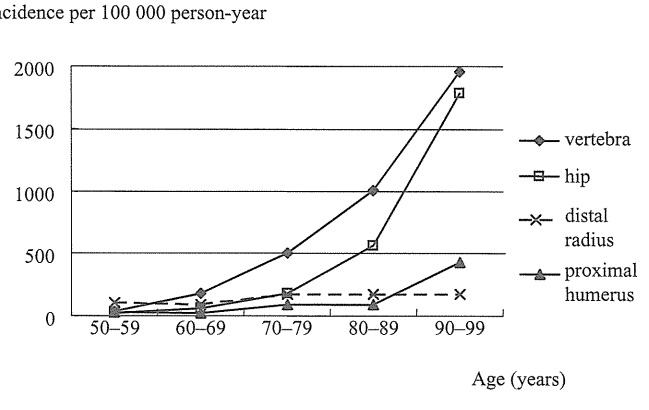

Fig. 2. Incidence of each type of fracture by age in years

Table 2. Incidence of each fracture in men and women

Site	Males			Females		
	Number of fractures	Incidence (per 100000 person-year)	Mean age (years)	Number of fractures	Incidence (per 100000 person-year)	Mean age (years)
Vertebra	45	134.7	75.0 ± 13.7 (18–96)	118	322.5	78.7 ± 10.9 (19–97)
Hip	20	59.8	75.2 ± 15.9 (42–94)	65	177.6	83.3 ± 8.2 (56–101)
Distal radius	18	53.9	36.0 ± 27.7 (8–82)	57	155.8	69.1 ± 16.7 (11–91)
Proximal humerus	3	9.0	57.3 ± 36.7 (15–79)	23	62.9	78.2 ± 11.2 (56–92)
Total	86	257.3	—	263	718.7	—

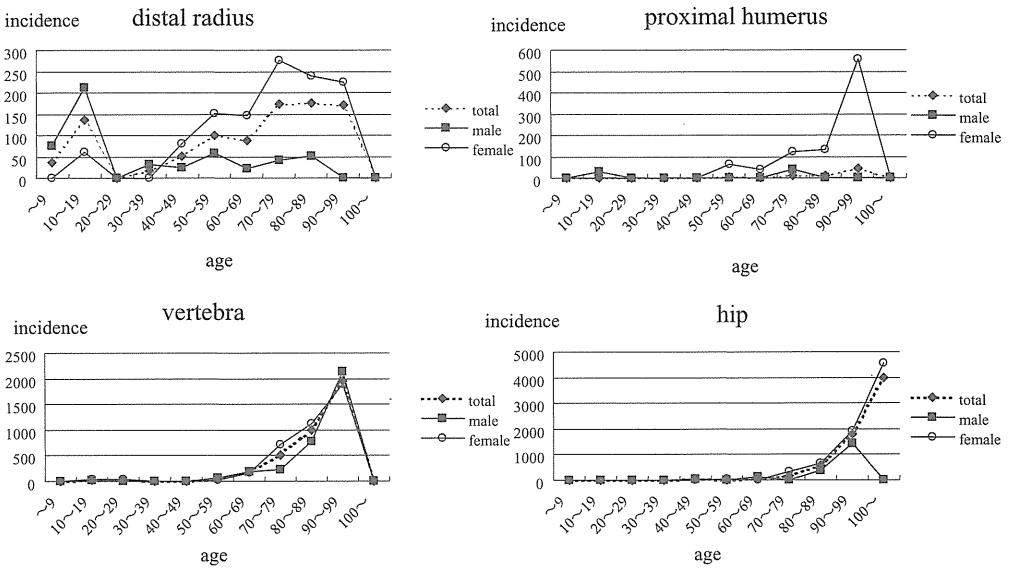

Fig. 3. Incidence of each type of fracture by age in years for males and females

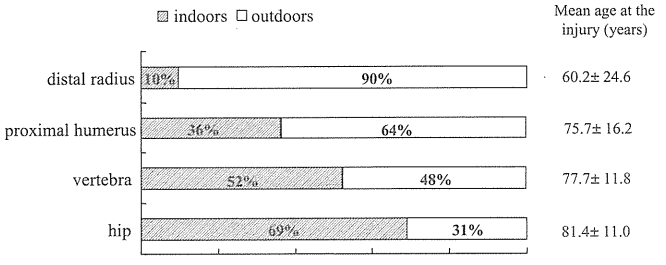

Fig. 4. Place where injury occurred, by each type of fracture: indoors or outdoors

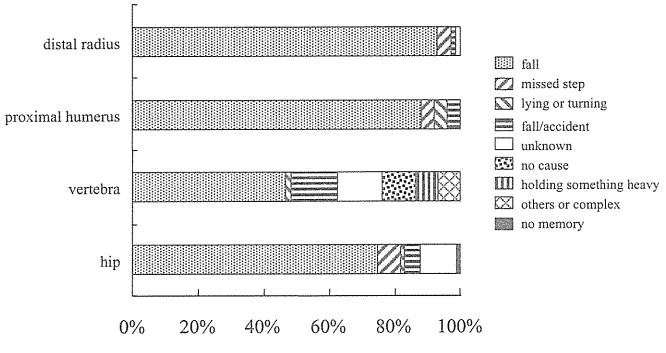

Fig. 5. Cause of injury leading to fracture

Fig. 6. Of patients with a fracture of a vertebra, 87% were discharged to home, whereas only 55% of patients with a hip fracture were discharged to home and 36% were transferred or discharged to a nursing home. The average hospitalization period was 30.5 days for a hip fracture and 20.4 days for a vertebral fracture.

Drugs taken before injury

The percentage of patients taking agents for osteoporosis before the injury is shown in Fig. 7. In most cases of hip and vertebral fractures, the patients did not take any anti-osteoporosis medicine before the injury occurred.

Discussion

The key aspect of the study was to examine all major osteoporosis-related fractures over a defined period of time in a limited area. Our results showed that there were 350 fractures (499.9 fractures per 100000 population per year), including fractures of the vertebra, hip, distal radius, and proximal humerus, in Sado City in 2004. Vertebral fractures were most common, followed by fractures of the hip, distal radius, and proximal humerus; for the last three fractures, this order is similar to those found in past surveys in Japan [9–12]. Concerning vertebral fractures, previous surveys of the Japanese population have found an incidence of 4000 per 100000 person-years (PY) for women in their seventies and 8400 per 100000 PY for women in their eighties [13]. A study in Europe found an incidence of 920–977 per 100000 PY for women of all ages [14]. Our survey showed an incidence of 322.5 per 100000 PY for all women and 1117 per 100000 PY for women in their eighties. Therefore, our incidence rate was lower than those found in previous studies, which may be because the survey was carried out in hospital subjects only, and some patients with a vertebral fracture may not consult with a hospital or clinic. Further examination of this issue is needed; however, it seems likely that vertebral fracture has a higher incidence than other kinds of osteoporotic fractures. Furthermore, we found that most hip fracture patients already had a vertebral fracture, suggesting that patients with a vertebral compression fracture have a high risk of a subsequent hip fracture. We note that previous data suggest that the Japanese population have a similar or greater number of vertebral fractures and fewer fractures of the long bone (including the hip and upper extremities) compared to European and American Caucasian populations [6,10,15–17].

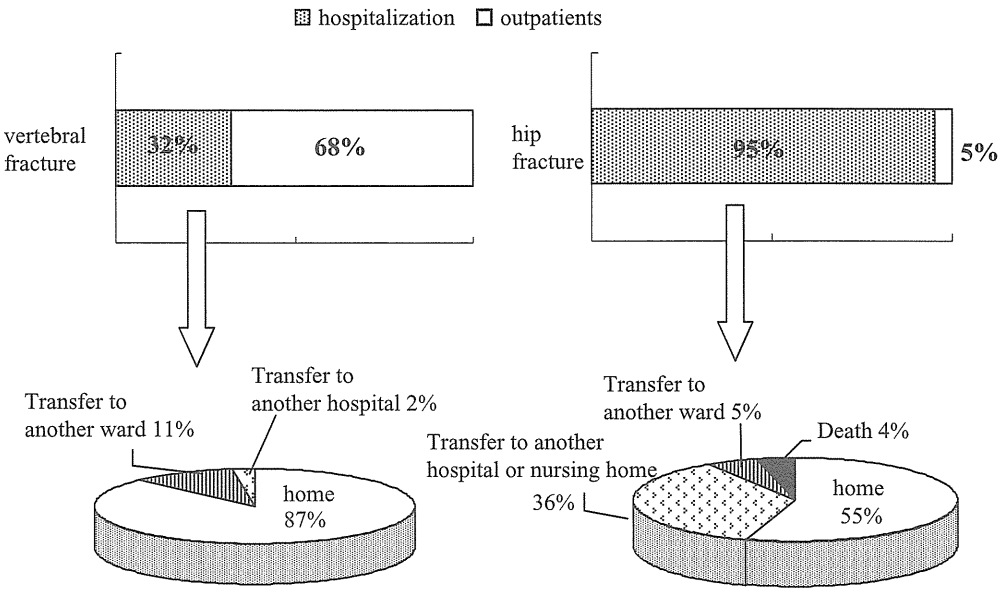

Fig. 6. Outcome of hospitalized patients after discharge. Average hospitalization period in the orthopedic ward was 20.4 ± 10.3 days for vertebral fractures and 30.5 ± 15.9 days for hip fractures

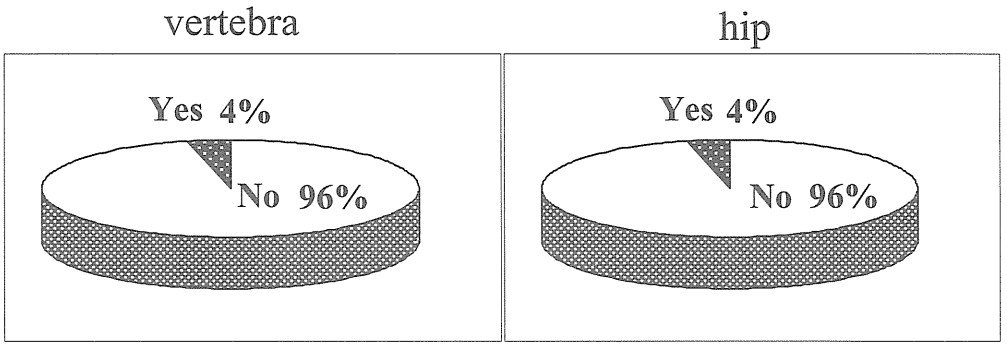

Fig. 7. Most patients who suffered vertebral or hip fracture had not taken anti-osteoporosis drugs before injury

Morita et al. [11] reported that the incidence of hip fractures in Niigata Prefecture in 1999 was 68.2 per 100000 PY, which was double the rate in 1985. In the current study, the incidence in Sado City was higher than all previous reports in Niigata Prefecture (Table 1). Therefore, hip fracture incidence appears to have increased since 1999, perhaps because the proportion of aged persons has increased more in Sado City than in Niigata Prefecture overall. The incidence of fracture of the distal radius in women in our study was lower than that found in Tottori Prefecture in 1995 (211.4 per 100000 PY) [10], but our incidence of proximal humerus fracture was higher than that in the earlier study (47.9 per 100000 PY) [10]. The mean age for injury of the proximal humerus is higher than that of the distal radius, which also suggests that the high aging rate in Sado City (34.0%) might account for these observations.

Our results indicated that the incidence of distal radius fracture increased for people in their fifties onward, but that there was no upward trend in incidence after the eighties (see Fig. 3), possibly because physical activity in the fifties to seventies leads to a higher rate of fracture of the distal radius, whereas reduced physical activity in people above 80 years of age tends to decrease the incidence of this fracture. Fracture of the distal radius may also occur more frequently in younger persons because such people are more likely to use a hand to protect against a fall, whereas elderly people might hit a hip or shoulder joint directly under such circumstances, thereby accounting for the higher incidence of fractures of the hip or proximal humerus in older people. However, the number of fractures of the radius or humerus was very small in males, and so this argument might not apply to men. The peak incidence of fracture of the distal radius occurred in teenagers in males, which we speculate is mainly the result of accidents.

There were more left-side fractures of both the distal radius and proximal humerus, compared to the right side, although the difference was not significant (distal radius, $P = 0.358795$; proximal humerus, $P = 0.161513$). Previous studies have reported similar results [10,18], and it has been suggested that dextral individuals are predisposed to injury on the opposite side as a consequence of environmental factors, or that there is decreased hand coordination of the left hand relative to the right in right-hand-dominant people [18]. The dominant hand was not checked in the current study, but most of the Japanese population are right handed; therefore, the larger number of left-side fractures is consistent with the expected data.

Injury while indoors was most common for fractures of the hip, followed by the vertebra, proximal humerus, and distal radius. The age at the time of injury decreased in a similar order; that is, the average age was highest for fractures of the hip. Injury indoors tended to increase with age, making it important to focus on prevention of slight falls or injury indoors in elderly people. About half the patients with a hip fracture were able to be discharged to their home. Both physical exercise by rehabilitation and maintenance and practical use of social welfare resources are important to increase the percentage of patients who can return home after hospitalization.

Drugs for osteoporosis were not taken before injury in most cases of hip and vertebral fractures. A past investigation performed on Sado Island indicated that the incidence of hip fracture significantly decreases with vitamin D treatment, compared with a nontreatment group, and that stopping the treatment increased the risk of hip fracture [19]. As it appears that vertebral fracture leads to hip fracture, fracture prevention from an early stage by treatment with drugs should be carried out to reduce the chance of this series of fractures, and preventive treatment should be further encouraged in osteoporotic elderly people.

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MINI REVIEW

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Serum 25-OHD insufficiency as a risk factor for hip fracture

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Abstract The aging population and an increasing number of hip fractures worldwide have made prevention of hip fractures a matter of importance. The prevalence of hypovitaminosis D in patients with acute hip fracture has been reported widely in recent years, and the vitamin D nutritional status in such reports is usually evaluated based on serum 25-hydroxyvitamin D (25-OHD). The aim of this article is to review the relationship of serum 25-OHD and osteoporotic fracture and the prevalence of 25-OHD insufficiency in patients with hip fracture, including assessment of nutritional status, oral status, activity, and dementia. We conclude that the serum 25-OHD level may be a useful index for risk of hip fracture in elderly people.

Key words 25-hydroxyvitamin D · intact PTH · hip fracture · number of remaining teeth · activity · dementia

25-OHD insufficiency and hip fracture

The number of cases of hip fracture has been increasing with the aging of societies worldwide, and methods for prevention of hip fracture are therefore of value. Vitamin D is an important nutrient for bone health and is a regulator of calcium metabolism. Vitamin D nutritional status is evaluated by measuring serum 25-hydroxyvitamin D (25-OHD), and 25-OHD insufficiency may occur in elderly people because of malnutrition, dementia, and inactivity leading to decreased exposure to sunlight. Serum 25-OHD insufficiency leads to an increase in parathyroid hormone (PTH) levels (secondary hyperparathyroidism), resulting in bone loss [1] and leading to hip fracture and decreased activities of daily living (ADL) or quality of life (QOL). Subclinical 25-OHD insufficiency is also considered to be a risk factor for osteoporotic hip fracture in elderly people [2–4] (Fig. 1). Hollis [5] reported that the normal range of 25-OHD is 32–100 ng/ml, and other studies performed in the United States and Australia [6,7] have shown that a serum 25-OHD level of at least 15–20 ng/ml is needed to achieve optimum PTH levels. Therefore, we defined a 25-OHD level of less than 20 ng/ml as vitamin D insufficiency (Fig. 2); we note that vitamin D deficiency defined as a 25-OHD of less than 5 ng/ml causes osteomalacia/rickets [8,9].

Serum 25-OHD status in hip fracture patients: the Sado study

In the United States, a serum 25-OHD level lower than 12 ng/ml was observed in 50% of women with osteoporotic hip fractures [4], and in Italy this value was found to be 13.5%, with 21.6% of patients having a serum 25-OHD level less than 20 ng/ml [3]. We compared the serum 25-OHD level in hip fracture patients with that in non-hip fracture control subjects over 1 year in the elderly population on Sado Island, Niigata, Japan (total population, 70 011; 34% were 65 years old and older); these data showed that the serum 25-OHD level was significantly lower in the hip fracture patients [10]. In addition to checking the 25-OHD levels and determining other laboratory data, we collected serum and urine samples at admission and also examined changes in the levels of serum 25-OHD in acute hip fracture patients at another general hospital in Niigata City [11]. Although the sample size was small (n = 12), serum 25-OHD did not show large changes (less than ±10%)

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