(Table.5). No information about physical activity prior to the accident was available for 22 cases. Only 153 of the 316 females, and 28 of the 75 males were independent.

Therefore, over a half of the fracture caused by "simple falls" among the elderly were associated with impaired physical activity. However, the ambulatory status did not affect the type of fracture.

5. Preexisting diseases (Table.6)

Major problems prior to injury which were possibly related to the fracture were divided into 2 groups: i.e., diseases affecting ambulatory status, and osteopenia.

Table.6 Preexisting diseases

A. Preexisting diseases affecting ambulatory status	
Neurologic paresis	123
Cerebro vascular disease	93
Parkinson's disease	12
Poliomyelitis	2
Cervical spondylotic myelopathy (post op.)	2
Others	14
Rheumatoid arthritis	14
Artificial limb	1
Short leg cast (ankle Fx.)	1
Severe visual disorder	11
B. Preexisting diseases affecting osteopenia	
Diabetes mellitus	56
Gasterectomy	34
Renal failure	14
Steroid	8
Anti-epileptic drugs	3

a. Preexisting diseases affecting ambulatory status

There were 123 patients with various kinds and different degrees of neurologic disorders. These were 93 patients with cerebrovascular disease, 12 with Parkinson's disease, 2 with paresis due to poliomyelitis, 2 who had surgery for cervical spondylotic myelopathy, and 14 with other neuromuscular problems such as cerebral palsy, brain tumor, cerebellar ataxia, muscular dystrophy, etc.

Furthermore there were 14 patients with rheumatoid arthritis including one patient with bilateral total knee replacements. One patient had an artificial limb after mid thigh amputation, and another had a short leg cast for an ankle fracture. Also, 11 patients had severe visual disorders.

A total of 150 preexisting disorders that were related to the patient's ambulatory status prior to injury, were noted in 142 patients, and trochanteric fracture occurred in 66% of this group. Of 87 patients with hemiplegics, fracture occurred in their hemiplegic side in 79 patients and the percentage of trochanteric fracture was 71% in hemiplegics.

b. Preexisting diseases affecting osteopenia

There were 56 patients with diabetes, 34 who had gasterectomy, 14 with chronic renal failure (5 of them undergoing hemodialysis), 8 patients being treated with steroids and 3 with antiepileptic drugs.

A total of 115 preexisting disorders related to osteopenia in 108 patients were noted, and trochanteric fractures amounted to 70% of the fractures in this group. No significant difference in the type of fracture was found that related to complications prior to injury of the patients in this series.

6. History of other fractures

A history of fractures prior to the hip fracture was found in 45 instances.

There were 15 cervical fractures, 7 trochanteric fractures, 4 supracondylar fractures of the femur, 10 humeral neck fracture, and 11 Colles' fractures. Of the 15 patients who had a previous cervical fracture, 9 had the same type of fracture, while all 7 patients who had a previous trochanteric fracture, suffered the same type of fracture on the opposite side.

7. Singh's index

Singh, et al.[13,14], classified trabecular patterns of the proximal femur into 7 grades. The author classified the non-injured hips with an A-P film taken with neutral position. In order to eliminate the factors of age and type of trauma, the author selected 413 cases of fractures due to "low energy trauma" (simple fall) in the elderly. Of the 295 cases available for grading, fewer than 30 % of the cases were graded lower than grade 3 (osteoporosis). The lower the Singh's index the higher the incidence of trochanteric fractures (Table.7).

8. Femoral cortical index (FCI)

To evaluate the cortical thickness from x-rays, the author measured femoral cortical index at a point 5 cm distal to the tip of the lesser trochanter as follows.

Table.7 Singh grades of fracture cases in the elderly (over 65 years of age) caused by "low energy trauma" (N = 295)
Note that the trochanteric fracture rate tended to increase with a decrease in grade.

Singh grade	Number of cases				Trochanteric fx. %	
	Female		Male			
	cervical fx.	trochanteric fx.	cervical fx.	trochanteric fx.	Female	Male
7	0	0	0	0	-	-
6	6	2	4	2	25%	33%
5	29	39	4	17	57%	81%
4	30	65	1	18	68%	95%
3	17	43	1	4	72%	80%
2	3	10	0	0	77%	-
1	0	0	0	0	-	-

$$FCI = \frac{\text{medial cortical width + lateral cortical width}}{\text{bone width}} \times 100$$

A total of 380 fractures was available for the group "over age 65" with "low energy trauma". Of 314, females 218 with trochanteric fracture had FCI of 34.8 ± 7.6 (mean ±SD) and 96 with cervical fracture had FCI of 39.4 ± 8.7.

Fifty-four male patients with trochanteric fractures and 12 with cervical fractures had FCI of 41.8 ± 7.2 and 45.1 ± 5.9, respectively. The FCI in trochanteric fractures was smaller than in cervical fractures in both sexes, but a statistically significant difference was found only in females ($p < 0.001$).

Disucussion

In contrast to the epidemiological studies of fractures of the proximal femur in other countries, the author found a significantly lowerincidence in Niigata, Japan (**Table.2**). As in other countries, the age-specific incidence of the fracture in Niigata showed an exponential increase with aging, but the incidence curve of Japanese was shifted to the right by more than 10 years from the incidence curve of Uppsala, Sweden[3] (**Fig.2**).

The female/male ratio of age-adjusted incidence of the Niigata residents, i.e., 2.43, showed some similarity to the results from Europe (Uppsala 3.15, Dundee-Oxford 2.61) and the USA (Rochester 3.48). There was a preponderance of fractures in females with approximately three times as many as that of males in these countries. (**Table.2**). It has been widely accepted that the non-white populations have lower incidence of hip fractures and also a preponderance in males. For example females had slightly lower fracture rate than male in Singapore (sex ratio = 0.77), and less than twice as many fractures as males in Yugoslavia (Istra 1.23, Podravina 1.13), in Hong Kong (1.44), Bantu population in South Africa (1.25) and Asia African group in Jerusalem (1.62).

The author observed differences in the etiological factors of fractures between males and females. As to the location at the time of injury and severity of trauma by sex, females tended to be injured indoors by a simple fall whereas males tended to be injured outdoors by trauma more severe than a simple fall. Thus, the author speculates that the differences in sex ratio among countries are not only due to racial or genetic factors but also to different environmental and socioeconomic factors which tend to increase the incidence of higher energy trauma in males.

Why was the fracture incidence low in Japan?

It has been thought that at least three factors may contribute to differences in fracture incidence; namely 1. senile osteoporosis, 2. osteomalacia and 3. increase of falls due to impaired physical activity.

The relation between osteoporosis and hip fractures has been a subject of keen interest. Several biomechanical studies showed a correlation between strength of neck of femur and bone density[15,16]. More over the measurement of bone mass by various methods disclosed that it was lower in patients with hip fractures than in control groups[17].

Several papers which dealt with the measurement of bone mass suggested that the bone mass in Japanese people was in general lower than in Caucasians, probably due to genetic factors. Garn found that cortical bone mass of metacarpals in persons of Chinese and Japanese descent, whether American-born or not was lower than in Americans of European descent[11]. Yano found that the Japanese in Hawaii had lower bone

mineral content of the radius, as compared with caucasian Americans[10]. Norimatsu also reported that the Japanese in Okinawa had lower bone mineral content of the femoral neck than white Americans[18]. Furthermore, calcium intake which thought to be a major nutritional determinant of bone mass had been lower in Japan. The average calcium intake among Japanese has increased since the early 1940s but it is still only 550 mg per day according to "Present Nutritional State of the Nation in 1985", which is considerably lower than that among Americans.

Therefore, the low incidence of fracture of femoral neck in Japan suggests that the prevalence of osteoporosis may not be directly related to fracture incidence and that some other factors such as the person's size or weight may play an important role given the fact that Japanese are smaller and less heavy than Americans or Europeans.

Another possible factor affecting hip fracture rate is osteomalacia. In England, histologic evidence of osteomalacia was observed in 37% of the fracture patients and the incidence of osteomalacia increased from February to April. Aaron pointed out the relation between daylight exposure and osteomalacia and hip fractures from this observation[19,20], whereas Evans found no evidence of osteomalacia among fracture patients in Australia[21].

Osteomalacia may play an important role in countries situated at high latitude. Although Niigata is situated near latitude 38 N (**Fig.1**), there was no serologic or radiologic evidence of osteomalacia among fracture patients, except for a few cases of renal osteodystrophy. Therefore, a low incidence of osteomalacia could be a reason for the low rates of fractures of the proximal femur in this study.

Physical activity is an important factor in the incidence of hip fracture.

It not only influences the peak skeletal bone mass at maturity and speed of bone loss thereafter, but may also be related to the risk of falling in the elderly. Also Japanese customs in activities of daily living, such as squatting and sitting on the "tatami" mattress may contribute to the muscular strength of the hip joint.

This study revealed that a half of the patients had an impairment of physical activity, which was often complicated by accumulation of different diseases. Johnell[22] also found that a history of falling was more common among patients with hip fracture than among control subjects, and Abdon[23] found that more than one third of patients with fracutures had occult arrythmias severe enough to cause dizzy spells. Hansson[24] found a high incidence of hip fractures among patients in mental hospitals. Therefore, when assessing fracture risk in an individual person, multiple factors must be considered. One is an osseous factor which includes both quality and quantity of bone and the others are non-osseous factors which increase the risk of accidental falls.

Hip fractures can be divided into cervical (intracapsular) fracture and trochanteric (extracapsular) fracture. There are several studies of the factors determining the type of fracture. Dretakis[25] reported that the percentage of trochanteric fracture was lower in patients with advanced osteoporosis. On the other hand Pogrund[26] reported predominance of trochanteric fracture among osteoporotic patients. The present study suggest that the percentage of trochanteric fractures tends to increase with age and with the progress of cortical and trabecular osteopenia but that it is not related to the ambulatory status nor to the intensity of trauma. Exceptionally spontaneous fractures occurred at the level of subcapital area among older females. The author speculates that osteomalacia or other unknown qualitative deterioration of bone may play an important role in these spontaneous cervical fractures and may affect the overall incidence of cervical fracture.

The author concludes that the incidence of the femoral neck fractures depends on many, often interrelated factors affecting an elderly population; furthermore the Japanese elderly people are 10 years younger with respect to hip fractures than Euro-Americans. Further world wide epidemiologic studies of fracture of the proximal femur using standardized methods are needed for a better understanding of the factors leading to this devastating fracture.

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Epidemiology of Femoral Neck Fractures in 1989, Niigata Prefecture, Japan

— A Comparison with the Incidence in 1985 and 1987 —

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ABSTRACT

The incidence of the femoral neck fractures in 1989 was studied in Niigata Prefecture, which has a population of 2,481,441 (1,204,349 males and 12,277,092 females) as of January 1, 1989. The population over 65 years of age was 352,003, 12.5% of the total population (139,518 males and 212,485 females).

The authors visited all hospitals in Niigata Prefecture to study roentgenograms and records of patients. In order to cover possible neglected patients, questionnaires were sent to nursing homes and mental hospitals.

During 1989, there were 996 femoral neck fractures (259 males and 737 females, i.e., 1:2.85) the ratio of cervical and trochanteric fractures was 327:667 (1:2.04). The average age of these patients was 71.7 years for males and 77.7 years for females. The incidence over 65 years of age was 14.2 in males and 31.2 in females and that over 85 was 49.8 in males and 108 in females per 10,000 population per year.

Key Words

Epidemiology, Femoral neck fracture, Japan

Introduction

The incidence of femoral neck fracture, closely related to senile osteopenia, has been studied in Japan and other countries during the last several years.

In 1985 and '87, Kawashima[1] and Dohmae reported the incidence of femoral neck fracture in Niigata prefecture, Japan which was much lower than in North America and Europe[2-4]. In this paper, we report the incidence in 1989 compared with that in 1985 and '87.

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Materials and Methods

This study was carried out in Niigata Prefecture which is located approximately in the center of the main island of Japan. Information concerning all femoral neck fractures that occurred in residents in Niigata Prefecture from January 1 to December 31 in 1989 was collected from 65 hospitals in this prefecture together with their X-rays. The medical records and roentgenograms of all patients with a diagnosis of femoral neck fracture were reviewed by the author and co-authors, excluding subtrochanteric or pathological fractures. The patients from the other prefectures and / or under the age of twenty were excluded from this study.

Basic demographic informations, such as the patients' age, sex, and type of femoral neck frac-

ture were included in this study.

The data was analyzed using the X^2-test and t-test at the Medical Computer Center of Niigata University. The residents of Niigata Prefecture who had sustained femoral neck fractures in 1989 and received treatment outside of this prefecture were included in this study also previous studies performed in 1985 and '87. In order to cover possible neglected patients with femoral neck fracture, the questionnaires were sent to 50 nursing homes and 23 mental hospitals without an orthopedic department in which femoral neck fractures might occur.

Statistics

In Niigata Prefecture, the prefectural office takes a census every year. As of January 1, 1989, the population of Niigata Prefecture was 2,481,441 (1,204,349 males and 1,277,092 females). Residents defined as "elderly" (over 65 years) numbered 352,003 (139,518 males and 212,485 females).

Results

1. Incidence of fractures

In Niigata Prefecture, femoral neck fractures occurred in 996 cases. As shown in **Table 1.** and **Fig.1**, the incidence of fractures per 10,000 per year increased exponentially with increasing age from the 6th decade in both sexes. And that of males was slightly greater than that of females under the age of 55. After 55 the relationship reversed and more females developed hip fractures. In the "elderly population", 86.5% (861 fractures) occurred in all fractures, and residents defined as the "abvanced age group" (over 75 years) had 66.6% (663 fractures) of all the fractures. The crude incidence of all femoral neck fractures was 2.98 per 10,000 per year in males and 8.27 in females. Of "elderly population" the incidence of male was 14.2 and that of female 31.2. However, the incidence in patients over 85 years of age increased to 49.8 in males, and 108 in females. The female/male ratio based on the number of fractures was 773/259 (2.85) also, the ratio based on the crude incidence was 3.47/2.15 (1.61) (**Table 1**).

Concerning the type of femoral neck fracture, there were 667 (67%) trochanteric fractures and 327 (33%) cervical neck fractures. Trochanteric fracture was observed twice as many times as cervical neck fracture. The percentage of trochanteric fracture was higher in males, 78%, than in females, 63%.

The average age of patients with cervical neck fracture was 64.8 years in males, and 73.6 years in females and that of patients with trochanteric fracture was 72.8 years in males and 78.7 years in females. The average age of patients with trochanteric fracture was significantly higher than that of patients with cervical neck fracture in both sexes ($p<0.01$). Also in both type of fractures the average age of females was sighnificant higher than that of males ($p<0.01$).

Table 1. Age-specific incidence rates of hip fracture and percentage of trochanteric fracture in 1989. (Fracture rates are expressed as fractures per 10,000 population per annum as estimated over in 5 year age group)

Age	Male							Female						
	Cervical fractures cases	Rate	Trochanteric fractures cases	Rate	Both cases	Rate	Troch. fx %	Cervical fractures cases	Rate	Trochanteric fractures cases	Rate	Both cases	Rate	Troch. fx %
−49	8		17		25		68	7		3		10		30
50−54	1	0.31	9	2.79	10	3.11	90	5	9.59	1	0.12	6	0.71	17
55−59	2	0.40	4	0.80	6	1.20	67	14	1.59	8	0.90	22	2.50	36
60−64	4	0.54	16	2.16	20	2.71	80	24	2.67	12	1.33	36	4.01	33
65−69	8	1.63	15	3.07	23	4.72	65	24	3.44	27	3.86	51	7.32	53
70−74	6	1.55	28	7.25	34	8.80	82	33	6.09	57	10.51	90	16.59	63
75−79	14	4.79	38	13.01	52	17.80	73	50	10.97	115	25.23	165	36.12	70
80−84	9	5.80	43	27.70	52	33.51	83	70	41.88	113	25.72	183	67.60	62
85−	5	6.73	32	43.07	37	49.82	86	43	26.69	131	81.31	174	108.0	75
Total	57	0.66	202	2.32	259	2.98	78	270	3.03	467	5.24	737	8.27	63
age over 65	42	3.01	156	11.18	198	14.20	79	237	11.15	446	20.99	663	31.20	67

Answers to questionnaires were obtained from 16 (70%) of 23 mental hospitals and 46 (92%) of 50 nursing homes. Femoral neck fractures were suspected in 44 patients in mental hospital and 92 patients in nursing homes. Of 136 patients 116 were transferred to the hospital with an orthopedic department and diagnosed as femoral neck fracture, and were already included and duly checked in the fractures previously mentioned. Twenty patients were suspected femoral neck fractures but not transferred to hospitals, because of mental problems and general poor conditions. These possible neglected hip fractures corresponded to about only 2% (20/996 cases) of total femoral neck fractures in Niigata Prefecture.

2. Comparison of the incidence in 1985, 1987 and 1989.

As shown in **Table 2**, the total number of the fractures increased 319 from 1985 to 1989. There was a minor difference in the population pyramid by age and sex in 1985 and that in 1989. The population over 55 years increased, and that under 40 years decreased in both sexes in 1989 in comparison with the population in 1985 (**Fig.2**).

In 1989, the expected number of femoral neck fractures was caluculated from the adjusted population of 1989 to 1985. The expected number of trochanteric fracture were 176 in males, 359 in females, and that of expected cervical neck fractures was 47 in males, and 266 in females. The expected number compared statistically with the observed number in 1989 using the X^2-test. There was quite a difference in only trochanteric fracture of females, however no significant differences in the others, i.e. only trochanteric fractures in females increased (**Table 3**).

The average age of patients with fractures is increasing in both sexes, however there were no significant differences among the three years and the cervical neck fracture/trochanteric fracture ratio showed the same trend (**Table 2**).

The crude incidence of fractures was not of a significant difference for every 2 year interval. In the elderly (age over 65 years), the incidence of fracture rose from 9.33 in 1985, to 14.2 in 1989 in males, and from 23.60 to 31.20 in females, and the incidence in patients over the age of 85 also rose

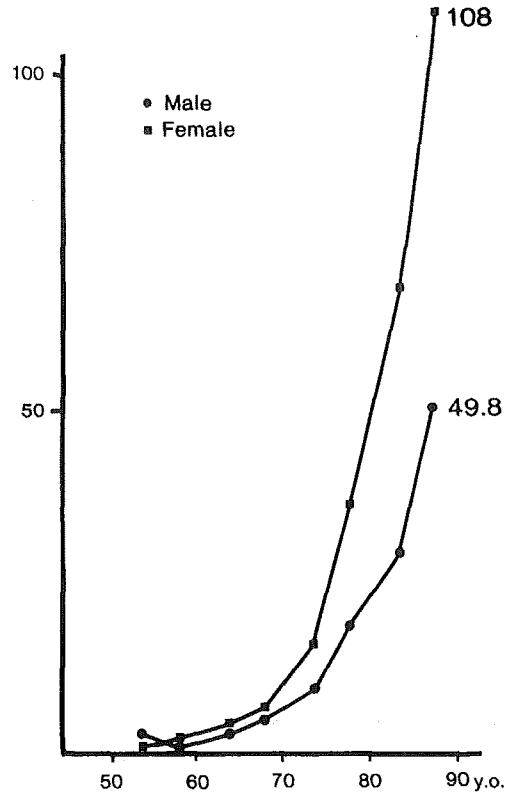

Fig. 1 Age-apecific incidence of hip fractures of female and male residents of Niigata in 1989 Fracture incidence with patients over 85 years was 49.7 in males and 108 in females.

Table 2. The summary of femoral neck fractures for every 2 year internal

		1985	'87	'89
Cases		677	773	996
Ave. Age	M	67.5	70.4	71.7
	F	76.2	76.9	77.7
Cerv./Troch. fx		1 : 1.9	1 : 2	1 : 2
M/F		1 : 2.7	1 : 2.4	1 : 2.8

Table 3. Statisticaly analysis between the number in 1985 and expected number in 1989 with adjusting population from 1989 to 1985.

		1985	1989 (Exp. No.)	X^2
Cervical fx	M	35	47	N.S.
	F	181	266	N.S.
Trochanteric fx	M	124	176	N.S.
	F	303	359	$p<0.01$

significantly from 29.7 in 1985, to 49.5 in 1989 in males, and from 80.3 to 108 in females (**Table 1**).

3. Femoral neck fracture without trauma

Since it was difficult to determine the cause of fractures, only the patients without obvious trauma were investigated for every 2 year interval. In the trochanteric fracture group, there were only 2 cases with trauma (2/503:0.4%) in males, and 7 cases (7/1122:0.6%) in females. In the cervical neck fracture group there was one case (1/167:0.6%) in males, and 98 cases (98/646:15.2%) in females. The extremely higher percentage of the patient without obvious trauma was indicated only in the cervical neck fracture group in females in comparison with the other groups.

Ambulatory status before injury was also observed in these two groups. All cases of cervical neck fracture was ambulatory without support except one patient; in contrast, 7 cases of 9 trochanteric fractures were bedridden, and were diagnosed for when their mal-positions on the bed.

In the cervical neck fracture group, the average age of the patients without trauma (78.6 years) was higher than that of patients with trauma (74.8 years) ($p<0.05$).

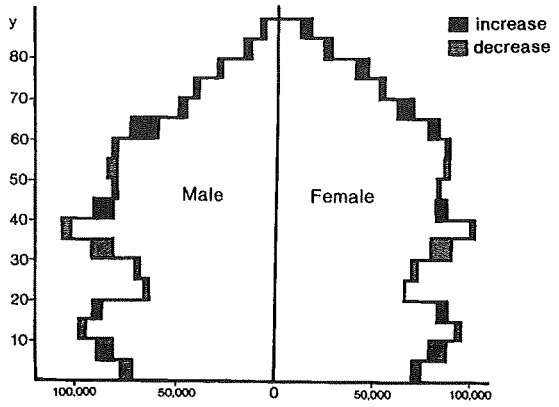

Fig. 2 The change of populationpyramid between 1985 and 1989.

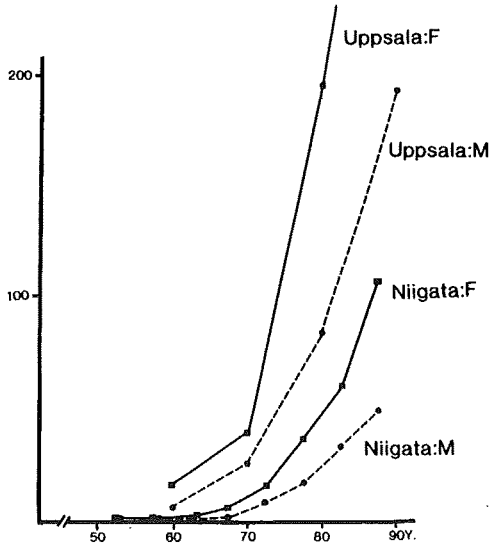

Fig. 3 Age-specific incidence of hip fractures of male and female residents of Niigata in 1989, compared with Uppsala in 1980.

Discussion

The incidence of femoral neck fracture in Niigata Prefecture was still lower than that in Caucasian populations. The age-specific incidence of fracture in Niigata showed an exponential increase with aging, but the incidence curve of Niigata in 1989 shifted to the right by more than 10 years from the incidence curve of Uppsala (Sweden) concerning both sexes (**Fig.3**). The incidences of fracture reported from the other areas of Japan (Wakayama[5], Tottiri[6] were of the same trend as that in Niigata. Kawashima has already discussed why the fracture incidence is low in Japan.

How is the future trend of hip fracture incidence in Japan ? After five years of observation, there is no doubt that the number of fractures has been increasing. In order to compare the incidence in 1985 and in 1989, the following corrections were made. Fractures treated in the 3 hospitals where general surgeons managed fractures were deducted, but fractures treated in newly opened hospital after 1986 were counted. Because the number of trochanteric fracture increased in female excluding neglected fractures in 1989 and also the natural increase of population over 55 years, an increase is judging by the change of the population pyramid from 1985 to 1989. The crude incidence of fracture was not of a significant difference among the three years, but the fracture incidence for patients above the age of 65 years rose from 9.3 to 14.2 in males, and from 23.4 to 31.2 in females, and also the incidence for patients of 85

years significantly rose from 1985 to 1989 (from 29.7 to 49.8 in males, and from 80.3 to 108.0 in females). On the other hand, the fracture incidence is affected by many factors, such as osteopenia, osteomalacia, physical activities and so on which have already been mentioned by Kawashima. Since it is impossible to predict changes of these factors from only this epidemiologic study, the trend of fracture incidence is uncertain. Further epidemiologic studies of femoral neck fracture are needed.

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

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Abstract: This study aimed to determine the incidence of cervical and trochanteric fractures of the proximal femur in 1994 in Niigata Prefecture, Japan, and to compare this incidence with those previously reported in Niigata in 1985, 1987, and 1989. We 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 1994. The population of Niigata Prefecture was determined in 1994 to be 2483879 (1205151 males and 1278728 females). The population over 65 years of age was 428795 (172788 males and 256007 females), representing 17.3% of the total population. In 1994, there were 1468 cervical or trochanteric fractures in 378 males and 1090 females, with a male-to-female ratio of 1:2.9. The incidence of these fractures in persons over 65 years of age was 304 fractures per 100000 population per year. Of 528 cervical and 940 trochanteric fractures, the latter accounted for 64% of the total number. The age-specific incidence of the fractures in Niigata exhibited an exponential increase with age, similar to those reported in Sweden and the United States. However, the incidence was lower than in those countries. When comparing the number of cervical and trochanteric fractures in 1994 with the numbers reported in 1985, 1987, and 1989, it is evident that the overall number and incidence of these fractures has been increasing over this period. Even if the difference of the age-specific population among these years is adjusted, the fractures have been increasing.

Key words: epidemiology, cervical femoral fracture, trochanteric femoral fracture, hip fracture, femoral neck fracture, Niigata, Japan

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Introduction

Hip fractures are related to senile osteoporosis and impaired physical activity, which accompanies aging [1]. Studies have shown that the incidence of hip fractures differs from country to country and among different races [2–4].

Orientals and Africans are thought to have a lower incidence of hip fractures, compared with Caucasians [4–7]. However, several studies of the prevalence of osteoporosis reported that the Japanese tend to have a lower bone mineral content and a higher incidence of postmenopausal spinal osteoporosis than Caucasians [8,9]. Kawashima [2] reported the first study of the incidence of hip fractures in Niigata Prefecture, Japan. 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 of Caucasians [3,10–12].

The goals of this study were to determine the incidence of cervical and trochanteric fractures of the proximal femur that occurred in 1994 in Niigata Prefecture, Japan, and to document the change in the incidence of these fractures from 1985 to the present.

Subjects and methods

This study was carried out in Niigata Prefecture, which is located in the middle of the main island of Japan, on the Sea of Japan (Fig. 1). 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 structure of the people in Niigata Prefecture is almost exclusively Oriental Japanese. Because this region is bounded by mountains and sea, most residents are treated in medical institutions within Niigata Prefecture.

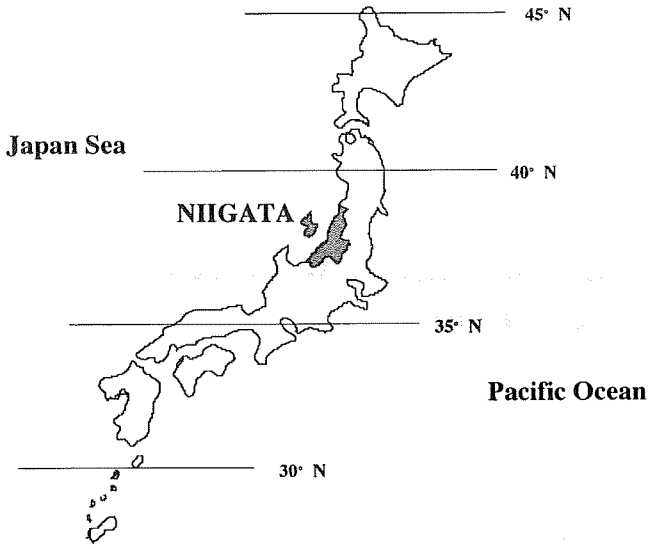

Fig. 1. Location of Niigata Prefecture, Japan

Number of hip fractures in 1994

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, 1994, were collected by the authors from 69 hospitals in the prefecture. Basic demographic information such as patient sex and age and the type of hip fracture were 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 either being 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 1994 were included in the study.

Change in the incidence of fractures from 1985 to 1994

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 or rate of the cervical or trochanteric fractures in each 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 previously performed in 1985, 1987, and 1989 [2,3]. To compare the incidence of the cervical or trochanteric fractures in the individual and combined 5-year age groups among the 4 study years, a standard or "reference" study year was chosen, for example, 1985. The number of fractures "expected" to occur in each age interval in a "particular" study year, for example, 1994, was compared with the number that was actually "observed" in 1994. 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, 1994 (Pn), and then dividing by 100000:

$$En = In \times Pn/100000$$
$$E_{total} = \Sigma En$$

The expected number of fractures refers to the number of fractures that would be expected to occur in 1994, based on the incidence previously recorded in 1985 and the current population in 1994. In other words, the expected number of fractures refers to the number expected to occur, assuming that the incidences are 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 number of fractures in the particular study year was larger 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 the particular study year would be higher than that in the reference year. The expected numbers of males and females with cervical or trochanteric fractures in each of the age intervals were calculated with these procedures. Comparisons were made using different combinations of reference and particular study years. The differences between the expected and the observed numbers of fractures were compared using chi-square analysis. An alpha level of 0.05 was considered significant.

The prefectural office in Niigata collects census data each year. As of October 1994, the population of Niigata Prefecture was 2483879 (1205151 males and 1278728 females). The population of residents over 65 years of age was 428795 (172788 males and 256007 females), or 17.3% 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.

Results

Number of hip fractures in 1994

In Niigata Prefecture, a total of 1468 cervical or trochanteric fractures of the proximal femur occurred in 1994 (378 males and 1090 females), with a male-to-female ratio of 1:2.9 (Tables 2, 3; Fig. 2). The combined number of cervical and trochanteric fractures per 100000 population per year increased exponentially in

Table 1. Relevant populations in Niigata Prefecture during the 4 years of the study

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

Table 2. Summary of cervical and trochanteric fractures in the proximal femur in Niigata Prefecture, Japan, 1994

	Number	incidence (number of fractures /100000 population/year)
Total number of fractures	1468	59.1
Gender		
Male	378	31.4
Female	1090	85.2
Type of fracture		
Cervical	528	21.3
Trochanteric	940	37.9
Cervical-to-trochanteric ratio	1:1.8	
Male-to-female ratio	1:2.9	

Table 3. Age-specific number and incidence of cervical and trochanteric fractures of the proximal femur in 1994

	Males		Females		Total	
Age (years)	Number	Incidence	Number	Incidence	Number	Incidence
0–49	22	2.8	21	2.7	43	2.7
50–54	14	17.5	10	12.3	24	14.9
55–59	20	25.9	17	20.3	37	23.0
60–64	23	29.5	39	45.2	62	37.8
65–69	36	52.8	62	76.6	98	65.7
70–74	44	101.7	129	196.1	173	158.6
75–79	62	199.6	192	394.3	254	318.5
80–84	90	455.9	290	792.4	380	674.4
85+	67	635.4	330	1373.9	397	1148.6
Total	378	31.4	1090	85.2	1468	59.1
Over 65	299	173.0	1003	397.0	1302	303.6
%	79.1		92.0		88.7	
Over 75	219	357.0	812	742.8	1031	604.1
%	57.9		74.5		70.2	

both sexes with increasing age from the sixth decade of life. Eighty-nine percent of all cervical or trochanteric fractures (1302) occurred in the "elderly population", persons more than 65 years of age; 70% of all fractures (1031) occurred in the "advanced age group," those over 75 years of age.

The overall incidence of the combined number of cervical and trochanteric fractures was 31.1 per 100000 population per year for males, and 85.5 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 173.0 for malesand 397.0 for females. The incidence in those more than 85 years of age increased to 635.4 for malesand 1373.9 for females. There were 940 trochanteric fractures (64.0%) and 528 cervical fractures (36.0%) (Table 2). The percentage of trochanteric fractures was higher in males (70.9%) than in females (61.9%).

The average age of the patients with cervical fractures was 71.7 years for malesand 75.1 years for females. The average age of the patients with trochanteric fractures was 74.4 years for males and 80.9 years for females. The average age of the patients of both sexes with trochanteric fractures was significantly higher than the age of

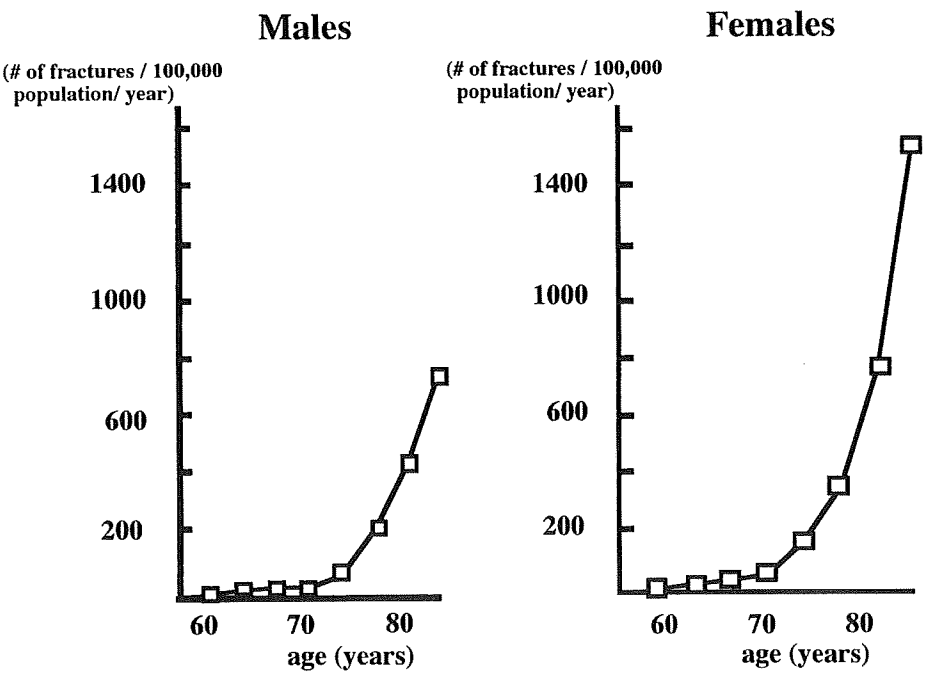

Fig. 2. Age-related incidence of cervical and trochanteric fractures of the proximal femur in males(*left*) and females (*right*) in Niigata Prefecture in 1994

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

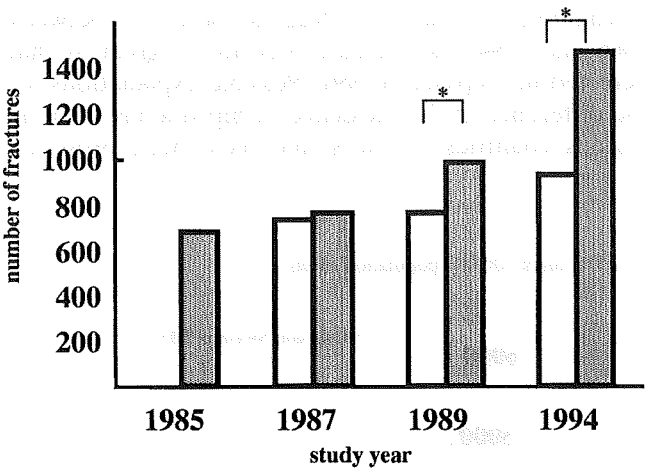

Fig. 3. Comparison of the expected (*open columns*) and observed (*shaded columns*) numbers of cervical and trochanteric hip fractures in the 4 study years.*, Statistically significant, $P < 0.05$

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

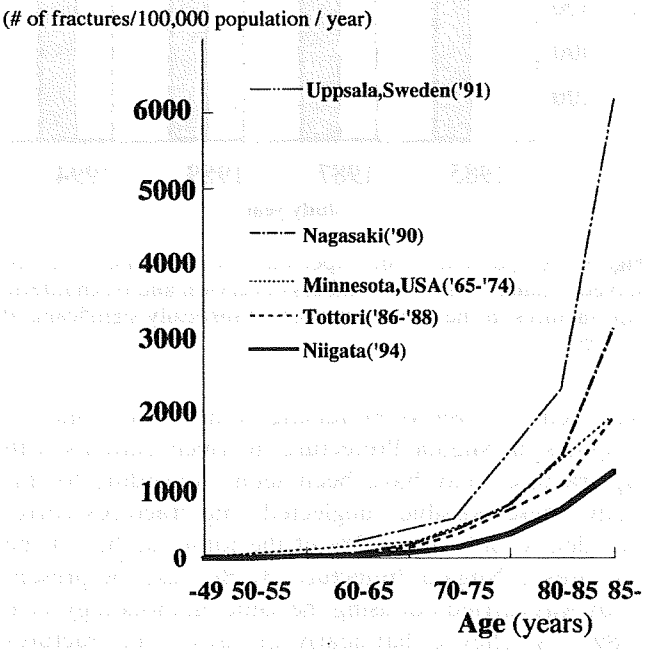

Fig. 4. Comparison of the age-related incidence of cervical and trochanteric hip fractures in several regions of Japan and in other countries

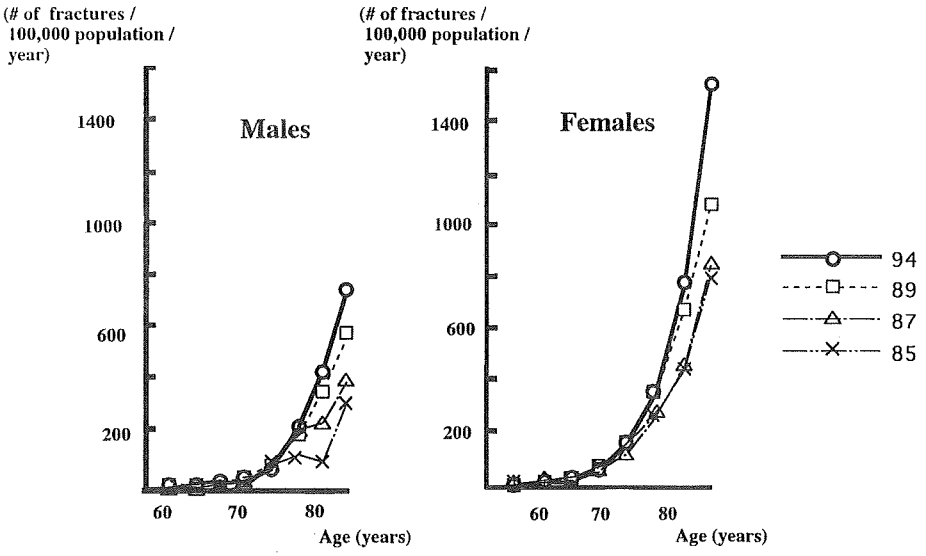

Fig. 5. Change in the incidences of cervical and trochanteric hip fractures in Niigata, Japan, from 1985 to 1994

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

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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