

during hip fracture healing, in comparison with the levels of other biochemical markers.

In the Sado study, 62% of 50 hip fracture patients had vitamin D insufficiency, which was defined as a serum 25-OHD concentration less than 20 ng/ml (Fig. 3). The average serum 25-OHD concentration was 17.8 ng/ml in hip-fracture patients and 25.8 ng/ml in non-hip fracture controls [10]; the mean for the patient population was lower than the recent mean value of 20.9 ng/ml reported for nonosteoporotic Japanese women more than 70 years of age [12]. In an age-matched comparative analysis, serum 25-OHD (means of

16.6 ng/ml and 22.0 ng/ml in hip fracture patients and controls, respectively) and albumin (3.6 g/l and 4.0 g/l, respectively) were significantly lower and intact PTH (45.8 pg/ml and 35.8 pg/ml, respectively) was significantly higher in the hip fracture patients [10]. In addition, the serum PTH level was not elevated (<65 pg/ml) in about 80% of hip fracture patients with 25-OHD insufficiency (see Fig. 3). Chapuy et al. [13] have reported that low serum 25-OHD does not always lead to an increase in serum PTH, and Sahota et al. [14,15] suggested that a slight reduction in serum calcium and a substantial decrease in 1,25-(OH)₂D may be partly related to the failure of the parathyroid gland to mount an adequate PTH response; however, the mechanisms underlying the PTH response remain unclear, and the cutoff for definition of an elevated PTH level requires further examination. A better understanding of the mechanism of serum 25-OHD and intact PTH and their relationship to bone metabolism is important for prevention of osteoporotic fractures and development of individualized treatment.

Regarding the relationship of serum 25-OHD and the number of remaining teeth, for which the average is 6.3 in hip fracture patients and 8.9 in controls, there was no significant difference between the hip fracture group and the control group. However, a significant negative correlation between age and number of teeth was found ($\alpha = -0.45, P < -0.01$) [10] and a significant correlation between 25-OHD and number of teeth ($\alpha = 0.20, P < 0.05$) was also observed. It appears likely that the number of remaining teeth is mainly influenced by age; however, Krall et al. [16] have suggested that intake levels of calcium and vitamin D have a beneficial effect on tooth retention, which suggests a mutually beneficial relationship between the status of the oral cavity and nutritional status.

We also examined the relationship of the severity of dementia and physical activity level with serum 25-OHD in hip fracture patients, using a classification based on the criteria of the long-term care insurance system developed by the Ministry of Health, Labor and Welfare of Japan [17,18]. The mean 25-OHD level was highest, at more than 20 ng/ml,

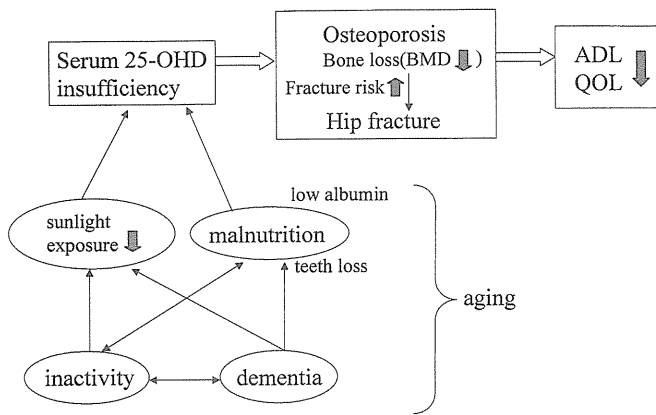


Fig. 1. Schema for the risk of fracture resulting from 25-hydroxyvitamin D (25-OHD) insufficiency and related factors. *BMD*, bone mineral density; *ADL*, activities of daily living; *QOL*, quality of life

<u>25-OHD insufficiency</u>	<20ng/mL osteoporosis (osteopenia, fragile bone)
<u>25-OHD deficiency</u>	<5ng/mL rickets, osteomalacia bone mineralization problems

Fig. 2. 25-OHD insufficiency and deficiency

Fig. 3. Percentages of patients with 25-OHD insufficiency and elevated parathyroid hormone (*PTH*). In patients with hip fracture, 62.0% (31 of 50) had serum 25-OHD levels <20 ng/ml (a). In non-hip fracture controls, 18.9% (10 of 53) had serum 25-OHD levels <20 ng/ml (b). In hip fracture patients with low 25-OHD, 19.4% (6 of 31) had elevated PTH levels (>65 pg/ml) (c). (From [9])

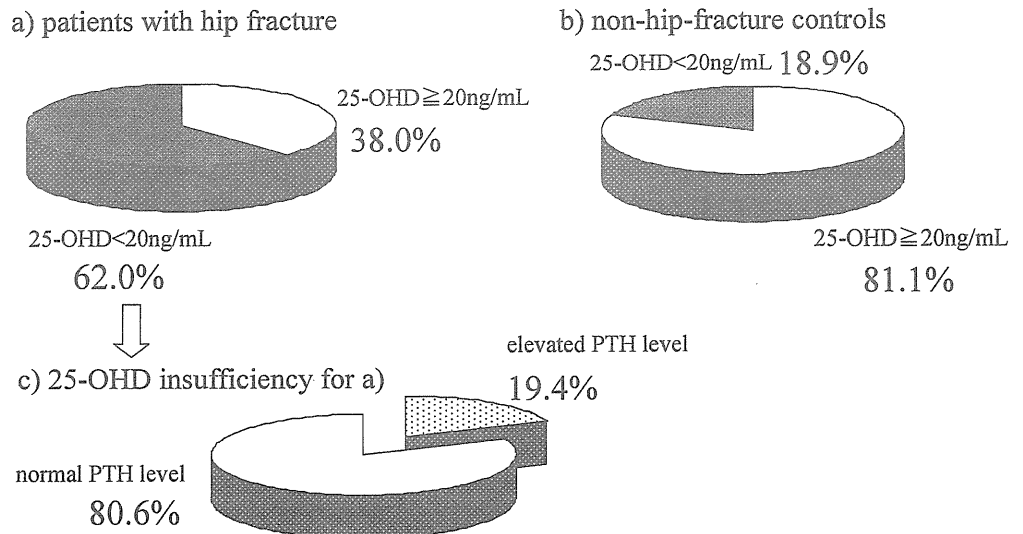


Table 1. Relationship between dementia level and mean serum 25-hydroxyvitamin D (25-OHD)

Dementia level	25-OHD	<i>P</i> value
↓ Independent I II Severe III-IV	↓ Lower	<i>P</i> < 0.05*

*Kruskal-Wallis test

in the independent (based on dementia level) group, and then tended to decrease as the degree of dementia progressed ($P < 0.05$) (Table 1). Sato et al. [19] reported that serum 25-OHD levels are significantly decreased in Alzheimer disease (AD) patients, and that vitamin D deficiency is more common among AD patients. They also reported that AD patients with lower bone mineral density (BMD) and low serum 25-OHD concentrations have an increased risk of hip fracture [20].

We have also examined the relationship between physical activity level and serum 25-OHD in hip fracture patients [10]. The mean level of 25-OHD was more than 20 ng/ml in the group assessed to be independent, and tended to decrease as the degree of activity decreased. Bischoff-Ferrari et al. [21] reported that 25-OHD concentrations between 40 and 94 nmol/l are associated with better musculoskeletal function in the lower extremities, and Di Monaco et al. [22] found a significant positive correlation between serum 25-OHD₃ and Barthel index score in hip fracture patients. Nakamura et al. [23,24] reported that elderly people requiring care at home have a high risk of hypovitaminosis D, and their low serum 25-OHD levels are mainly associated with low ADL levels. Therefore, although the relationships among dementia, activity level, and 25-OHD are not completely clear, decreased exposure to sunlight, decreased vitamin D production in the skin, and malnutrition appear to be of importance. Overall, these results suggest that dementia, decreased activity, and vitamin D deficiency are mutually associated and carry a high risk for hip fracture.

Summary and conclusion

Vitamin D insufficiency is prevalent in hip fracture patients and is associated with the status of the oral cavity, nutritional status, recognition function, and physical activity levels. Although these conditions are not caused by vitamin D insufficiency alone, we suggest that a good vitamin D status will reduce fragility in elderly people. The serum PTH level was not elevated in about 80% of hip fracture patients with 25-OHD insufficiency, but the mechanism of this observation remains unclear. Therefore, accumulation of more data linking 25-OHD, intact PTH, and hip fracture is required; this information should lead to better prevention of hip fracture in at-risk individuals and improved treatment of hip fracture and osteoporosis.

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ORIGINAL ARTICLE

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Risk factors for vertebral fracture in menopausal or postmenopausal Japanese women with rheumatoid arthritis: a cross-sectional and longitudinal study

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Abstract The occurrence of vertebral fracture was examined cross-sectionally and longitudinally over a 4-year interval in 117 menopausal and postmenopausal Japanese women with rheumatoid arthritis (RA), whose ages ranged from 50 to 64 years. Patients treated with bisphosphonate were excluded. Vertebral fracture was diagnosed by lateral thoracic and lumbar spine radiography at the start and end of a 4-year period. Bone mineral density (BMD) at L2–L4 according to dual-energy X-ray absorptiometry (DXA), the administration of corticosteroids or methotrexate, and urinary excretion of N-telopeptide of type I collagen (NTx) were also recorded. In the cross-sectional study, the prevalence of vertebral fracture in the initial radiographs of RA patients was 21%, while it was 5% in healthy age-matched controls. Among RA patients treated with corticosteroids, 33% had vertebral fracture, which was a significantly higher prevalence than that in RA patients without steroid administration. In the longitudinal study, vertebral fracture prevalence was also increased in patients more than 60 years old. RA patients having steroid treatment and a BMD/YAM (young adult mean) ratio below 70% had higher risk of vertebral fracture than patients with a BMD/YAM ratio of 70%–80%, which in turn exceeded the risk with a BMD of 80% or more. No adverse effect of low-dose methotrexate on vertebral fracture was found. Urinary NTx was high

in RA patients, as reported previously, and did not differ between patients with or without new fracture after 4 years. In conclusion, Japanese RA patients more than 60 years old who were treated with corticosteroid or had a BMD below 80% had high risk of vertebral fracture.

Key words rheumatoid arthritis · vertebral fracture · steroid administration · postmenopausal age · longitudinal study design

Introduction

Joint surgery using a prosthesis improves the performance of activities of daily living (ADL) and quality of life (QOL) in appropriately selected patients with rheumatoid arthritis (RA). Evidence of generalized osteoporosis has been reported in RA patients [1–12]. Osteoporosis in terms of reduced bone mineral density (BMD) is well known, but the clinically important end-point of osteoporosis is fracture. For example, symptomatic vertebral compression fracture is a significant problem which compromises both ADL and QOL. Recent reports concerning vertebral fracture in RA indicated that corticosteroid use significantly increased the risk of fracture [1–3,13]. Kanis et al. [2] reported an international metaanalysis concerning prior corticosteroid use and fracture risk, but Japanese data were not included. Reports by de Nijs et al. [13] and Ørstavik et al. [3] dealt with patients in Europe. In primary osteoporosis, the incidence of cervical and trochanteric fractures of the proximal femur was shown to be lower in Japan than in Europe and the United States [14,15]. We performed the present cross-sectional and longitudinal study to determine the incidence and risk factors for vertebral fracture in menopausal and postmenopausal Japanese women with RA.

The cross-sectional part of the present study involved a comparison of the radiographically demonstrated prevalence of vertebral fracture in RA patients with that in age-matched menopausal and postmenopausal women without RA. We then longitudinally examined how many RA

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patients with or without glucocorticoid therapy sustained a new vertebral fracture during a 4-year period.

Patients and methods

Cross-sectional study

We examined 117 menopausal and postmenopausal women who fulfilled the revised 1987 RA criteria of the American College of Rheumatology [16], and who were treated in our RA outpatient clinic between September and November 1998. Patients treated with bisphosphonate were excluded, while those treated with vitamin D or vitamin K were included. No patients represented class 4 of the Steinbrocker classification; most were in class 2. The ages of the 117 patients were as follows: 50–54 years (designated group A), 32 patients; 55–59 years (group B), 35 patients; 60–64 years (group C), 50 patients. The healthy control group consisted of 62 women who had been admitted to the hospital for a comprehensive osteoporosis evaluation (mean age \pm SD, 57.4 ± 4.5 years). No difference in age was evident between RA patients and healthy controls.

Vertebral fracture was diagnosed from lateral radiographs of the thoracic and lumbar spine. Such a fracture was considered to have occurred when either the ratio of the height at the center of a vertebra (*C*) to the height at the anterior portion of the vertebra (*A*), or the ratio of *C* to the posterior portion of the vertebra (*P*), was less than 0.8, or when *A/P* was less than 0.75 [17]. This cross-sectional examination of 117 RA patients for vertebral fractures was carried out in 1998.

Longitudinal study

We followed up the 117 RA patients until 2002. Four patients died, while another became bedridden because of cerebral infarction. These five patients were excluded from the longitudinal analyses. In 2002, we reassessed vertebral fractures radiographically by the method used in 1998. As part of the longitudinal study, BMD at L2–L4 was determined in 1998 by dual-energy X-ray absorptiometry (DXA; Hologic QTR 2000, Waltham, MA, USA).

Treatments with corticosteroid and/or methotrexate (MTX) were recorded, as were the results of assays for N-telopeptide of type I collagen (NTx) in urine.

Statistical analysis

The results are expressed as the mean \pm SD. To compare numerical data not normally distributed, a Mann–Whitney *U* test was used. When the distributions were normal and the variances approximately equal, the differences between means were compared by Student's *t* test. For categorical data comparisons, a χ^2 test was used. Differences were considered to be significant when *P* was below 0.05. We computed 95% confidence intervals (CI) for differences between means, and for odds ratios for paired data. Cut-off values were defined as the value at which subjects with vertebral fracture were distinguished with optimal sensitivity and specificity from those without vertebral fracture.

Results

Cross-sectional study (Table 1)

In 1998, vertebral fracture was detected in 25 RA patients among 117. The 117 RA patients included 55 receiving an oral steroid (6.0 ± 2.4 mg prednisolone daily). Among these, the 18 (33%) who had a vertebral fracture received 7.1 ± 3.1 mg prednisolone per day, compared with 5.4 ± 1.8 mg prednisolone per day in the 37 steroid-treated RA patients without vertebral fracture. This difference in dose between prednisolone-treated RA patients with and without a vertebral fracture was significant ($P < 0.05$). Fractures were found in 7 of 62 RA patients without oral steroid therapy (11%). The odds ratio for vertebral fracture associated with steroid administration compared with no steroid administration was 3.82 (95% CI, 3.01–4.85). In relation to the dose of prednisolone, the odds ratio for vertebral fracture associated with a daily dose of 5 mg or higher compared with less than 5 mg daily was 3.80 (95% CI, 3.03–4.76); that associated with a daily dose of 7.5 mg or higher compared with less than 7.5 mg daily was 4.34 (95% CI, 3.21–5.86). On the other hand, 3 of 62 healthy controls had a vertebral fracture (5%). Thus, the difference in the prevalence of vertebral fracture was significant between RA patients considered overall and healthy control subjects ($P < 0.05$), but was not significant between RA patients who did not have oral treatment with a steroid and the controls.

Table 1. Prevalence of vertebral fracture in 117 RA patients and 62 healthy control subjects in 1998

	No. of subjects	Age (years)	Prevalence of vertebral fracture
RA patients	117	58.0 ± 4.6	25 (21%)*
Steroid (+)	55	58.6 ± 4.4	18 (33%)**
Steroid (–)	62	57.4 ± 4.8	7 (11%)
Healthy controls	62	57.4 ± 4.5	3 (5%)****

There were no age differences between these groups

* ** * Designated pairs compared; finding $P < 0.05$

Longitudinal study

We radiographically evaluated 112 RA patients for vertebral fracture in 1998 as part of the cross-sectional RA group above, and again in 2002. Four patients began oral steroid therapy between 1998 and 2002; these were considered as steroid-treated patients in the longitudinal study.

Patients with vertebral fractures in 2002 vs 1998, by age-defined group and therapy

In age-group A, 19 patients who received no steroid included none with a vertebral fracture in 1998 (0%) and 1 in 2002 (5%). Two patients began oral steroid therapy during 1998–2002, but did not sustain an additional vertebral fracture. Among 11 group-A patients receiving oral prednisolone (6.0 ± 2.3 mg daily) in 1998, 3 had a fracture in 1998 (27%); this increased to 4 by 2002 (36%). In age-group B, 2 of 21 patients with no steroid had a fracture in 1998 (10%), and this had increased to 6 by 2002 (29%). Among 12 patients in group B receiving oral prednisolone (5.5 ± 1.0 mg daily), 2 had a fracture in 1998 (17%), and this had increased to 3 by 2002 (25%). In age-group C, 4 of 21 patients with no steroid had a fracture in 1998 (19%), and this had increased to 7 by 2002 (33%). Two group-C patients began oral steroid therapy between 1998 and 2002, but did not sustain an additional vertebral fracture. Among 28 group-C patients receiving oral prednisolone (6.1 ± 2.8 mg daily), 12 had a fracture in 1998 (43%); this had increased to 21 by 2002 (75%; Table 2).

The fracture rate between 1998 and 2002 was analyzed in terms of age in 89 RA patients with no vertebral fracture in 1998. Sensitivity and specificity for vertebral fracture were calculated for each age, yielding a cut-off value of 59 years (Fig. 1).

Occurrence of new vertebral fractures in patients with preexisting fracture in 1998

In group A, no patient receiving no steroid had a preexisting fracture. Among group-A patients with oral steroid therapy, 3 had a fracture at the 1998 baseline, 1 of whom had sustained a fracture in another vertebra by 2002. In

Table 2. Vertebral fracture prevalence in 1998 and 2002

Age in 1998 (years)	Steroid	No.	Fracture (+)	
			1998	2002
Group A: 50–54	(–)	19	0 (0%)*	1 (5%)**
	(+)	11	3 (27%)*	4 (36%)**
Group B: 55–59	(–)	21	2 (10%)	6 (29%)
	(+)	12	2 (17%)	3 (25%)
Group C: 60–64	(–)	21	4 (19%)	7 (33%) [#]
	(+)	28	12 (43%)	21 (75%) [#]

Only 112 patients were evaluated (5 were excluded because of death or their bedridden state). Two group A patients and 2 group C patients began oral steroid therapy between 1998 and 2002; these patients did not sustain an additional vertebral fracture

***[#] Designated pairs compared; finding $P < 0.05$

group B, 2 patients with no steroid had a fracture at baseline, while none showed a new fracture in 2002. Among group-B patients receiving an oral steroid, 2 had fractures at baseline, including 1 with a new fracture in another vertebra by 2002. In group C, among patients with no steroid, 4 had a fracture at baseline, while none had a new fracture by 2002. Group-C patients with oral steroid therapy included 12 with fractures at baseline, 6 of whom had a new fracture in another vertebra by 2002 (Table 3). Steroid administration increased the risk of new vertebral fractures in patients with a preexisting fracture ($P < 0.05$).

Influence of BMD and steroid administration on the risk of a first vertebral fracture during a 4-year period

Patients with no fracture in 1998 who were reevaluated in 2002 were divided into three groups according to their BMD relative to the young adult mean (YAM). Among patients with a BMD/YAM below 70%, 10 had prednisolone therapy (5.6 ± 1.9 mg daily), while 7 of these 10 had a vertebral fracture by 2002 (70%). Eight patients in this BMD range receiving no steroid included 3 with a vertebral fracture by 2002 (38%). Among patients with a BMD/YAM between 70% and 80%, 8 patients received prednisolone (4.6 ± 0.88 mg daily), with 3 showing a vertebral fracture by 2002 (38%). Among 12 patients in this BMD range with no steroid, 2 had a vertebral fracture by 2002 (18%). Among patients with a BMD/YAM of at least 80%, 19 patients received prednisolone (5.7 ± 1.9 mg daily), with 1 of 19 having a vertebral fracture by 2002 (5.3%). Of 32 patients in this BMD range with no steroid therapy, 3 patients had a vertebral fracture by 2002 (9.4%; Table 4).

The fracture rate was analyzed in terms of BMD/YAM (%) in RA patients treated with corticosteroid during a 4-year period. Sensitivity and specificity for BMD–YAM in predicting vertebral fracture were plotted for each 1% BMD/YAM increment. The cut-off value was 73%–74% of patients (Fig. 2).

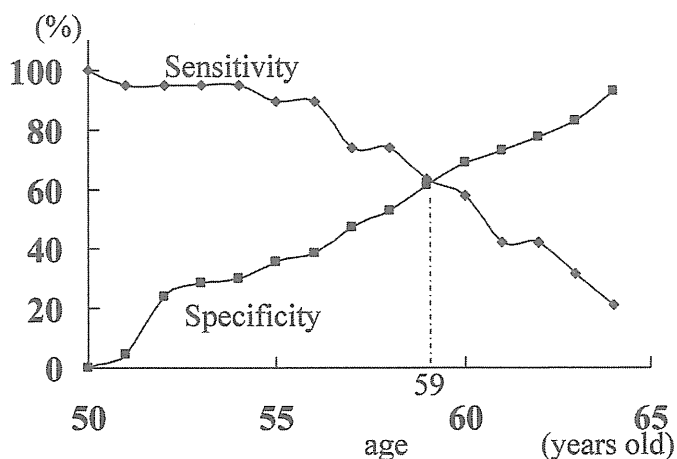


Fig. 1. Determination of a cut-off value for the age predicting a first vertebral fracture in RA patients during a 4-year period. The cut-off value for the age that best separates fracture from nonfracture cases among patients with RA was 59 years

Table 3. New vertebral fractures among patients with a fracture 4 years previously

Age in 1998 (years)	Steroid	No. with a vertebral fracture	No. with an additional vertebral fracture in 2002
Group A: 50–54	(–)	0	0
	(+)	3	1
Group B: 55–59	(–)	2	0
	(+)	2	1
Group C: 60–64	(–)	4	0
	(+)	12	6

Steroid administration increased the risk of new vertebral fractures in patients with a preexisting fracture ($P < 0.05$)

Table 4. BMD/YAM in 1998 according to fracture incidence in 2002

BMD/YAM (%)	1998 Fracture (–)	2002 Fracture (+)
<70%		
Steroid (+)	10	7 (70%)
Steroid (–)	8	3 (38%)
70%–80%		
Steroid (+)	8	3 (38%)
Steroid (–)	12	2 (18%)
≥80%		
Steroid (+)	19	1 (5%)
Steroid (–)	32	3 (9%)

BMD, bone mineral density; YAM, young adult mean

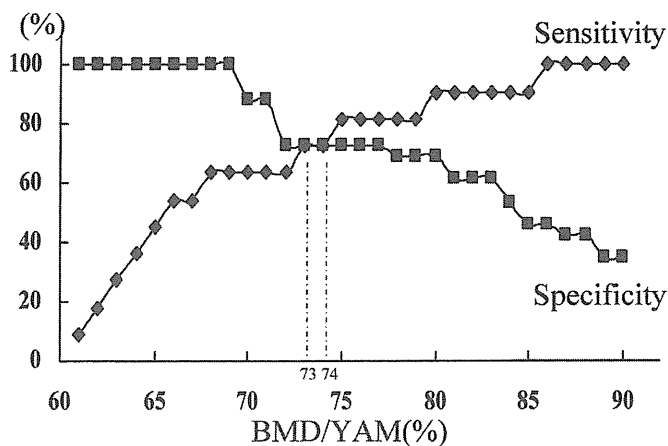


Fig. 2. Determination of a cut-off value for the BMD/YAM (%) predicting a first vertebral fracture in corticosteroid-treated RA patients during a 4-year period. The cut-off value for the BMD/YAM that best separates fracture from nonfracture cases among corticosteroid-treated RA patients was 73%–74%

The occurrence of new vertebral fractures between 1998 and 2002 was also examined specifically in relation to BMD in patients receiving no oral steroid. Of patients who had no fracture in 1998, 16% had a new vertebral fracture in 2002; their BMD/YAM was $76\% \pm 14\%$ in 1998. The BMD/YAM of patients who did not have a new fracture in the 4-year period was $88\% \pm 16\%$ in 1998. The BMD/YAM in patients who had a new vertebral fracture during the 4 years was significantly lower than that in patients who had no fracture.

Table 5. The odds ratio for the occurrence of new vertebral fractures between 1998 and 2002 associated with BMD/YAM (%) in patients receiving no oral steroid

BMD/YAM (%) in 1998	Odds ratio	95% CI
65	6.14	0.74–51.32
66	14.33	2.74–75.09
67	14.33	2.74–75.09
68	25.80	5.61–118.61
69	6.00	2.72–13.25
70	4.68	2.22–9.85
71	4.68	2.22–9.85
72	3.17	1.59–6.32
73	4.50	2.37–8.53
74	3.40	1.83–6.30
75	5.00	2.63–9.50
76	4.44	2.36–8.39
77	3.57	1.91–6.67
78	3.57	1.91–6.67
79	3.57	1.91–6.67
80	3.22	1.73–6.00

CI, confidence interval

The odds ratio for the occurrence of a new vertebral fracture between 1998 and 2002 associated with a BMD/YAM (%) in patients receiving no oral steroid was computed for each 1% BMD/YAM increment (Table 5). The odds ratio for vertebral fracture associated with a BMD/YAM (%) of 68% or higher compared with less than 68% was 25.80 (95% CI, 5.61–118.61). In RA patients receiving no oral steroid, a BMD/YAM below 69% indicates risk for vertebral fracture, as was suggested for primary osteoporosis.

Influence of steroid and/or MTX administration on vertebral fracture risk

Table 6 gives the fracture risk in patients treated with steroid and/or MTX in 1998. In 1998, 24 RA patients had treatment with oral prednisolone (5.6 ± 2.3 mg daily) plus MTX. In that year, 31 RA patients received oral prednisolone (6.3 ± 2.5 mg daily) without MTX. RA patients receiving MTX but no oral steroid numbered 22, while 35 RA patients had neither oral steroid nor MTX. There were no age differences between steroid (+) MTX (+), steroid (+) MTX (–), and steroid (–) MTX (+) groups, while MTX (–) steroid (–) patients were younger than the others. In steroid (+) MTX (+) patients, the prevalence of vertebral fracture

Table 6. Vertebral fracture according to steroid and MTX therapy

Steroid	MTX	No.	Age \pm SD (years)	Prevalence of fracture	
				1998	2002
+	+	24	58.6 \pm 4.2	7 (29%)	15 (63%)
+	-	31	59.1 \pm 4.8	11 (35%)	14 (45%)
-	+	22	58.7 \pm 4.5	1 (5%)	3 (14%)
-	-	35	56.2 \pm 4.5	4 (11%)	10 (29%)

MTX, methotrexate

was 7 (29%) in 1998 and 15 (63%) in 2002. In steroid (+) MTX (-) patients, the prevalence was 11 (35%) in 1998 and 14 (45%) in 2002; in steroid (-), MTX (+) patients, the prevalence was 1 (4.5%) in 1998 and 3 (14%) in 2002; in steroid (-) MTX (-) patients, the prevalence was 4 (11%) in 1998 and 10 (29%) in 2002 (Table 5). New vertebral fracture during the 4-year period showed a significant excess in steroid (+) MTX (+) patients above the occurrence in steroid (-) MTX (+) and MTX (-) steroid (-) patients ($P < 0.05$). Steroid (+) MTX (-) patients also showed an excess over the two steroid (-) groups ($P < 0.05$), which did not differ between MTX (+) and MTX (-).

Urinary NTx in RA patients with or without fracture

Urinary NTx in RA patients with any vertebral fracture in 2002 was 66.6 ± 28.6 nmol BCE/mmpl-Cr, while in RA patients with no vertebral fracture in 2002 it was 66.8 ± 32.0 nmol BCE/mmpl-Cr. Thus, urinary NTx was high in RA patients with or with no fracture, with no difference between fracture-defined groups.

Discussion

This study sought to identify the risk factors for vertebral fracture in menopausal and postmenopausal Japanese women with RA. The cross-sectional part of our study indicated a prevalence of vertebral fracture of 21%, which was considerably higher than in age-matched healthy women without RA (5%, $P < 0.05$). As for steroid treatment, 33% of RA patients with corticosteroid administration had vertebral fracture, which is higher than that seen without steroid administration; this implicated corticosteroid therapy as a risk factor for fracture (see Table 1). In this study, the steroid-related odds ratio for vertebral fracture compared with RA patients without steroid administration was 3.82 (95% CI, 3.01–4.85), indicating an increased risk of developing vertebral fracture in patients treated with corticosteroid. This finding is in agreement with data reported by de Nijs et al. [13] (odds ratio 2.34; 95% CI, 1.39–3.93). Their study included 410 patients with RA, half of whom were treated with corticosteroid; the mean age was 65. The 148 women in this study included 91 postmenopausal women. The dose of prednisolone appeared to be related to the vertebral fracture risk. Steroid-treated patients in our current study showed an odds ratio of 3.80 (95% CI, 3.03–4.76)

for vertebral fracture for a daily dose of prednisolone of 5 mg or higher vs. a dose of less than 5 mg. This increased to 4.34 (95% CI, 3.21–5.86) for a daily prednisolone dose of 7.5 mg or higher vs. a dose of less than 7.5 mg. The Japanese Society for Bone and Mineral Research has suggested starting treatment at a dose of 5 mg/day or higher for prednisolone or an equivalent dose of another corticosteroid [18].

Fracture rates also increased with advancing age. In primary osteoporosis, the occurrence of fracture becomes high in Japanese women aged 75 years or older [14,15]. However, vertebral fracture showed an earlier increase in RA patients, beginning at approximately 60 years; patients 60–64 years old receiving no steroid showed a prevalence of 19% with fractures and this in 1998, increased to 33% in 2002. For 28 patients at this age receiving an oral steroid, the prevalence was 43% in 1998 and 75% in 2002 (see Table 2). Fracture rate also was analyzed in terms of age as a variable in RA patients in whom the cut-off age was 59 years (see Fig. 1). An age of 60 years or more was thus identified as a risk factor for vertebral fracture in patients with RA.

A previous history of vertebral fracture was reported to increase the risk of another [19]. Over the 4 years of follow-up in this study, new vertebral fractures occurred in eight patients with a previous fracture. As all eight patients were treated with corticosteroids, this also implicates corticosteroids in compounding the risk of vertebral fracture ($P < 0.05$, Table 3).

Cohen et al. [20] reported that during 12 months of follow-up in 77 patients receiving more than 7.5 mg of prednisolone per day (given for RA in 31 patients), 20.8% (5/24) of all postmenopausal patients in their study group sustained a vertebral fracture. Similarly, Reid et al. [21] found that in 96 patients given over 7.5 mg of prednisolone per day (for RA in 39), 15% (9/60) had a vertebral fracture during a 12-month interval. The importance of BMD in patients with glucocorticoid treatment was questioned by these authors, who suggested that the relationship between BMD and vertebral fracture was tenuous. A working committee of the Japanese Society for Bone and Mineral Research concerned with the development of diagnostic criteria for osteoporosis suggested a BMD/YAM below 70% as a diagnostic criterion for primary osteoporosis in Japanese women [17]. Among our RA patients with a BMD/YAM less than 70%, those treated with prednisolone (5.6 ± 1.9 mg daily) had a 70% prevalence of vertebral fracture at the second evaluation after 4 years; even without steroid therapy the prevalence was 38%. Thus, in RA patients, a BMD/YAM below 70% indicates a risk for vertebral fracture, as was proposed for primary osteoporosis. Among patients with a BMD/YAM between 70% and 80%, some 38% of patients receiving prednisolone (4.6 ± 0.88 mg daily) had a vertebral fracture after 4 years, while 18% of our patients with a BMD/YAM in the same range, but without steroid treatment, had vertebral fractures in 2002. RA patients who had both steroid therapy and a BMD/YAM from 70% to 80% were at increased risk of vertebral fracture. Finally, however, when BMD/YAM was at least 80% in RA

patients receiving prednisolone at 5.7 ± 1.9 mg daily, the risk of vertebral fracture did not appear to be excessive. The fracture rate during a 4-year interval was also analyzed in terms of BMD/YAM (%) as a variable in patients treated with corticosteroid. The cut-off BMD/YAM value that best separated fracture and nonfracture in RA patients was 73%–74% (see Fig. 2); the Japanese Society for Bone and Mineral Research similarly reported a cut-off value for BMD of 73.6% [18]. This suggests that RA patients with a BMD/YAM between 70% and 80% who receive corticosteroid treatment, and all patients with a BMD/YAM below 70%, should undergo treatment for the prevention of vertebral fracture.

We previously compared the structural characteristics of bone loss in iliac biopsy specimens between RA and primary osteoporosis, including a node–strut analysis [1]. Briefly, in RA, trabecular thickness and wall thickness showed a decline with age that was accelerated by glucocorticoid treatment. Decreased connectivity between trabeculae was more prominent than a disappearance of nodes. The connectivity of cortical bone to nodes and the cortical thickness decreased significantly with age, especially in RA patients not treated with corticosteroid. Corticosteroid therapy accelerated the loss of connections between trabeculae and the disappearance of nodes. In this study, fractures were increased in patients aged 60 years or older, while corticosteroid therapy accelerated, the occurrence of fracture. However, the clinical risk of vertebral fracture incidence in menopausal or postmenopausal RA patients treated without a corticosteroid did not clearly differ from that in controls. A 50-year-old patient whose BMD/YAM was 98% and a 63-year-old patient whose BMD/YAM was 95% received no corticosteroid but still sustained vertebral fracture during the 4-year follow-up interval. However, these fractures might conceivably be related to the RA itself. Ørstavik et al. [3] demonstrated vertebral deformity in 141 of 249 female RA patients in Oslo, compared with 51 in 249 control subjects matched for age, sex, and area of residence. A diagnosis of RA and low BMD were both significantly associated with vertebral deformities. In their study, the relative risk with these factors was 1.95 (95% CI, 1.30–2.76) and 1.53 (95% CI, 1.30–1.81), respectively, after controlling for age, body mass index, and use of estrogens or bisphosphonate. When long-term corticosteroid use was added to this analysis, the association between RA and vertebral deformities was weaker, and the relative risk was 1.47 (95% CI, 1.03–2.31). They concluded that a diagnosis of RA was associated with vertebral deformities independently of BMD and long-term corticosteroid use.

In children receiving antineoplastic chemotherapy for up to 5 years, high-dose MTX has been identified as a short- and long-term risk factor for osteoporosis [22,23]. In addition, some case reports have described pathological fractures related to osteoporosis occurring in adult patients who had been treated long-term with low-dose MTX for RA or psoriatic arthritis [24–27]. However Buckley et al. [28], Minaur et al. [29], and Mazzantini et al. [10] found no effect of MTX on BMD. In our study, fracture prevalence

was high in patients receiving MTX when given with corticosteroids. No adverse effect on vertebral fracture of low-dose MTX alone was found in RA.

In general, osteoclastic activation, as opposed to the suppression of bone formation, has been suggested as the dominant process leading to bone loss in patients with RA [30–32]. Assessing bone resorption markers in patients with RA may therefore improve our understanding of the pathogenesis of bone loss with bone resorption in RA. Urinary cross-linked N-telopeptides of type I collagen (NTx) serve as a bone resorption marker that was previously reported to be significantly higher in women with RA than in age-matched controls; the RA-related increase in urinary NTx was suggested to be associated with physical inactivity and increased RA activity [33]. In the present study, urinary NTx was high in RA patients, as previously reported, but no difference was seen between patients with and without a new fracture after 4 years. Since urinary NTx is generally elevated in RA patients, increases in urinary NTx resulting from vertebral fracture may have been masked. Another reason for the lack of difference may involve the variability in the duration of intervals from the occurrence of vertebral fracture to the measurement of urinary NTx.

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Secular change of the incidence of four fracture types associated with senile osteoporosis in Sado, Japan: the results of a 3-year survey

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Abstract We conducted a three-year survey of fracture incidences associated with senile osteoporosis—compression fractures of the spine, femoral neck fractures, distal radius fractures, and fractures of the proximal end of the humerus—to examine secular change. The survey was conducted between 2004 and 2006 on patients in Sado City. We calculated the incidence of each fracture based on the population of Sado City (per 100,000 person-years). Only clinical or incident fractures were diagnosed as new fractures for compression fractures of the spine. Incidence of compression fracture of the spine was the highest, followed by femoral neck fracture, distal radius fracture, and fracture of the proximal end of the humerus. The incidence of femoral neck fracture increased annually from 2004 to 2006, significantly among the elderly in their 80s ($P < 0.05$). Compression fracture of the spine also increased but not significantly. The incidences of distal radius fracture and fracture of the proximal end of the humerus did not increase. This increase in incidence of

femoral neck fractures associated with senile osteoporosis will become an important issue for an aging society such as Japan.

Keywords Fracture · Osteoporosis · Incidence

Introduction

Japan has an increasingly aging society which is expected to experience an increasing number of fractures associated with senile osteoporosis; namely, compression fracture of the spine, femoral neck fracture, distal radius fracture, and fracture of the proximal end of the humerus. In fact, the incidence of femoral neck fractures is reportedly on the rise [1, 2]. However, the incidences of other fracture types are not entirely clear, nor are the relationships among these fracture types. Moreover, there are currently few reports on any consecutive surveys of the incidence of four kinds of fractures associated with senile osteoporosis which were conducted simultaneously and in a defined geographic area. Therefore, we conducted a survey on the incidences of four fracture types associated with senile osteoporosis in the city of Sado, Japan for three consecutive years.

Patients and methods

We conducted a survey of patients at Sado General Hospital (inpatients and outpatients) between 2004 and 2006 for compression fractures of the spine, femoral neck fractures, distal radius fractures, and fractures of the proximal end of the humerus. Sado General Hospital is the only hospital on Sado Island capable of treating fractures and manages 95% of all such cases in Sado. In 2004, a few

Data represented in the Journal of Bone and Mineral Metabolism [2] are included in a table and figures in this article, to examine secular change from 2004.

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other medical institutions in Sado City were included in this study, but as they contributed only a small percentage of all cases, these were eliminated from the study in 2005. All fractures were examined by X-ray. Diagnosis of compression fractures was based on dimensions of the vertebral body and diagnostic criteria issued by The Japanese Society for Bone and Mineral Research, used widely in Japan [3]. We diagnosed clinical or incident fractures as new fractures. These were found in patients who visited the hospital for symptoms such as back pain and were judged by the orthopedic doctor based on X-ray and physical examination to have a new vertebral fracture. Prevalent fractures and asymptomatic older fractures observed accidentally by X-ray were excluded from the analysis.

We first counted the number of patients with each fracture type for each year and then calculated the incidences based on the Sado City population for each year (per 100,000 person-years). We also calculated the incidences in 2004 adjusted to the population structure of Japan in 2005. Patients were divided into groups according to age (10-year intervals). The incidence of each fracture type per age group per study year was calculated according to the population of each age group in Sado City for a given study year (per 100,000 person-years). We focused on patients who resided in Sado, an island, as it is unlikely that patients would go elsewhere for treatment, and thus would remain on the island for the duration of the survey. We excluded any fractures experienced by tourists to Sado. The population of Sado was 70,011 in 2004, 68,045 in 2005, and 66,592 in 2006. At the same time, the aging rate (ratio of population ≥ 65 years relative to total population) for these three years was 34.0, 34.7, and 35.2%, respectively (Table 1). The fracture incidences surveyed in 2004 were reported in a previous paper [4]; however, these are also included in this report in order to illustrate changes over three consecutive years, from 2004 to 2006 in Sado City.

Statistical analysis

Chi-square test followed by Tukey's multiple comparison was used to compare the incidence of each fracture across all observation years.

Results

The combined number of compression fractures of the spine, femoral neck fractures, distal radius fractures, and fractures of the proximal end of the humerus was 350 patients in 2004, 369 in 2005, and 405 in 2006. The incidence per 100,000 people was 499.9 in 2004, 542.3 in 2005, and 608.2 in 2006. Therefore, both the number of fractures and incidence increased every year from 2004 to 2006 (Table 1) (N.S.). We analyzed the result by classifying the incidences for the four fracture types by year and by age.

Compression fractures of the spine

The incidence per 100,000 was 232.8 in 2004, 246.9 in 2005, and 282.3 in 2006, indicating an annual increase (N.S.). In age group analysis the annual increase in incidences from 2004 to 2006 was shown in octogenarian patients (N.S.) (Fig. 1).

Femoral neck fractures

The incidence per 100,000 was 121.4 in 2004, 141.1 in 2005, and 177.2 in 2006, also indicating an annual increase (N.S.). In particular, there was a significant increase in incidence of femoral neck fractures among octogenarian patients between 2004 and 2006 ($P < 0.05$) (Fig. 2).

Table 1 Number and incidence of each fracture in Sado

Year	2004		2005		2006		
Total population	70,011		68,045		66,592		
Aging rate	34.00%		34.70%		35.20%		
	2004		2005		2006		
	Number	Incidence	Incidence adjusted for Japanese population	Number	Incidence	Number	Incidence
Spine	163	232.8	138.4	168	246.9	188	282.3
Femoral neck	85	121.4	69.8	96	141.1	118	177.2
Distal radius	76	108.6	76.9	84	123.4	74	111.1
Proximal end of humerus	26	37.1	37.3	21	30.9	25	37.5
Total	350	499.9	322.4	369	542.3	405	608.2

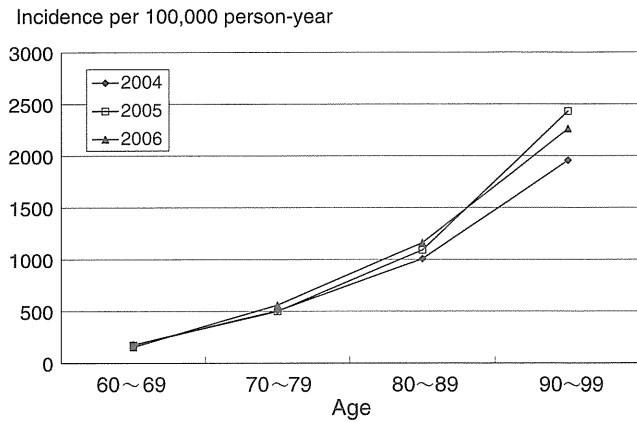


Fig. 1 Incidence of compression fractures of spine

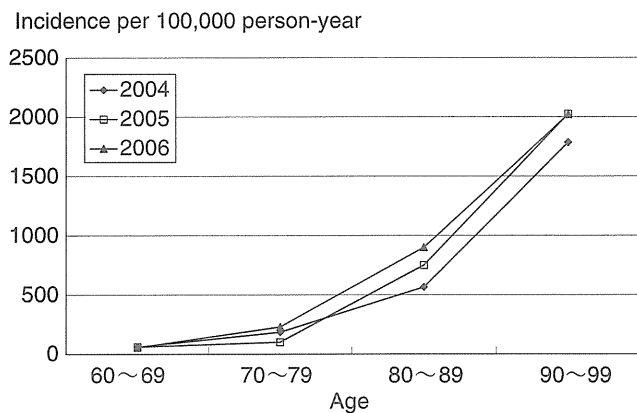


Fig. 2 Incidence of femoral neck fractures

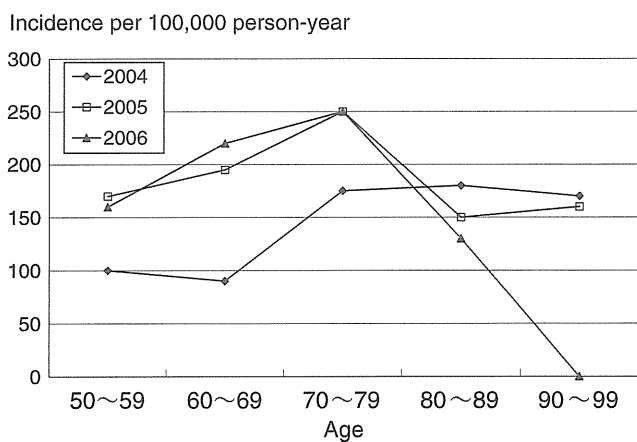


Fig. 3 Incidence of distal radius fractures

Distal radius fractures

The incidence per 100,000 was 108.6 in 2004, 123.4 in 2005, and 111.1 in 2006, indicating a plateau. The incidence was highest among septuagenarian patients each year (Fig. 3).

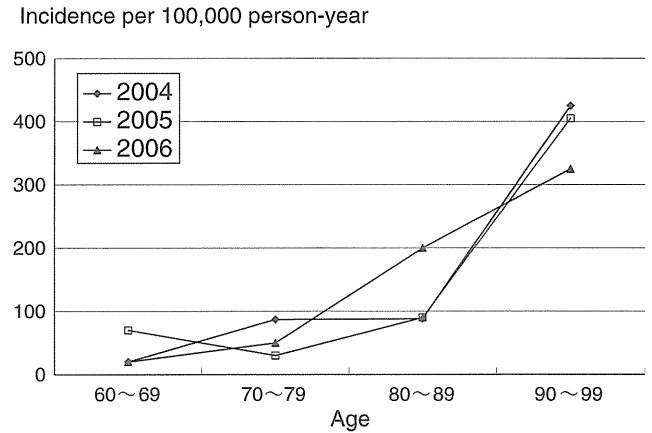


Fig. 4 Incidence of proximal end of humerus fractures

There was no significant age-dependent difference in incidence across all years.

Fractures of the proximal end of the humerus

The incidence per 100,000 was 37.1 in 2004, 30.9 in 2005 and 37.5 in 2006, also indicating a plateau. Nonagenarian patients had the highest incidence each year (Fig. 4).

There was no significant age-dependent difference in incidence across all years.

Discussion

Sado is an island city whose residents attend the Sado General Hospital, which allows us to conduct a complete survey of four types of fractures associated with senile osteoporosis within the same location and at the same time. Furthermore, since Sado has a high aging rate of 35%, we believe that it represents a good indication of future trends in Japan.

The incidence of compression fractures of the spine and femoral neck fractures increased most markedly among octogenarian patients, particularly in 2006 ($P < 0.05$; between 2004 and 2006 on femoral neck fracture).

One reason for the increased hip fracture incidence may be that the elderly population over 80 years of age in Sado grew by approximately 300 people each year, despite a decline in the total population from 2004 to 2006. Other studies reported similar increases in hip fracture with time [1, 2, 5–7]. In the current study, the incidence increased 1.46-fold in 3 years—a steep increase rate compared to the 1.4-fold increase observed in other Asian regions in a recent decade [6]. In addition, pre-existing compression fractures of the spine have been suggested as risk factors for femoral neck fractures [8]. Eighty percent of patients with femoral neck fractures reportedly have a history of

compression fractures of the spine, and femoral neck fractures are thought to occur 3–5 years after patients have been diagnosed with a compression fracture [9, 10]. We are therefore confident that the increase in compression fractures of the spine is associated with later increases in femoral neck fractures. Osteoporosis patients should be educated and enlightened about these issues, and we recommend that physicians also take this into consideration in their treatment of such patients.

Studies from Northern Europe and North America have reported that fracture incidences have decreased in recent years. Initially, these regions had higher incidences than Japan, but these have since declined, most likely as a result of proper osteoporosis diagnoses and the use of osteoporosis drugs [11, 12].

This survey revealed that distal radius fractures have a different incidence pattern compared to compression fractures of the spine and femoral neck fractures. The incidence of distal radius fractures did not increase by age or by year. Hagino et al. [5] reported that the fracture of upper extremities increased significantly with time in their study of 1986–1995, but in the current study we did not observe such an obvious increase (Table 1, Figs. 3, 4). It is possible that the shorter observation period and fewer fractures in upper extremities contributed to this discrepancy.

Some studies report that while the elderly must remain sufficiently active in order to prevent distal radius fractures by using their hands during a fall, it may not be possible to prevent the other types of fractures [5, 13]. Unmistakably, one of the contributing factors, other than an increasingly aging population, is reduced physical ability, as seen in individuals who are unable to use their hands during a fall to prevent fractures or those who fall while being transferred onto a bed or a wheelchair. The elderly who are over 80 years of age clearly have a lower physical activity level and, therefore, a decreased ability to walk and an increased likelihood to stumble or fall, a condition which necessitates assistance [5, 13].

A survey conducted in 2004 reported that patients who suffered femoral neck fractures reported low levels of serum vitamin 25(OH)D and albumin [9, 10]. A drop in serum vitamin 25(OH)D levels generally suggests reduced torso flexibility [14] and, therefore, an increased risk of falling [15], which can also be related to dementia [16]. Levels of 25(OH)D are significantly related to vitamin D levels, and also correlate with low levels of albumin, indicating the important role of nutrition among the elderly, particularly those over 80 years of age. We believe that decreased activity and poor nutrition may have contributed to the increased incidence of fractures.

The increase in bone fractures among the elderly is an important concern for Japan's aging society, and indicates a disparity between long life expectancy and a high quality

of life. The decline in activity and the rise in assisted living increase the risk of falls and are linked to increased rates of bone fractures. The increase in bone fractures, especially femoral neck fractures, indicates the need for increased care. Moreover, it is reported that only 55% of patients with femoral neck fractures return home after leaving the hospital [4], which creates a large burden of medical care expenses.

The results of our survey on the incidence of fractures associated with senile osteoporosis, particularly among the elderly over 80 years old, should serve as a warning to our society. A national survey on femoral neck fractures also indicates increasing incidence of bone fractures among those 80 years and older [17]. We believe that it is critical to implement comprehensive bone fracture prevention programs, including fall prevention, nutrition, and the appropriate use of osteoporosis therapy drugs to rehabilitate the current generation.

We conclude that reducing the risk of falls among the elderly will have a significant impact on the incidence of fractures associated with senile osteoporosis.

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Epidemiology of cervical and trochanteric fractures of the proximal femur in 1994 in Tangshan, China

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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 1994 in Tangshan City, China. There are many reports on hip fracture incidence in many countries, suggesting that there are many factors affecting hip fractures. We visited 15 hospitals with an orthopaedic department within Tangshan City, and reviewed the medical records and radiographs of all patients with hip fractures occurring between January 1 and December 31, 1994. The population of Tangshan in 1994 was determined to be 1454543 (746015 males and 708528 females). The population of those over 65 years of age was 88490 (41519 males and 46971 females), representing 6.08% of the total population. This study detected 184 cervical and trochanteric fractures of the proximal femur in 1994 in Tangshan (127 men and 57 women). The overall incidence or rate of the combined number of cervical and trochanteric fractures was 25 fractures per 100000 population per year for men and 12 for women. There were a total of 147 cervical fractures (80%) and 37 trochanteric fractures (20%). The incidence of the combined number of cervical and trochanteric fractures in patients over 70 years of age increased to 108 for men and 156 for women. The incidence of hip fractures increased with age in both sex groups, especially in women over 65. Severe trauma fractures happened more often in younger groups, and mainly occurred in men, which may be a result of the particular composition of the population in Tangshan, which is young and male dominated. In addition, because Tangshan is an industrial city, many of its citizens are involved in occupations requiring a high level of physical activity.

Key words: epidemiology, cervical femoral fracture, trochanteric femoral fracture, hip fracture, Tangshan, China

Introduction

The incidence of hip fractures is increasing worldwide because of the growth of the elderly population [1–11] and impaired physical activity [12]. The rate of increase differs from country to country, and also among different races; especially, it is reported that there are large differences between Asian and European populations [13]. Osteoporosis has become one of the major health problems confronting the elderly population. The incidence of fractures of the proximal femur is one of the indicators reflecting bone fragility in the elderly population. Most previous epidemiological studies of hip fractures were performed in certain periods and to compare with results with other areas. More recently, it has been reported that the incidence of hip fractures has increased with year and time in the same area [14,15]. There are many factors affecting hip fractures. The aims of this study were to determine the age-specific incidence of cervical and trochanteric fractures of the proximal femur in Tangshan City, and to compare this rate with the incidence of these fractures as detected in other areas, in Asia and in Western countries.

Materials and methods

This study was carried out in the city of Tangshan, which is located in the north of China, 240 km east of Beijing, and at a latitude of 38° north (Fig. 1). Data included the patients' age and sex, the type of hip fracture, and the date on which the patient sustained hip fracture. We visited 15 hospitals with an orthopaedic department in Tangshan. The medical records and radiographs of all patients who sustained a hip fracture between January 1 and December 31, 1994, were reviewed. The remaining 12 hospitals in Tangshan City did not have an orthopaedic department. The type of hip fracture was categorized as either cervical or trochanteric. Patients with

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Fig. 1. Location of Tangshan City, China

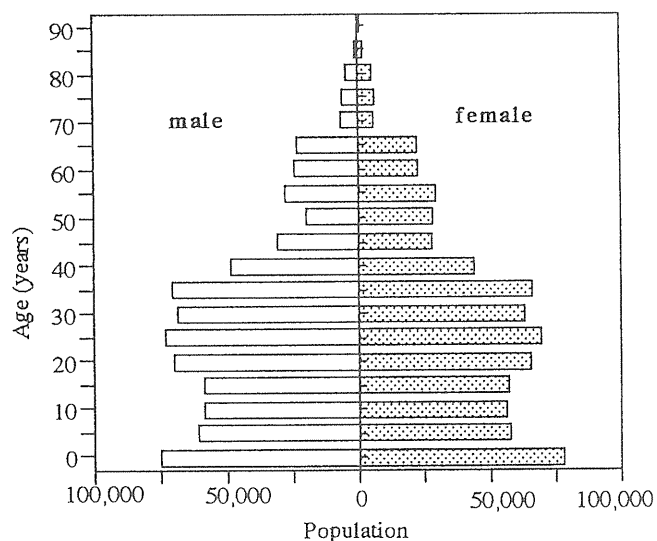


Fig. 2. Population pyramid in Tangshan City, based on sex and age in 1994

subtrochanteric or pathological fractures, residents of other cities, and patients under the age of 20 years were excluded from the study. Each patient with a fracture was given a personal code to ensure that every fracture was recorded only once in the study.

Demographic information for 1994 was obtained from the census office in Tangshan. The population of Tangshan in 1994 was determined to be 1 454 543 (746 015 males and 708 528 females). The population of those over 65 years of age was 88 490 (41 519 men and 46 971 women), representing 6.08% of the total population (Fig. 2).

The population in this study was divided into four 5-year age groups, ranging from 50–54 years to 65–69 years. Individuals aged 49 years or less and those 70 years and older formed two additional groups. We de-

termined the age-specific incidence of cervical and trochanteric fractures of the proximal femur in Tangshan in 1994. Fracture incidence or rate was expressed as the number of cervical or trochanteric fractures per 100 000 population per year, and was computed for each of the age groups.

Results

Incidence of cervical and trochanteric fractures in 1994

The population pyramid of the city of Tangshan, based on age and sex, is shown in Fig. 2. Approximately 240 000 residents died in Tangshan because of an earthquake in 1976. Because Tangshan is an industrial center, the population is young and male dominated. The ratio of males to females was nearly 1 to 1. Women over the age of 65 comprised only 6.62% of the total female population.

In Tangshan in 1994, 184 cervical and trochanteric fractures of the proximal femur occurred, with 127 in males and 57 in females (male-to-female ratio, 2.2:1). The average age at the time of fracture was 56.1 years for men and 62.8 years for women. The age-specific number and incidence of cervical and trochanteric fractures are shown in Table 1. There were 35 fractures in men over 65 years of age, and 34 in women in the same age range. The overall incidence of the combined number of cervical and trochanteric fractures was 25 per 100 000 population per year for men and 12 for women. In the range of 50 to 55 years, the incidence of hip fracture is higher in men than in women. However, the incidence of these fractures in patients over 70 years of age increased to 108 for men and 156 for women. The incidence of the combined number of cervical and trochanteric fractures increased in both males and females with increasing age (Fig. 3).

There were 147 cervical fractures (80%) and 37 trochanteric fractures (20%). The ratio of cervical to trochanteric fractures was 4.0 to 1 (Table 2). There were 104 cervical fractures and 23 trochanteric fractures in men, and 43 cervical fractures and 14 trochanteric fractures in women. The percentage of trochanteric fractures was greater in men under 65 years of age compared to females in the same age range. However, above the age of 65 years, the percentage of trochanteric fractures in women was higher than in men.

Discussion

The incidence of hip fractures is related to a society's economy, industrial structure, geographic location, and composition of its population, as well as the occurrence of global traumas such as earthquakes, and the presence

Table 1. Number and age-specific incidence of cervical and trochanteric fractures of the proximal femur, and the percentage of trochanteric fractures, in 1994 in Tangshan

Age	Male						Female									
	Cervical fractures		Trochanteric fractures		Combined		Trochanteric fractures (%)		Cervical fractures		Trochanteric fractures		Combined		Trochanteric fractures (%)	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
-49	49		4		53		8		2		0		2		0	
50-54	5	24.8	2	9.9	7	34.8	28		4		0		4		0	
55-59	14	49.5	3	10.6	17	60	17		6		0		6		0	
60-64	11	44.3	4	16.1	15	60.5	26		10	43.3	2	8.6	12		16	
65-69	13	65.3	4	5	17	70.3	23		11	60	4	21.8	15		36	
70+	12	72	6	36	18	108	35		10	82	9	74.5	19		64	
Total	104	21.2	23	4.7	127	25.8	18		43	9.4	14	14.5	57		12.4	

Fracture incidence or rate is expressed as the number of fractures per 100000 population per annum, computed over each age interval

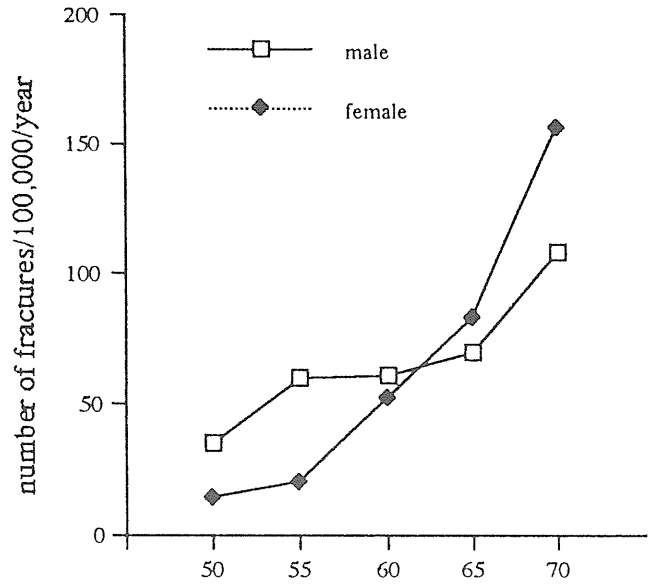


Fig. 3. Age-specific incidence of the combined number of cervical and trochanteric fractures of the proximal femur in female and male residents of Tangshan in 1994

Table 2. Summary of proximal femur fractures in Tangshan City in 1994

Number of fractures	184
Male/female ratio	2.2:1
Average age	
Males	56.1
Females	62.8
Cervical/trochanteric ratio	4.0:1

of osteopenia. Osteopenia, in turn, depends upon genetics, as well as a society's climate, lifestyle, food intake, and the level of physical activity of its people. This is the first report of the incidence of hip fractures in the city of Tangshan, which is a large coal industrial center in China. This preliminary study provides an understanding of the trends and the reasons for hip fractures in Tangshan.

Changes in the trend of incidence of cervical and trochanteric fractures in Tangshan

It is very interesting to find that in the age range from 50 to 55 years the incidence in men is higher than that in women. This phenomenon may indicate that in this age group the male mainly has severe force fractures related to occupation. Further, this variation may be related to more than the trauma degree of fracture; old women often fall in their home, but men more often fall in public places or places of work. After 65 years of age, the incidence of hip fractures in women was higher than

in men, which could be explained by fractures related more to the decline of estrogen secretion in women and osteoporosis. Also, it is related to the loss of bone mass and a slighter force, as mainly occurred in hip fractures of women.

Characteristics of cervical and trochanteric fractures in Tangshan

Most of the cervical and trochanteric fractures of the proximal femur that occurred in the adult males in this study were caused by severe traumatic situations. Females tended to be injured by a simple fall and most fractures occurred indoors, whereas males tended to be injured by more severe traumatic occurrences. Traffic accidents and high-energy traumatic events accounted for most of the cervical and trochanteric fractures in the adult men. The highest age-specific incidence of fractures in this study occurred in women over 70 years of age, reflecting the fact that hip fractures are closely related to the presence of osteoporosis.

Characteristics of lifestyle in Tangshan may cause the lower incidence of fractures

There are several factors for the lower incidence of fractures in Tangshan: physical activity, nutrition and food intake, body weight, and living habits. Each of these factors is discussed here.

A number of epidemiological studies have indicated that lack of physical activity is a risk factor for osteoporotic fractures [15,16]. These studies also found that physical activity in early life is a significant factor in the development of peak bone mass [17,18]. Because Tangshan is the biggest coal industry center of China, most people in Tangshan are engaged in occupations related to coal or the steel industry, and perform physically intense work daily. Most women have a job, even after retirement. Some of them also have a second job, perform physical activities in the morning such as Chinese dance, or provide care for their grandchildren. They also frequently travel from place to place by walking or bicycling. This higher level of physical activity may be mainly responsible for slowing the onset of osteoporosis.

People in Tangshan consume many coarse cereals and have meals that include beans. Their food intake is very similar to that in Daqing, China [9], where a low incidence of hip fractures has also been reported. Accelerated bone loss from a deficient diet does not appear to be a problem.

Body weight may be an important determinant of bone loss [19,20]. Alcoholism is a recognized cause of osteoporosis [21,22]. One study reported that even modest alcohol consumption may have an adverse

effect on bone mass [23]. Tobacco consumption is also a risk factor for osteoporosis [24,25]. A recent study reported that smokers not only have a lower bone mass but also a greater rate of bone loss [26]. In Tangshan, very few women smoke or drink alcohol. Also, most postmenopausal females tend to gain body weight, compared to their younger years. These factors most likely influence the low incidence of hip fractures in Tangshan.

Comparison of incidence of fractures in Tangshan and other areas

The incidence of cervical and trochanteric fractures is considered to be related to osteoporosis or aging, races and other factors [1–3,6,12–14,19]. The incidence of cervical and trochanteric fractures in Tangshan was lower than that reported for other prefectures in Japan such as Niigata, Tottori, and Nagasaki in Asia, as well as in Rochester, MN, in the United States [6–8,10–15]. In addition, this incidence was also lower than that reported in Taiwan [27]. The possible reason may be the particular composition of the population, which is young and male dominant; also, people in Tangshan have needed to maintain a high level of physical activity [12,27].

From this preliminary study, it was found that some patients with a suspected hip fracture present to a hospital outside the city of Tangshan and are not transferred to a hospital in Tangshan because of mental problems. By checking surgical and outpatient records in one hospital outside Tangshan City, it was estimated that the current study was able to detect approximately 80% of those with hip fractures. As previously mentioned, the incidence of hip fractures is affected by many factors. Because it is difficult to predict changes in these factors from only a single epidemiological study, more detailed studies are required.

In summary, this study detected a low incidence of cervical and trochanteric fractures of the proximal femur in Tangshan. This low incidence may result from the particular composition of the population, which is young and male dominant, and to the fact that many people have industrial-related occupations requiring a high level of physical activity.

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