Osteoporos Int (2015) 26:2249–2255
DOI 10.1007/s00198-015-3124-z

ORIGINAL ARTICLE

Epidemiology of fragility fractures in Sakaiminato, Japan: incidence, secular trends, and prognosis

Y. Tsukutani[1] · H. Hagino[2] · Y. Ito[3] · H. Nagashima[1]

Received: 18 November 2014 / Accepted: 31 March 2015 / Published online: 19 May 2015

Abstract
Summary We investigated the incidence of fragility fractures from 2010 to 2012 in Sakaiminato, Japan. The incidence rates of limb fractures in Sakaiminato were lower than in Caucasian populations but had increased relative to data obtained in Japan in the 1990s. Clinical vertebral fractures occurred at higher rates in Sakaiminato than in Caucasian populations.
Introduction To elucidate the incidence and prognosis of fragility fractures in Sakaiminato, Japan.
Methods A survey of all hip, distal radius, proximal humerus, and clinical vertebral fractures was performed from 2010 to 2012 in patients aged 50 or older in Sakaiminato city, Tottori prefecture, Japan. The age- and gender-specific incidence rates (per 100,000 person-years) were calculated based on the population of Sakaiminato city each year. The incidence rates of hip, distal radius, and proximal humerus fractures were compared with previous reports. We conducted a follow-up study assessing patients within 1 year following their initial treatment at two Sakaiminato hospitals.
Results The age-adjusted incidence rates in population aged 50 years or older (per 100,000 person-years) of hip, distal radius, proximal humerus, and clinical vertebral fractures were, respectively, 217, 82, 26, and 412 in males and 567, 432, 96, and 1229 in females. Age-specific incidence rates of hip, distal radius, and proximal humerus fractures all increased since the 1990s. Our study also revealed that anti-osteoporotic pharmacotherapy was prescribed 1 year post-fracture at rates of 29, 20, 30, and 50 % for patients with hip, distal radius, proximal humerus, and clinical vertebral fractures, respectively.
Conclusions The incidence rates of limb fractures in Sakaiminato were substantially lower than Caucasian populations in northern Europe but had increased relative to data obtained in Japan in the 1990s. Unlike upper and lower limb fractures, clinical vertebral fractures occurred at higher rates in our study population than in other Asian and North European countries.

Keywords Fragility fractures · Incidence rates · Osteoporosis · Prognosis

✉ Y. Tsukutani
tukuyasu@med.tottori-u.ac.jp

[1] Department of Orthopedic Surgery, Faculty of Medicine, Tottori University, 36-1 Nishi-Cho, Yonago, Tottori 683-8504, Japan

[2] School of Health Science, Tottori University, Tottori, Japan

[3] Ome Keiyu Hospital, Tokyo, Japan

Introduction

Osteoporosis constitutes a major public health problem through its association with fragility fractures. It is difficult to accurately estimate the number of patients with osteoporosis because the prevalence rate varies depending on the diagnostic criteria used. However, since the occurrence of fragility fractures can be relatively easily determined, analyzed, and compared between different regions and ethnic or racial groups, the incidence rate of these fractures can be used as a surrogate for that of osteoporosis. Osteoporosis-related fragility fractures usually involve the hip, distal radius, proximal humerus, and vertebra. It has been reported that hip fracture incidence is lower in Asian and Latin American than in western populations [1, 2]. Distal radius and proximal humerus fractures have also been reported to occur at lower frequencies in Asian than in western populations [3]. Few Asian studies have reported the prevalence or incidence of clinical vertebral fractures by sex and age, and the paucity of available data

prevents a meaningful geographic comparison of this type of fracture.

Whereas chronological changes in the incidence of hip fracture have been reported in Asia and other parts of the world, no Asian studies have examined changes over time in the incidence of distal radius or proximal humerus fractures.

With this background, it is necessary to clarify the numbers and incidence rates of fragility fractures over time in Asian countries. The main purpose of our survey was to elucidate the incidence rates of hip, distal radius, proximal humerus, and clinical vertebral fractures in Sakaiminato, Tottori Prefecture, and to evaluate recent trends in the incidence of all four fracture types.

Patients and methods

Study site

The study was conducted in Sakaiminato, located in midwestern Japan. The city population was 35,259 in 2010; 35,887 in 2011; and 36,176 in 2012. The percentage of the total population aged ≥65 years was 26 % in 2010 and 2011 and 27 % in 2012.

Patients

The study included men and women aged 50 or older who lived in Sakaiminato and visited medical institutions for hip, distal radius, proximal humerus, or clinical vertebral fractures occurring between January 2010 and December 2012. In Sakaiminato, there were two hospitals with a department of orthopedic surgery or general surgery, and four clinics operated by orthopedic surgeons or general surgeons that might possibly treat patients with fractures. All patients presenting with fractures at these hospitals and clinics during the abovementioned timeframe were the initial subjects of this survey. In addition, this study included patients who visited four hospitals in Yonago, which is situated adjacent to Sakaiminato. Survey registration was performed prospectively by the doctors or medical staff at each hospital and clinic. Exclusion criteria were pathological fractures and residence in cities other than Sakaiminato. Registration information included name, gender, age, place of residence, date of fracture, type of fracture (for hip fractures), treatment, whether injury occurred indoors or outdoors, cause of fracture (in hips only), anti-osteoporotic drug intake at the time of the fracture, and previous fracture history (occurring at or after age 50). Duplication of cases was avoided by checking patients' ages, dates of fracture, types of fracture, and addresses. Incident fractures at each site were counted independently.

Mortality, ambulatory ability, and osteoporosis treatment

We conducted a follow-up study assessing patients within 1 year following their initial treatment at two Sakaiminato hospitals. Co-investigators at each hospital sent letters to patients who met the study inclusion criteria. The informed consent forms and survey documents were sent to the billing addresses reported at the time of the patients' last hospitalizations. Patients and/or their family members were asked to sign the consent form and complete and return the questionnaire in a self-addressed, stamped envelope if they agreed to participate in the study. The questionnaire evaluated the following: if the patient was currently alive or dead, if osteoporosis medications were being taken, changes in ambulatory ability, and the occurrence of any new fractures within 1 year after the first fracture. Patients' ambulatory ability was divided into the following five categories: ability to walk without difficulty, ability to walk outside with a walking aid, ability to walk only inside with an aid, inability to walk without support, and complete inability to walk. A review of medical records determined whether questionnaires contained insufficient data. If missing data could not be obtained by other means, the information was ascertained by telephone interview.

Diagnosis

All limb fractures were examined by X-ray. The hip fractures accounted for cervical and trochanteric fractures of the femur. Distal radius and proximal humerus fractures accounted for approximately one-third and one-fourth of the overall bone length, respectively. For vertebral fractures, we defined clinical incident fractures as new fractures. These were found in patients who visited the hospital for symptoms such as back pain and were judged to be new vertebral fractures by an orthopedic doctor based on X-ray and physical examination. Magnetic resonance imaging was used when conventional radiographs were insufficient for diagnosing a fresh fracture. Prevalent and old fractures were excluded from the analysis.

Statistical analysis

The patients were divided into groups according to age (subdivided into 5-year increments), gender, and fracture type. The age- and gender-specific incidence rates (per 100,000 person-years) were calculated based on the yearly populations of Sakaiminato. The age- and gender-specific populations during each survey year were estimated by the Bureau of Statistics of the Sakaiminato Government Office according to its resident registration records. The results of the current survey were compared with the fracture incidences in Sakaiminato from 1992 to 1995 as reported before [3]. For the purpose of this comparison, these previous data were reanalyzed. To compare the incidences in this survey with those from the

previous data, we used age-standardized incidence rates, which are weighted averages of the age-specific incidence rates of people in the corresponding age group in a standard population in Japan in 1985. The Poisson regression model was used to test the time trend. Standard rate ratios (SRRs) were calculated with 95 % confidence intervals. The study was approved by the local ethics research committee at the Faculty of Medicine, Tottori University.

Results

Incidence rates

Hip fracture

The survey found 211 new hip fractures in 50 males and 161 females, giving a male-to-female ratio of 1:3.2 (Table 1). The incidence rate per 100,000 person-years in patients aged 50 years or older was 217 in males and 567 in females. In both genders, incidence rates increased with age, and the highest incidence rate was observed in the group aged 85 years or older.

Distal radius fracture

The survey found 141 new distal radius fractures in 19 males and 122 females, giving a male-to-female ratio of 1:6.4. The incidence rate per 100,000 person-years in patients aged 50 years or older was 82 in males and 432 in females. The highest incidence rate was observed in the group aged 60–69 years.

Proximal humerus fracture

The survey found 33 new proximal humerus fractures in 6 males and 27 females, giving a male-to-female ratio of 1:4.5. The incidence rates per 100,000 person-years in patients aged 50 years or older were 26 in males and 96 in females, and as was the case with hip fractures, incidence rates increased with age in females.

Clinical vertebral fracture

The survey found 442 new clinical vertebral fractures in 95 males and 347 females, giving a male-to-female ratio of 1:3.7. The incidence rates per 100,000 person-years in patients aged 50 years or older were 412 in males and 1229 in females and were higher than those observed with hip, distal radius, and proximal humerus fractures. As with hip fractures, incidence rates increased with age in both genders.

Trends in age-specific incidence over time

We examined the changes in incidence rates of hip, distal radius, and proximal humerus fractures compared with the previous data from Sakaiminato (Table 2). The Poisson estimated SRRs were 1.32 (95 % CI, 1.25–1.39) for hip fractures, 1.63 (95 % CI, 1.57–1.69) for distal radius fractures, and 1.10 (95 % CI, 1.01–1.20) for proximal humerus fractures.

Past history of fragility fractures

Previous fractures were identified by interview (Table 3). Previous fractures were found in 35 % (290/827) of the patients surveyed. Previous fractures of hip, distal radius, proximal humerus, and clinical vertebral fractures were, respectively,

Table 1 Age- and gender-specific incidence of fragility fractures in Sakaiminato, Japan

	Hip				Distal radius				Proximal humerus				Clinical vertebral			
	Male		Female		Male		Female		Male		Female		Male		Female	
50–54	0	(0)	0	(0)	60	(2)	279	(9)	0	(0)	0	(0)	0	(0)	63	(2)
55–59	30	(1)	55	(2)	56	(2)	139	(5)	0	(0)	55	(2)	164	(6)	84	(3)
60–64	67	(3)	0	(0)	67	(3)	460	(21)	22	(1)	0	(0)	90	(4)	238	(11)
65–69	115	(4)	151	(6)	29	(1)	769	(30)	57	(2)	0	(0)	200	(7)	282	(11)
70–74	181	(5)	343	(12)	72	(2)	371	(13)	0	(0)	57	(2)	465	(13)	1115	(39)
75–79	393	(10)	704	(24)	160	(4)	323	(11)	40	(1)	234	(8)	795	(20)	2150	(73)
80–84	408	(7)	1336	(39)	115	(2)	593	(17)	57	(1)	204	(6)	1178	(20)	3193	(93)
85–	1658	(20)	2447	(78)	264	(3)	504	(16)	85	(1)	284	(9)	2128	(25)	3610	(115)
Total	217	(50)	567	(161)	82	(19)	432	(122)	26	(6)	96	(27)	412	(95)	1229	(347)

Data are the age- and gender-specific incidence rates per 100,000 person-years

Number of patients with fractures is given in parentheses

Table 2 Changes in the incidence of limb fractures in Sakaiminato (patients aged 50 years and over)

	ASR±SE			SRR (95 % CI)
	1992–1995	1992–1994	2010–2012	
Hip		153.3±3.7	202.4±3.2	1.32 (1.25–1.39)
Distal radius	121.0±2.6		197.0±1.4	1.63 (1.57–1.69)
Proximal humerus	34.8±1.3		38.3±1.0	1.10 (1.01–1.20)

Data are the expected numbers of patients adjusted for the age- and gender-specific incidences in each year based on a model population in 1985 in Japan

The incidence rates were calculated using each year's population

ASR age-standardized incidence rates, *SE* standard error, *SRR* standard rate ratio=ASR (2010–2012)/ASR (1992–1995 or 1992–1994)

11, 2, 2, and 30 in males and 69, 24, 10, and 142 in females. We found that female patients with hip fractures had a significantly higher prevalence of past fractures compared to their male counterparts. Of patients who were treated for hip fractures during the study period, previous hip fractures were detected in 34 % (27/80). Of patients who were treated for clinical vertebral fractures during the study period, previous fractures were noted in 39 % (172/442). The recurrence rate of clinical vertebral fractures was 76 % (130/172). Among the patients who presented with distal radius fractures, 12 % (3/26) had a previous fracture of the same type. Patients treated for proximal humerus fractures reported no previous history of such fractures.

Anti-osteoporotic drugs taken

The proportions of patients receiving anti-osteoporotic drug therapy at the time of hip, distal radius, proximal humerus, and clinical vertebral fractures were 16, 9, 15, and 18 %, respectively. Of patients with a previous fracture, 31 % were on an anti-osteoporotic medication at the time of fractures.

Mortality, ambulatory ability, subsequent fractures, and post-injury osteoporosis treatment

Two hundred and ninety-seven of the 516 patients (58 %) returned their questionnaires (Table 4). There were no significant differences in age, sex, or fracture type between responders and nonresponders. Four respondents experienced fractures on multiple occasions; in these cases, only the first fracture was counted. Twenty-seven patients (9 %) died within 1 year after the first fracture, 83 (28 %) had impaired ambulatory ability, and 55 (19 %) experienced subsequent fractures within 1 year after the first fracture. A total of 110 patients (37 %) were receiving osteoporosis medications.

Discussion

Because Sakaiminato is surrounded on three sides by the sea, patient transfer to one of the core regional hospitals in the adjacent districts can be time-consuming. Therefore, all patients with fractures should be treated at a hospital or a clinic within Sakaiminato itself. Its population is not large, but it is homogeneous, making this area appropriate for an epidemiological study of osteoporotic fractures. As Sakaiminato is comparable to other areas in Japan with respect to the proportion of children aged 14 years or younger, rate of employment, mean longevity, and the number of medical institutions per 100,000 residents, this community could reflect overall health trends in Japan. In comparison with the incidence rates of hip, distal radius, and proximal humerus fractures previously reported in Caucasian populations in northern Europe [4–9], the incidence rates for both genders in Sakaiminato were

Table 3 Previous fracture history before fracture identified during study

	Previous fracture						
	Total	Hip	Vertebral	Distal radius	Proximal humerus	Other	two or more fracture sites
Hip	80*	27 (34 %)	34 (43 %)	9 (11 %)	2 (3 %)	23 (29 %)	15 (19 %)
Distal radius	26	4 (15 %)	9 (35 %)	3 (12 %)	1 (4 %)	9 (35 %)	1 (4 %)
Proximal humerus	12	3 (25 %)	6 (50 %)	0 (0 %)	0 (0 %)	3 (25 %)	0 (0 %)
Clinical vertebral	172	29 (17 %)	130 (76 %)	6 (3 %)	1 (1 %)	21 (12 %)	15 (9 %)
Total	290	63 (22 %)	179 (62 %)	18 (6 %)	4 (1 %)	56 (19 %)	31 (11 %)

*Previous fracture rates were significantly higher in females than in males (Pearson's chi-squared tests, $P<0.05$)

Table 4 Outcomes during the first year after initial fragility fracture

	Total	Died	Impairment of ambulatory ability	Subsequent fractures			Anti-osteoporotic pharmacotherapy	
				Hip	Vertebral	NHNV		
Hip	104	16 (15 %)	41 (39 %)	7 (7 %)	2 (2 %)	6 (6 %)	30 (29 %)	[20 (19 %)]
Distal radius	46	0 (0 %)	2 (4 %)	1 (2 %)	0 (0 %)	8 (17 %)	9 (20 %)	[6 (13 %)]
Proximal humerus	10	0 (0 %)	1 (10 %)	1 (10 %)	0 (0 %)	2 (20 %)	3 (30 %)	[2 (20 %)]
Clinical vertebral	137	11 (8 %)	39 (28 %)	7 (5 %)	7 (5 %)	14 (10 %)	68 (50 %)	[43 (31 %)]
Total	297	27 (9 %)	83 (28 %)	16 (5 %)	9 (3 %)	30 (10 %)	110 (37 %)	[71 (24 %)]

The numbers of patients not yet prescribed anti-osteoporotic pharmacotherapy at the time of fracture are given in brackets []

NHNV non-hip and non-vertebral fractures

substantially lower. Specifically, we identified hip fracture rates of 194 and 491 in males and females, respectively, while those in other studies ranged from 264 [6] to 399 [5] and from 573 [4] to 880 [5], respectively. The proximal humerus fracture rates in this study were 24 and 85 in males and females, respectively, compared to previous findings of 152 [8] to 265 [7] and 416 [8] to 497 [7], respectively. The distal radius fracture rates in this study were 76 and 427 in males and females, respectively, compared to previous rates of 116 and 501 [9], respectively (per 100,000 person-years). The data from the studies cited above were adjusted to a population aged 50 years or older in 2010 in Japan (http://www.stat.go.jp/english/index.htm). Overall, these findings suggest a trend similar to those previously reported in the literature [1–3].

The incidence rates of hip fractures in Sakaiminato have increased since the 1990s. Increases in the incidences of hip fractures over time have been reported in Asian countries, including Japan [10, 11]. However, studies in North America, Europe, and Oceania have reported incidence decreases [12–19]. Secular trends in the incidence of distal forearm fractures have been evaluated in North America [19], Australia [20], Sweden [21], and the Netherlands [9, 22]. The incidence rates of distal forearm fractures due to mild trauma appear to be relatively stable or to have decreased in most of these studies. The incidence rates of proximal humerus fractures in Finland increased between 1970 and 2002 in both genders [23]; while in Iceland, the incidence of this fracture type increased until 2001 but has declined in women over the last decade [24]. We previously reported significant increases in the incidences of fractures of the distal radius (in females) and proximal humerus from 1986 to 1995 [3]. In the current study, we found that the incidence rates of distal radius and proximal humerus fractures increased from 1995 to 2012, suggesting that the incidence rates of distal radius and proximal humerus fractures may continue to increase in Sakaiminato in coming years. The secular increases in hip fractures coincided with inadequate treatment of osteoporosis, the obesity epidemic, lifestyle factors, increased treatment of seniors due to poor health secondary to other conditions, and increasing urbanization [10, 25]. However, the definitive factors responsible for the secular increases in the incidences of these fractures are unknown. Compared with previous data from 2004 to 2006 in Tottori Prefecture, Japan [10], the incidence of hip fractures in females remained nearly unchanged from 2004 to 2012, although in males it increased over time. In Hong Kong and Taiwan, the incidence rates of hip fractures reached a plateau in the late 2000s [26, 27].

Sakuma M et al. reported the incidence of clinical vertebral fractures in Sado, Japan [27]. However, the current study was the first to report the gender- and age-specific incidence rates of clinical vertebral fractures in a Japanese population. The incidence rates of clinical vertebral fractures in this study were higher than those in Sweden or Hong Kong [28, 29]. We identified clinical vertebral fracture rates of 381 and 1089 in males and females, respectively, while those in other studies ranged from 225 [29] to 260 [28] and 427 [29] to 916 [28], respectively (per 100,000 person-years). The data from the studies cited above were adjusted to a population aged 50 years or older in 2010 in Japan (http://www.stat.go.jp/english/index.htm). Comparison with previous reports showed that the incidence of morphometrically evaluated incident vertebral fractures was higher in a Japanese than a Caucasian population [30]. It is suspected that small bone size, lower bone mineral density, or lifestyle differences such as low calcium intake are responsible for this difference [31–35]. A past survey of morphological vertebral fractures in a Japanese population found incidences per 100,000 person-years of 4000 in women in their seventies and 8400 in women in their eighties [30]. We identified rates of clinical vertebral fractures that were about a third of these values, which is consistent with a previous report [36].

The percentages of patients receiving anti-osteoporotic medication at the time of hip, distal radius, proximal humerus, and clinical vertebral fractures were 16, 9, 15, and 18 %, respectively. The percentage of patients receiving anti-osteoporotic pharmacotherapy among those who had previous fracture episodes was 31 %. Our findings showed that similar to other studies [37–39], the prevalence of anti-osteoporotic

therapy was low among patients who had sustained fractures. Our study also revealed that anti-osteoporotic pharmacotherapy was prescribed 1 year after fracture at rates of 29, 20, 30, and 50 % for patients with hip, distal radius, proximal humerus, and clinical vertebral fractures, respectively. Research conducted in Japanese patients indicated that anti-osteoporotic pharmacotherapy was administered to 18.7 % of patients with hip fractures 1 year after injury and 13.4 % of patients with distal radius [40, 41]. Similar trends were observed in Denmark, the United States, and Belgium [38, 42, 43], suggesting inadequate anti-osteoporotic treatment for secondary fracture prevention in fragility fracture patients.

Our results suggest that strategies need to be developed to provide osteoporosis drug therapy to patients with fragility fractures and to increase subsequent compliance.

Limitations

Our study has some limitations. First, it is possible that some Sakaiminato residents may have received fracture treatment outside Sakaiminato and were therefore not included in this study. However, considering the area's geographical features, the number of such patients is likely to be very small. Second, the population of Sakaiminato is not large. We therefore used a 3-year survey period to obtain an adequate amount of data. Third, we excluded pathological fractures from this survey, but they generally comprise only a small portion of overall fractures.

Conclusion

In the current study, the incidence rates of hip, distal radius, and proximal humerus fractures in Sakaiminato increased relative to data obtained in the 1990s. At the same time, the incidence of hip fractures remained unchanged from 2006 onwards. Unlike upper and lower limb fractures, clinical vertebral fractures occurred at higher rates in our study population than in other Asian and North European countries. The prevalence of anti-osteoporotic therapy was low among patients with fragility fractures, both before and after the fractures.

Acknowledgments The authors sincerely acknowledge Dr. Kimiko Tsuda, Dr. Kazuomi Fujise, Dr. Yoichiro Watanabe, Dr. Mitsuru Takigawa, Dr. Kazushi Ichiba, Dr. Nin Yamamoto, Dr. Tatsuhiko Nakamura, Dr. Takeshi Minamizaki, Dr. Takeo Otsuki, and the staff of the hospitals in Sakaiminato and Yonago that participated in this study. The authors express their sincere appreciation to Dr. Mikizo Okamoto for his statistical help. The authors also acknowledge Ms. Ryoko Ikehara for her help in the analyses and secretarial assistance.

Conflicts of interest Yasuto Tsukutani and Yasuyo Ito declare that they have no conflict of interest. Hiroshi Hagino and Hideki Nagashima have received consulting fees from Asahi Kasei Pharma Corp., Astellas Pharma Inc., Banyu Pharmaceutical Co. Ltd., Chugai Pharmaceutical Co. Ltd., Eisai Co. Ltd., Eli Lilly Japan K.K., Mitsubishi Tanabe Pharma Corp., Ono Pharmaceutical Co. Ltd., Pfizer Inc., Takeda Pharmaceutical Co. Ltd., and Teijin Pharma Ltd.

References

1. Yan L, Zhou B, Prentice A, Wang X, Golden MH (1999) Epidemiological study of hip fracture in Shenyang, People's Republic of China. Bone 24:151–155
2. Morales-Torres J, Gutierrez-Urena S (2004) The burden of osteoporosis in Latin America. Osteoporos Int 15:625–632
3. Hagino H, Yamamoto K, Ohshiro H, Nakamura T, Kishimoto H, Nose T (1999) Changing incidence of hip, distal radius, and proximal humerus fractures in Tottori Prefecture, Japan. Bone 24:265–270
4. Lonnroos E, Kautiainen H, Karppi P, Huusko T, Hartikainen S, Kiviranta I, Sulkava R (2006) Increased incidence of hip fractures. A population based-study in Finland. Bone 39:623–627
5. Bjørgul K, Reikerås O (2007) Incidence of hip fracture in southeastern Norway: a study of 1,730 cervical and trochanteric fractures. Int Orthop 31:665–669
6. Lippuner K, Johansson H, Kanis JA, Rizzoli R (2009) Remaining lifetime and absolute 10-year probabilities of osteoporotic fracture in Swiss men and women. Osteoporos Int 20:1131–1140
7. Pentek M, Horvath C, Boncz I, Falusi Z, Toth E, Sebestyen A, Majer I, Brodszky V, Gulacsi L (2008) Epidemiology of osteoporosis related fractures in Hungary from the nationwide health insurance database, 1999–2003. Osteoporos Int 19:243–249
8. Dimai H, Svedbom A, Fahrleitner-Pammer A, Pieber T, Resch H, Zwettler E, Thaler H, Szivak M, Amrein K, Borgstrom F (2013) Epidemiology of proximal humeral fractures in Austria between 1989 and 2008. Osteoporos Int 24:2413–2421
9. de Putter CE, Selles RW, Polinder S, Hartholt KA, Looman CW, Panneman MJ, Verhaar JA, Hovius SE, van Beeck EF (2013) Epidemiology and health-care utilisation of wrist fractures in older adults in The Netherlands, 1997–2009. Injury 44:421–426
10. Hagino H, Furukawa K, Fujiwara S, Okano T, Katagiri H, Yamamoto K, Teshima R (2009) Recent trends in the incidence and lifetime risk of hip fracture in Tottori, Japan. Osteoporos Int 20:543–548
11. Koh LK, Saw SM, Lee JJ, Leong KH, Lee J, Osteoporosis NWCo (2001) Hip fracture incidence rates in Singapore 1991–1998. Osteoporos Int 12:311–318
12. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB (2009) Incidence and mortality of hip fractures in the United States. JAMA 302:1573–1579
13. Kaastad TS, Meyer HE, Falch JA (1998) Incidence of hip fracture in Oslo, Norway: differences within the city. Bone 22:175–178
14. Melton LJ, Kearns AE, Atkinson EJ, Bolander ME, Achenbach SJ, Huddleston JM, Therneau TM, Leibson CL (2009) Secular trends in hip fracture incidence and recurrence. Osteoporos Int 20:687–694
15. Kannus P, Niemi S, Parkkari J, Palvanen M, Vuori I, Jarvinen M (2006) Nationwide decline in incidence of hip fracture. J Bone Miner Res 21:1836–1838
16. Goettsch WG, de Jong RB, Kramarz P, Herings RM (2007) Developments of the incidence of osteoporosis in The Netherlands: a PHARMO study. Pharmacoepidemiol Drug Saf 16:166–172

17. Chevalley T, Guilley E, Herrmann FR, Hoffmeyer P, Rapin CH, Rizzoli R (2007) Incidence of hip fracture over a 10-year period (1991–2000): reversal of a secular trend. Bone 40:1284–1289
18. Chang KP, Center JR, Nguyen TV, Eisman JA (2004) Incidence of hip and other osteoporotic fractures in elderly men and women: Dubbo Osteoporosis Epidemiology Study. J Bone Miner Res 19:532–536
19. Amin S, Achenbach SJ, Atkinson EJ, Khosla S, Melton LJ (2014) Trends in fracture incidence: a population-based study over 20 years. J Bone Miner Res 29:581–589
20. Boufous S, Finch C, Lord S, Close J, Gothelf T, Walsh W (2006) The epidemiology of hospitalised wrist fractures in older people, New South Wales, Australia. Bone 39:1144–1148
21. Jónsson B, Bengnér U, Redlund-Johnell I, Johnell O (1999) Forearm fractures in Malmö, Sweden. Changes in the incidence occurring during the 1950s, 1980s and 1990s. Acta Orthop Scand 70:129–132
22. Oskam J, Kingma J, Klasen HJ (1998) Fracture of the distal forearm: epidemiological developments in the period 1971–1995. Injury 29:353–355
23. Palvanen M, Kannus P, Niemi S, Parkkari J (2006) Update in the epidemiology of proximal humeral fractures. Clin Orthop Relat Res 442:87–92
24. Siggeirsdottir K, Aspelund T, Jonsson BY, Mogensen B, Gudmundsson EF, Gudnason V, Sigurdsson G (2014) Epidemiology of fractures in Iceland and secular trends in major osteoporotic fractures 1989–2008. Osteoporos Int 25:211–219
25. Cauley JA, Chalhoub D, Kassem AM, Fuleihan G-H (2014) Geographic and ethnic disparities in osteoporotic fractures. Nat Rev Endocrinol 10:338–351
26. Chau PH, Wong M, Lee A, Ling M, Woo J (2013) Trends in hip fracture incidence and mortality in Chinese population from Hong Kong 2001–09. Age Ageing 42:229–233
27. Chan DC, Lee YS, Wu YJ, Tsou HH, Chen CT, Hwang JS, Tsai KS, Yang RS (2013) A 12-year ecological study of hip fracture rates among older Taiwanese adults. Calcif Tissue Int 93:397–404
28. Kanis JA, Johnell O, Oden A, Sembo I, Redlund-Johnell I, Dawson A, De Laet C, Jonsson B (2000) Long-term risk of osteoporotic fracture in Malmö. Osteoporos Int 11:669–674
29. Bow CH, Cheung E, Cheung CL et al (2012) Ethnic difference of clinical vertebral fracture risk. Osteoporos Int 23:879–885
30. Fujiwara S, Kasagi F, Masunari N, Naito K, Suzuki G, Fukunaga M (2003) Fracture prediction from bone mineral density in Japanese men and women. J Bone Miner Res 18:1547–1553
31. Ruyssen-Witrand A, Gossec L, Kolta S, Dougados M, Roux C (2007) Vertebral dimensions as risk factor of vertebral fracture in osteoporotic patients: a systematic literature review. Osteoporos Int 18:1271–1278
32. Gilsanz V, Boechat MI, Gilsanz R, Loro ML, Roe TF, Goodman WG (1994) Gender differences in vertebral sizes in adults: biomechanical implications. Radiology 190:678–682
33. Duan Y, Parfitt A, Seeman E (1999) Vertebral bone mass, size, and volumetric density in women with spinal fractures. J Bone Miner Res 14:1796–1802
34. J K (1957) On geographical relationship between the chemical nature of river water and death-rate from apoplexy. Berichte des Ohara Instituts fur landwirt-schaftliche Biologie 11:11:12e21
35. Finkelstein JS, Lee ML, Sowers M, Ettinger B, Neer RM, Kelsey JL, Cauley JA, Huang MH, Greendale GA (2002) Ethnic variation in bone density in premenopausal and early perimenopausal women: effects of anthropometric and lifestyle factors. J Clin Endocrinol Metab 87:3057–3067
36. Black DM, Cummings SR, Karpf DB et al (1996) Randomised trial of effect of alendronate on risk of fracture in women with existing vertebral fractures. Fracture Intervention Trial Research Group. Lancet 348:1535–1541
37. Sakuma M, Endo N, Oinuma T, Miyasaka D, Oguma Y, Imao K, Koga H, Tanabe N (2013) Incidence of osteoporotic fractures in Sado, Japan in 2010. J Bone Miner Metab
38. Roerholt C, Eiken P, Abrahamsen B (2009) Initiation of anti-osteoporotic therapy in patients with recent fractures: a nationwide analysis of prescription rates and persistence. Osteoporos Int 20: 299–307
39. Rozental TD, Makhni EC, Day CS, Bouxsein ML (2008) Improving evaluation and treatment for osteoporosis following distal radial fractures. A prospective randomized intervention. J Bone Joint Surg Am 90:953–961
40. Hagino H, Sawaguchi T, Endo N, Ito Y, Nakano T, Watanabe Y (2012) The risk of a second hip fracture in patients after their first hip fracture. Calcif Tissue Int 90:14–21
41. Baba T, Hagino H, Nonomiya H, Ikuta T, Shoda E, Mogami A, Sawaguchi T, Kaneko K (2015) Inadequate management for secondary fracture prevention in patients with distal radius fracture by trauma surgeons. Osteoporos Int
42. Solomon DH, Johnston SS, Boytsov NN, McMorrow D, Lane JM, Krohn KD (2014) Osteoporosis medication use after hip fracture in U.S. patients between 2002 and 2011. J Bone Miner Res
43. Rabenda V, Vanoverloop J, Fabri V, Mertens R, Sumkay F, Vannecke C, Deswaef A, Verpooten GA, Reginster JY (2008) Low incidence of anti-osteoporosis treatment after hip fracture. J Bone Joint Surg Am 90:2142–2148