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ORIGINAL ARTICLE

Incidence of four major types of osteoporotic fragility fractures among elderly individuals in Sado, Japan, in 2015

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Abstract

The aim of this study was to survey the incidence of osteoporotic fragility fractures, which include vertebral, hip, distal radius, and proximal humerus fractures, in patients ≥ 50 years of age, from 2004 to 2015, in Sado City, Japan. We examined temporal changes in the incidence of these fractures from 2010 through 2015. The incidence of vertebral ($p < 0.001$) and radius fractures ($p = 0.001$) was lower in 2015 than in 2010, with only the incidence of hip fracture ($p = 0.013$) being lower in 2015 than in 2004. With regard to age-specific incidences, there was a sharp increase in vertebral and hip fractures among the segment of the population 70–89 years old, with no remarkable change in the incidence of radial and humeral fractures. Pre-existing vertebral fractures were identified in 69.6% of patients with a hip fracture, 35.6% of patients with a distal radius fracture, and 55% of patients with a humeral fracture. Among patients with pre-existing vertebral fractures, 42.5% had a single fracture, whereas 57.5% had 2 or more fractures. The proportion of patients on anti-osteoporotic agents before the occurrence of fractures increased to 14.5% in 2015, compared to 4% in 2004 and 7.6% in 2010. We speculate that the increase in the use of anti-osteoporotic agents is the main reason for the declining incidence of fractures. Therefore, considering the sharp increase in hip and vertebral fractures among individuals in their mid-1970s and older, judicious use of anti-osteoporotic agents among these individuals could be useful for lowering the occurrence of these fractures.

Keywords Distal radius fracture · Hip fracture · Humerus fracture · Incidence · Vertebral fracture

Introduction

Osteoporotic fragility fractures are prevalent in the aging population worldwide, leading to a decrease in the quality of life and serious morbidity and mortality [1]. These fractures are a serious public health concern in Japan, with the prevention of these fractures becoming increasingly important [2, 3] as the segment of the general population over the age of 65 years continues to increase, having reached 26.7% in 2015 [4]. Therefore, there is a need to understand trends in the prevalence and incidence of fragility fractures. In fact, the incidence rate of osteoporotic hip fractures has also increased from 1986 to 2008 [5, 6].

In a previous study, we confirmed an association between the increasing age of the population and the increasing rate of osteoporotic fractures. Specifically, we surveyed the incidence rate of fragility fractures in Sado City (Niigata Prefecture, Japan), which is located on an island and, thus, has a minimal change in its population. As such, we believe that the increase in the incidence in osteoporotic fractures

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(including hip, vertebral, distal radius, and proximal humeral fractures) that we observed in this population, between 2004 and 2010, reflects the age-related increase in risk of fragility fractures in Japan [7–9]. Our aim in the present study was to examine the incidence rate of these 4 types of osteoporotic fractures among individuals ≥ 50 years of age in Sado City in 2015, and to compare these results to our previous 2004–2010 survey results [7].

We also investigated the prevalence of the use of anti-osteoporotic agents, as well as the prevalence of pre-existing vertebral fractures based on radiographic assessment of the thoracic and lumbar spine. We believe that this information may be of importance in terms of implementing measures to reduce the incidence of fragility fractures in Japan.

Materials and methods

Sado City, located on Sado Island, had a population of 57,172 in October 2015, with 40.5% of individuals being > 65 years of age, based on the estimated population statistics of the Niigata Prefecture [10]. The age composition of the population in Sado City from 2004–2015 is shown in Supplementary Table 1.

The data of all individuals ≥ 50 years of age, in Sado City, who had been diagnosed with a fragility fracture (hip, vertebral, distal radius, and/or proximal humeral fracture) between January 1 and December 31, 2015, were collected using the same methods used in previous surveys [1, 11–15]. We defined a fragility fracture as one that occurs from a slight external force, such as a fall from standing height or less, as previously described [1, 15]. Patients residing in other prefectures or those < 50 years of age over the period of observation were excluded. Registration forms were sent to 2 medical clinics and 4 hospitals in Sado City, which includes all the main orthopedic facilities on the island. Any patient who sustains a fracture in Sado City would normally attend 1 of these 6 institutions to receive care. Therefore, we consider that our data would capture almost all fractures that occurred in Sado City. Of note, femoral shaft, pathological and periprosthetic fractures were not included in our analysis.

Our study was approved by the ethics review board of Niigata University Graduate School of Medical and Dental Sciences (No. 1985), and the need for informed consent was waived given the retrospective nature of the study.

We investigated the use of anti-osteoporotic medications, including bisphosphonate, selective estrogen receptor modulators, vitamin D, calcium preparation, teriparatid, and denosumab, for > 6 months before the fracture incidence as a secondary outcome of our analysis.

Fractures were diagnosed by plain radiography. As well, all patients underwent screening for pre-existing vertebral fractures, including incidental fractures, after management of the current fracture. This screening was performed by orthopedic surgeons who reviewed lateral spine radiographs and classified findings using the diagnostic criteria of The Japanese Society for Bone and Mineral Research [16]. Patients who had any symptoms of a vertebral fracture, such as local back pain, with compatible radiographic findings over the period of observation, were diagnosed as having new symptomatic fractures. If multiple fractures occurred in the same patient, each fracture was counted as a new fracture, regardless if fractures were of the same type (such as a hip fracture on the contralateral side) or at different sites (such as a hip and distal radius fracture), or if they occurred simultaneously or at different times.

The incidence for each of the 4 types of fracture in 2015 was compared to the data obtained over our previous period of observation, from 2004 to 2010 [7–9]. Data in each year were compared with respect to the incidence in patients aged ≥ 50 years. All patients were categorized according to age (10-year intervals) and sex (male or female). The incidence of each fracture type was calculated according to the number of fractures per 100,000 person-year. We calculated the incidence of each fracture type using the number of individuals who sustained a fracture and the population at risk for these fractures (whole population in Sado ≤ 50 years − number of fractured persons). Then, we calculated the age-adjusted incidence rate for each year to the proportion of the Japanese population ≥ 50 years of age in 2004.

Statistical tests for the overall trend were performed using the Mantel–Haenszel extension Chi-squared test [17], according to a previous research study [18]. First, we evaluated age-specific trends for the survey period. Then, we integrated all age-specific results of the Mantel–Haenszel test to show the age-adjusted trend for each fracture type. A p value < 0.05 was considered statistically significant. Microsoft Excel 2013 (Microsoft Corp., Redmond, WA, USA) was used for all calculations.

Results

In total, 337 cases of osteoporotic fractures were identified, with hip fractures accounting for 112 of these cases, including 22 males and 90 females, with a male-to-female ratio of 1:4.1. The calculated incidence of hip fractures among individuals ≥ 50 years of age was 322 per 100,000 person-year, with an age-adjusted incidence rate of 249 per 100,000 person-year (Table 1). The average age for hip fracture was 85.2 ± 8.2 years, which was the oldest among the 4 fracture types.

There were 145 cases of vertebral fractures, including 28 males and 117 females, with a male-to-female ratio of 1:4.2. The calculated incidence for vertebral fractures was

Table 1 Age-specific prevalence and incidence of hip fractures in 2015

Years	2004	2010	2015	*p* value[c]
Population > 50 years	38,410	37,013	34,868	
% > 65 years (= aging rate)[a]	34.3	36.8	40.3	
Number > 50 years				
Hip	83	115	112	
Vertebra	160	191	145	
Radius	51	89	60	
Humerus	25	23	20	
Incidence[b]				
Hip	216	267	249	0.470[c]
Vertebra	417	464	352	0.001[c]
Radius	133	237	170	0.955[c]
Humerus	65	58	51	0.358[c]

[a]Percentage of persons > 65 years in the total population

[b]Fractures/100,000 person-year

[c]Trend from 2004 to 2015

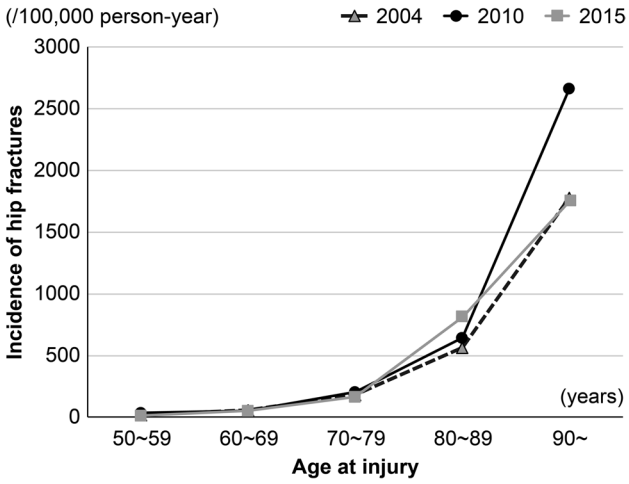

Fig. 1 Age-specific incidence of vertebral fracture from 2004 to 2015. The incidence of vertebral fractures among patients ≥ 90 years of age increased between 2004 and 2010, and subsequently increasing through 2015

418 per 100,000 person-year, which was the highest among the 4 fracture types, with an age-adjusted incidence rate of 352 per 100,000 person-year. The average age for vertebral fractures was 82.9 ± 8.3 years.

There were 60 cases of distal radius fractures, 7 males and 53 females, for a male-to-female ratio of 1:7.6, which was the highest ratio among the 4 fracture types. The calculated incidence for distal radius fractures was 172 per 100,000 person-year, with an age-adjusted incidence rate of 170 per 100,000 person-year (Table 1). The average age for distal radius fractures was 70.9 ± 11.0 years.

There were 20 cases of proximal humeral fractures. Of these, 4 were males and 16 females, with a male-to-female ratio of 1:4.0. The calculated incidence was 57 per 100,000 person-year. The age-adjusted incidence rate was 51 per 100,000 person-year (Table 1). The average age at the time of proximal humeral fractures was 79.3 ± 9.1 years.

The incidence of each fracture type is shown in Table 1, with only the incidence of vertebral fractures having decreased significantly among individuals ≥ 50 years of age over our 11-year period of observation ($p = 0.001$). With regard to the temporal change in the incidence of each fracture type, the incidence of hip fractures was significantly lower in 2015 than in 2004 ($p = 0.013$), with the incidence of vertebral ($p < 0.001$) and radius ($p = 0.001$) fractures being significantly lower in 2015 than in 2010.

The age-specific incidence of the 4 fracture types from 2004 to 2015 is shown in Figs. 1, 2, 3, and 4. As shown in Fig. 1, the incidence of vertebral fracture among patients ≥ 90 years of age increased between 2004 and 2010, but decreased between 2010 and 2015, with no change in incidence of vertebral fractures for the other age groups. Of note, the incidence of vertebral fractures increased after the age of 70–79 years in all years of observation.

As shown in Fig. 2, the incidence of hip fractures among patients 80–89 years of age increased between 2004 and 2010, but decreased between 2010 and 2015. As well, the incidence of hip fractures for the segment of the population ≥ 90 years of age decreased between 2004 and 2010, but increased slightly between 2010 and 2015. There was no change in the incidence of hip fractures for the other age groups. Overall, the incidence of hip fracture increased with increasing age.

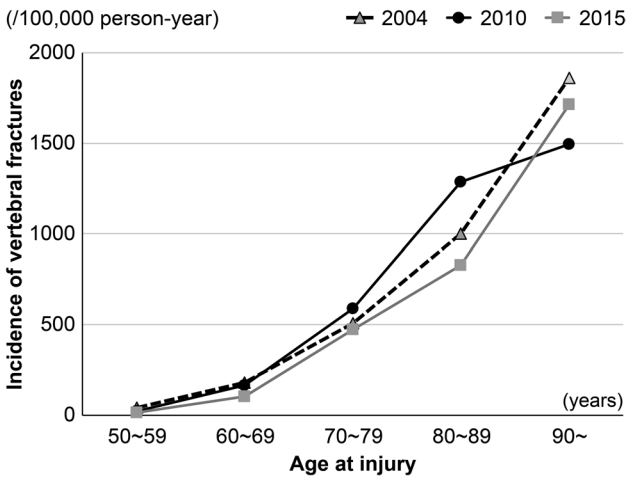

Fig. 2 Age-specific incidence of hip fracture from 2004 to 2015. The incidence of hip fractures was higher in 2015 than for the 2004–2010 period for the segment of the population 80–89 years of age, but lower for the segment of the population ≥ 90 years of age

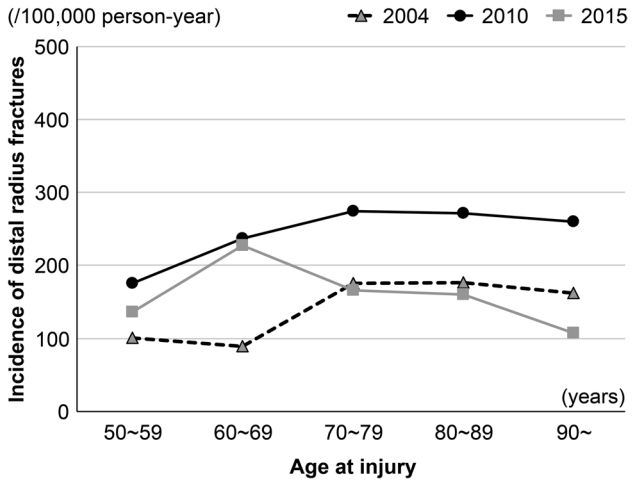

Fig. 3 Age-specific incidence of distal radius fracture from 2004 to 2015. The incidence of distal radius fractures decreased, overall, between 2004 and 2010, with the incidence further decreasing from 2010 to 2015 among the segment of the population ≥ 70 years of age

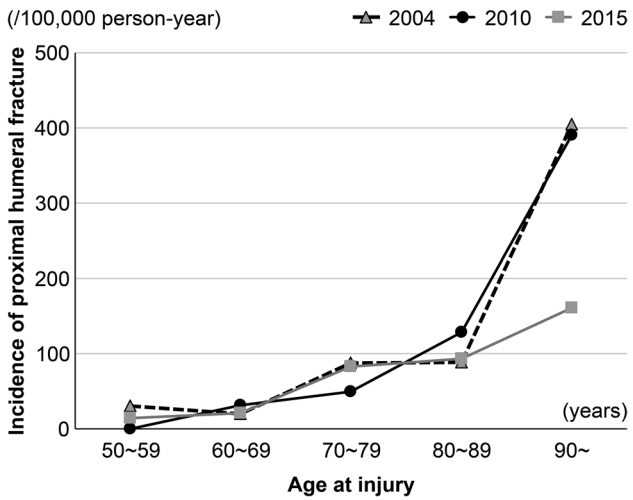

Fig. 4 Age-specific incidence of proximal humeral fracture from 2004 to 2015. The incidence of proximal humeral fractures was stable over time for all age groups, except the segment of the population ≥ 90 year of age. For this latter segment of the population, the incidence of proximal humeral fractures was stable between 2004 and 2010, decreasing sharply between 2010 and 2015. Of note, in the 2004–2010 data, the incidence of proximal humeral fractures increased steeply for the age group ≥ 90 years, but not in 2015, which was the highest among the 4 fracture types

As shown in Fig. 3, the incidence of distal radius fractures did not differ according to age. The incidence increased for all age groups between 2004 and 2010, and decreased for all age groups between 2010 and 2015.

As shown in Fig. 4, the incidence of proximal humeral fractures was stable over time for all age groups, except for the segment of the population ≥ 90 years of age. For this age group, the incidence of proximal humeral fractures was stable between 2004 and 2010, but decreased sharply between 2010 and 2015. The incidence of proximal humeral fractures increased steeply once patients reached the age of 90 years in 2004 and 2010, but not in 2015.

With regard to the use of anti-osteoporotic agents before the fracture, only 14.5% of the patients were on anti-osteoporotic drug therapy for > 6 months before the fracture. Without considering the length of anti-osteoporotic drug therapy, 25.7% of patients with vertebral fracture were taking anti-osteoporotic agents at the time of fracture, 11.6% of patients with hip fractures, 6.7% of patients with distal radius fractures, and 10.0% with humeral fractures. With respect to the type of anti-osteoporotic agent used, including those using a combined therapy of each anti-osteoporotic agent, the proportional distribution was as follows: 9.0%, bisphosphonate; 1.7%, selective estrogen receptor modulators; 10.0%, vitamin D; 0.3%, teriparatid; and 1.7%, calcium preparation. None of the patients in our study sample used denosumab. The percentage of patients who were on anti-osteoporotic drug therapy was higher in 2015 compared to 2004 (4% for both hip and vertebral fractures [4]) and 2010 (7.6%) [7].

Thoracic and lumbar spine radiographs were obtained from 332 of the 337 patients in our study sample, at an average age of 84.4±8.9 years. Pre-existing vertebral fractures were identified in 69.6% of patients with a hip fracture (one level, 21.4%, and ≥ 2 levels, 48.2%), in 55.0% of patients with a humeral fracture (one level, 15.0%, and ≥ 2 levels, 40.0%) and in 35.6% of patients with a distal radius fracture (one level, 15.6%, and ≥ 2 levels, 20.1%). Among patients with pre-existing vertebral fractures, the fracture was at a single level in 42.5% of cases, which likely was their first episode of vertebral fracture, whereas fractures at 2 or more levels were identified in the other 57.5% of cases, which were likely repeated episodes.

Discussion

In this population-based study, conducted in Sado City, Japan, we observed a significant decrease in the incidence of vertebral and radial humeral fractures between 2010 and 2015 elderly individuals. These findings are in agreement with those of previous studies, which have reported a decrease in the incidence of hip fractures from 1995 to 2010 in Europe and the United States [16, 19–22]. However, in Japan, the number of new cases of hip fractures and the incidence of these fractures have been reported to be increasing [23, 24]. In fact, in our previous study, we reported an increase in the incidence of hip fractures in Sado Island of the Niigata Prefecture from 2004 to 2006, which was a continuation of an increasing trend in hip fractures

that had been reported since 1985, but with no remarkable change in the incidence of hip fracture from 2006 to 2010 [7]. Of note was our observation of a significant decrease in the incidence of hip fractures in 2015, compared to the incidence in 2010 [15].

We also observed a 7% increase in the number of patients on anti-osteoporotic drug therapy before their hip fracture between 2010 and 2015. We consider this finding to reflect a general increase in the proportion of use of anti-osteoporotic agents in the general population in Japan, which likely contributed to the observed decrease in the incidence of fractures, particular vertebral fractures. In contrast, Orimo et al. [23, 24] reported a decrease in fracture incidence in some age groups, in both men and women, although the incidence of hip fractures may have increased. They attributed this decrease in fracture incidence to an increase in a wide variety of anti-osteoporotic medications, especially bisphosphonates, for the treatment of osteoporosis and prevention of hip fractures. The reason for the specific increase in the incidence of hip fractures in the segment of population between 80 and 89 years of age is unknown. We speculate that individuals of this age range were likely not prescribed anti-osteoporotic agents after a vertebral fracture or were among those with asymptomatic vertebral fractures. Moreover, a prior nutritional deficit in this age group (such as a calcium deficiency in childhood and adolescence) may have led to an increase in the prevalence of osteoporosis in adulthood. This is especially true for older individuals (> 80 years old) who lived in the 1940s during World War II and/or the postwar period [14].

We have yet to determine the reason why the incidence of vertebral fractures in those aged ≥ 90 years increased in spite of a reduction in hip fractures in the same age group. We speculate that vertebral fractures in these patients might occur at a lower external force application, without a fall, than the other types of fragility fractures [7].

In 2015, a sharp increase in vertebral and hip fractures was observed among patients in their seventies and eighties, respectively. Based on these results, we should consider the initiation of anti-osteoporotic drug therapy among individuals in their mid-1970s to prevent hip and vertebral fractures. This is important when we consider the decreasing trend in hip fractures that has been reported in North America, Europe, and Oceania, which was principally attributed to an increase in the use of anti-osteoporotic drug therapy and biophosphonates in particular [25–29]. In our study, we observed a 14.5% increase in the number of patients who were on anti-osteoporotic drug therapy before their fracture. Based on these findings, we believe that there is a need to focus on the treatment of osteoporosis through a judicious increase in the prescription anti-osteoporotic agents.

In the present study, the incidence of vertebral fractures was lower than previously reported [30–32]. The reason for this discrepancy is unclear, but the low overall incidence of vertebral fractures in Japan has previously been reported in several studies [31, 32], with our findings being in agreement with these reports. We speculate that this discrepancy results from differences in the design of our study compared to previous studies, including differences in the definition of fractures and survey protocol. Because of these differences, direct comparison between our findings and previously reported fracture incidence data in elderly populations may not be possible.

Of note, the mean age at the time of vertebral fracture in our study was higher than that in previous reports [31–34]. This finding likely reflects the increasing proportion of elderly individuals among the general population in Sado City (Supplementary Table 1), with an average aging rate of the general population of 40%, such that there is a greater proportion of much older adults at risk for vertebral fractures. We predict that a similar trend would be detected in Japan, overall, which has one of the longest life expectancies worldwide.

In the current study, pre-existing vertebral fractures were identified in 70% of patients with a hip fracture, similar to our previous report [9, 15, 35]. Moreover, 50% of patients with a hip fracture had vertebral fractures at 2 or more levels, indicative of a high likelihood of pre-existing vertebral fractures before the current fracture. We believe that vertebral fractures increase the risk of subsequent hip fracture and further vertebral fractures, which would lead to a further reduction in physical activity. As proponents of the "Stop at One" campaign, advocated by the International Osteoporosis Foundation [36] to prevent a 'vertebra-to-vertebra chain' of fractures and vertebra-to-hip fractures, we support an increase in the judicious prescription of anti-osteoporotic drugs therapy and exercise, which are both important to improving bone health.

One limitation of our study concerns the age-adjusted incidence rate for those ≥ 90 years old, which includes the following age groups: 90–94, 95–99, and ≥ 100 years. The proportion of the population in these age groups in Japan, including in Sado City, has been increasing over time and, consequently, the segment of the population in each of these very old age groups would be larger in 2015 than in previous years of observation. However, we could not analyze this in detail as the data for these age groups are not available prior to 2004. This may have led to a bias in the age-specific incidence for patients ≥ 90 years of age. Moreover, with regard to the definition of new vertebral fractures, the patients who had any symptoms, such as back pain, with compatible radiographic findings during the follow-up period were diagnosed as having a new fracture in this study. However, it is well known that most patients with a vertebral fracture are asymptomatic or have few symptoms [37]. Therefore, it is possible that the number and incidence of vertebral fractures

may be underestimated. Third, patients with repeated fractures had different background characteristics (such as not being on anti-osteoporosis drug therapy), with a possible over-inflation of findings as each fracture was counted as a new case, without taking into account patients' background. Finally, although we consider that our methods were sufficient to capture almost all fractures that occurred in Sado City, this assumption cannot be specifically evaluated and, therefore, there is a possibility that the incidence of the fractures might be underestimated.

In conclusion, we report a decreasing trend in the incidence of vertebral fractures from 2004 to 2015, with a specific significant decrease in the incidence of vertebral and distal radius fractures among elderly patients since 2010. We speculate that the main reason for this decrease in the incidence of these fractures reflects the increased use of anti-osteoporotic agents, such as bisphosphonates, with a specific benefit of these agents in preventing vertebral fractures. Based on our findings, we recommend the judicious prescription of anti-osteoporotic agents to individuals in their mid-1970s, and older, to lower the risk for fractures. This would be especially important to prevent the 'vertebra-to-vertebra' and the 'vertebra-to-hip' chain of fractures, as advocated by the "Stop at One" campaign.

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Compliance with ethical standards

Conflict of interest All authors have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The ethics review board of Niigata University Graduate School of Medical and Dental Sciences (No. 1985) approved the conduct of this study. The need for informed consent was waived given the retrospective nature of the study.

References

1. Miyasaka D, Endo N, Endo E, Sakuma M, Yamamoto N, Tanabe N, Imai N, Suda K (2016) Incidence of hip fracture in Niigata, Japan in 2004 and 2010 and the long-term trends from 1985 to 2010. J Bone Miner Metab 34:92–98
2. Park C, Ha YC, Jang S, Jang S, Yoon HK, Lee YK (2011) The incidence and residual lifetime risk of osteoporosis-related fractures in Korea. J Bone Miner Metab 29:744–751
3. Shin CS, Kim MJ, Shim SM, Kim JT, Yu SH, Koo BK, Cho HY, Choi HJ, Cho SW, Kim SW, Kim SY, Yang SO, Cho NH (2012) The prevalence and risk factors of vertebral fractures in Korea. J Bone Miner Metab 30:183–192
4. Annual Report on the Aging Society: 2015, Cabine office, Government of Japan. http://www8.cao.go.jp/kourei/whitepaper/w-2016/zenbun/pdf/1s1s_1.pdf. Accessed 3 Apr 2017
5. 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
6. Hagino H, Sakamoto K, Harada A, Nakamura T, Mutoh Y, Mori S, Endo N, Nakano T, Itoi E, Kita K, Yamamoto N, Aoyagi K, Yamazaki K, Committee on Osteoporosis of The Japanese Orthopaedic Association, (2010) Nationwide one-decade survey of hip fracture in Japan. J Orthop Sci 15:737–745
7. Sakuma M, Endo N, Oinuma T, Miyasaka D, Oguma Y, Imao K (2014) Incidence of osteoporotic fractures in Sado, Japan in 2010. J Bone Miner Metab 32:200–205
8. Oinuma T, Sakuma M, Endo N (2010) Secular change of the incidence of four fracture types associated with senile osteoporosis in Sado, Japan: the results of a 3-year survey. J Bone Miner Metab 28:55–59
9. Sakuma M, Endo N, Oinuma T, Endo E, Yazawa T, Watanabe K, Watanabe S (2006) Incidence and outcome of osteoporotic fractures in 2004 in Sado City, Niigata Prefecture, Japan. J Bone Miner Metab 26:373–378
10. Niigata Prefecture. Statistics of Sado City. http://www.pref.niigata.lg.jp/sado_kenko/1204737334720.html. Accessed 6 Feb 2017
11. Kawashima T (1989) Epidemiology of the femoral neck fracture in 1985, Niigata Prefecture, Japan. J Bone Miner Metab 7:118–126
12. Dohmae Y, Takahashi HE, Kawashima T (1991) Epidemiology of femoral neck fracture in 1989, Niigata Prefecture, Japan. A comparison with the incidence in 1985 and 1987. J Bone Miner Metab 9:94–98
13. Iga T, Dohmae Y, Endo N, Takahashi HE (1996) Increase of the incidence of cervical and trochanteric fractures of the proximal femur in Niigata Prefecture, Japan. J Bone Miner Metab 17:224–231
14. Morita Y, Endo N, Iga T, Tokunaga K, Ohkawa Y (2002) The incidence of cervical and trochanteric fractures of the proximal femur in 1999 in Niigata Prefecture, Japan. J Bone Miner Metab 20:311–318
15. Imai N, Endo N, Shobugawa Y, Ibuchi S, Suzuki H, Miyasaka D, Sakuma M (2017) A decrease in the number and incidence of osteoporotic hip fractures among elderly individuals in Niigata, Japan from 2010 to 2015. J Bone Miner Metab. https://doi.org/10.1007/s00774-017-0863-2
16. Azagra R, Lopez-Exposito F, Martin-Sanchez JC, Aguye A, Moreno N, Cooper C, Diez-Perez A, Dennison EM (2014) Changing trends in the epidemiology of hip fracture in Spain. Osteoporos Int 25:1267–1274
17. Mantel N (1963) Chi square tests with one degree of freedom; extensions of the Mantel–Haenszel procedure. JASA 58:690–700
18. Sneyd MJ, Cox B (2013) A comparison of trends in melanoma mortality in New Zealand and Australia: the two countries with the highest melanoma incidence and mortality in the world. BMC Cancer 13:372
19. Icks A, Arend W, Becker C, Rapp K, Jungbluth P, Haastert B (2013) Incidence of hip fractures in Germany, 1995–2010. Arch Osteoporos 8:140
20. Piscitelli P, Feola M, Rao C, Celi M, Gasbarra E, Neglia C, Quarta G, Liuni FM, Parri S, Iolascon G, Brandi ML, Distante A, Tarantino U (2014) Ten years of hip fractures in Italy: for the first time a decreasing trend in elderly women. World J Orthop 5:386–391

21. Korhonen N, Niemi S, Parkkari J, Sievanen H, Palvanen M, Kannus P (2013) Continuous decline in incidence of hip fracture: nationwide statistics from Finland between 1970 and 2010. Osteoporos Int 24:1599–1603
22. Stevens JA, Rudd RA (2010) Declining hip fracture rates in the United States. Age Ageing 39:500–503
23. Orimo H, Yaegashi Y, Onoda T, Fukushima Y, Hosoi T, Sakata K (2009) Hip fracture incidence in Japan: estimates of new patients in 2007 and 20-year trends. Arch Osteoporos 4:71–77
24. Orimo H, Yaegashi Y, Hosoi T, Fukushima Y, Onoda T, Hashimoto T, Sakata K (2016) Hip fracture incidence in Japan: estimates of new patients in 2012 and 25-year trends. Osteoporos Int 27:1777–1784
25. Kannus P, Niemi S, Parkkari J, Palvanen M, Vuori I, Jarvinen M (2006) Nationwide decline in incidence of hip fractures. J Bone Miner Res 21:1836–1838
26. Melton LJ III, 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
27. Leslie WD, O'Donnell S, Jean S, Legace C, Walsh P, Bancej C, Morin S, Hanley DA, Papaioannou A, Osteoporosis Surveillance Expert Working Group (2009) Trends in hip fracture rates in Canada. JAMA 302:883–889
28. Fielden J, Purdie G, Horne G, Devane P (2001) Hip fracture incidence in New Zealand, revisited. N Z Med J 114:154–156
29. Chevalley T, Guilley E, Hermann 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
30. Felsenberg D, Silman AJ, Lunt M, Armbrecht G, Ismail AA et al (2002) Incidence of vertebral fracture in Europe: results from the European Prospective Osteoporosis Study (EPOS). J Bone Miner Res 17:716–724
31. Ballane G, Cauley JA, Luckey MM, Fuleihan GE (2017) Worldwide prevalence and incidence of osteoporotic vertebral fractures. Osteoporos Int 28:1531–1542
32. Kim TY, Jang S, Park CM, Lee A, Lee YK, Kim HY, Cho EH, Ha YC (2016) Trends of incidence, mortality, and fracture projection of spinal fractures in Korea using national wide claims data. J Korean Med Sci 31:801–805
33. Marwaha RK, Tandon N, Gupta Y, Bhadra K, Mani K, Mithal A, Lukreja S (2012) The prevalence of and risk factors for radiographic vertebral fractures in older Indian women and men: Delhi Vertebral Osteoporosis Study (DeVOS). Arch Osteoporos 7:201–207
34. Fung HS, Fee WH, McCauley TR, Ha KY, Choi KH (2003) Discrimination of metastatic from acute osteoporotic compression spinal fractures with MR imaging. Radio Graphics 23:179–187
35. Imai N, Endo N, Hoshino T, Suda K, Miyasaka D, Ito T (2016) Mortality after hip fracture with vertebral compression fracture is poor. J Bone Miner Metab 34:51–54
36. Stop at One: Data and Publications, International Osteoporosis Foundation. https://www.iofbonehealth.org/stop-one-make-your-first-break-your-last. Accessed 25 June 2017
37. Cummings SR, Black DM, Thompson DE, Applegate WB, Barrett-Connor E, Musliner TA, Palermo L, Prineas R, Rubin SM, Scott JC, Vogt T, Wallace R, Yates AJ, LaCroix AZ (1998) Effect of alendronate on risk of fracture in women with low bone density but without vertebral fractures: results from the Fracture Intervention Trial. JAMA 280:2077–2082