Incidence and Mortality of Osteoporotic Refractures in Korea according to Nationwide Claims Data

Jun-Il Yoo¹, Yong-Chan Ha², Ki Soo Park³,⁴, Rock-Beum Kim³, Sung-Hyo Seo³, and Kyung-Hoi Koo⁵

¹Department of Orthopaedic Surgery, Gyeongsang National University Hospital, Jinju;
²Department of Orthopaedic Surgery, Chung-Ang University College of Medicine, Seoul;
³Institute of Health Science, Gyeongsang National University, Jinju;
⁴Department of Preventive Medicine, Gyeongsang National University School of Medicine, Jinju;
⁵Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, Seongnam, Korea.

Purpose: Studies on the incidence and mortality of refractures after primary osteoporotic fracture are limited by the relatively rare incidence of such refractures and small sample sizes. The objectives of this research were: 1) to determine the incidence of osteoporotic refractures and fracture locations and 2) to assess mortality rates associated with osteoporotic refracture over a median follow up of 3 years using nationwide claim database.

Materials and Methods: Patients over 50 years of age who had an osteoporotic fracture that was confirmed operationally were enrolled. Refracture was defined as that after 6 months of an untreated period. Mortality rate was calculated using the Charlson comorbidity index and was analyzed using Cox proportional hazards regression analysis.

Results: A total of 18956 first-time instances of osteoporotic fracture were reported between 2007 and 2012 after a median follow up of 3.1 years (range, 1 to 7 years). Among 18956 patients, 2941 (15.50%) experienced refracture. After follow up for 1 year, cumulative mortality rates for re-fracture and non-refracture groups were 9.1% and 7.2%, respectively. After adjusting for covariates, mortality rate was 1.2 times greater in patients with re-fracture than in patients without re-fracture over a median follow up of 3 years (hazard ratio: 1.20, 95% confidence interval: 1.08–1.34, p<0.001).

Conclusion: The incidence of osteoporotic re-fracture in this nationwide study was 15.5%, and the mortality rate of re-fracture patients was 1.2 times higher than that of non-refracture patients over a median follow up of 3 years.

Key Words: Incidence, mortality, nationwide claim data, osteoporotic fracture, refracture

INTRODUCTION

The population worldwide is aging. With increased life expectancy for older adults, the incidence of osteoporotic fractures has also increased.¹⁻⁵ To prevent osteoporotic fractures, every nation around the globe is dedicated to treating osteoporosis,⁶⁻¹¹ and initiatives are growing to minimize the incidence of osteoporotic fractures.¹² These fractures in older adults can lead to elevated mortality and morbidity that can decrease the quality of life,⁶⁻⁸ and osteoporotic fracture patients are also at risk of secondary osteoporotic fractures.¹³ According to several studies, the first osteoporotic fracture increases the risk of later fractures.¹⁴⁻¹⁶ A meta-analysis revealed that a history of fracture considerably increases the risk of any fracture, compared to the lack of a previous fracture (RR: 1.86; 95% CI: 1.75–1.98).¹⁷ Furthermore, a second hip fracture increases the risk of mortality, extra comorbidities, and reduced independence.¹⁸ Cheung, et al.¹⁹ reported the most updated incidence rate and projected population size of hip fractures for nine members of the Asian Federation of Osteoporosis Societies. They predicted that the number of hip fractures would increase from 1124060 in 2018 to 2563488 in 2050, an increase of 2.28-fold. This increase is mainly due to
changes in demographics of the population, particularly in China and India, which have the largest population sizes. The direct costs of hip fracture is expected to rise from USD 9.5 billion in 2018 to USD 15 billion in 2050 (a 1.59-fold increase). To keep the total number of hip fractures constant over time, a 2–3% decrease in the incidence rate of hip fracture is required annually. They concluded that, despite the availability of better diagnosis, treatment, and prevention for fracture over recent years, hip fracture remains a key public health issue in Asia and that healthcare policy should aim to reduce the burden of hip fracture in Asia. However, studies on the incidence and mortality of refractures following an initial osteoporotic fracture are restricted owing to their comparatively rare incidences and the need for a large sample size. Therefore, the objectives of this research were: 1) to determine the incidence of osteoporotic refractures and fracture locations and 2) to assess related mortality rates over a median follow up of 3 years using a nationwide claims database.

MATERIALS AND METHODS

Data source
This research used information from the 2002 to 2013 claims database of the Korean National Health Insurance (KNHI). The KNHI gathers cohort information representing the population of the country. The sample cohort covers 1025340 subjects (2.2% of the total population of 47851928) through random stratification according to sex, age, and income level. The database provides reimbursement data for each medical service, including fundamental demographics of the patients, clinic or hospital identifiers, disease code, expenses incurred, health screening outcomes, individual and family health history, health behaviors, and death-related data. This study was approved by the Institutional Review Board (IRB) of Chung-Ang University Hospital [IRB No. C2014086[1282]]. The requirement for informed consent was waived as this study was based on review of data that were regularly gathered.

Subjects
Selection criteria were: 1) those aged 50 years or older who were diagnosed with osteoporotic fractures, including the hip, spine, humerus, and distal radius, in the national database from 2007 to 2012; 2) those who were followed up until 2013 with original fractures reported from 2007 to 2012; and 3) those who were followed up for at least 1 year (Fig. 1). Patients with a history of fracture from 2002 to 2006 were excluded from this research. With the exception of cosmetic surgery and traffic accident-related injuries, the KNHI program includes 100% of the population. All clinics and hospitals send patient information including diagnosis [as described in the International Classification of Diseases, 10th Revision (ICD-10)] and NHIS claims medical expenses. The NHIS database allows for research of non-traumatic osteoporotic fractures as it does not include high-energy injuries, such as traffic accidents or industrial accidents. All information related to patients and diseases can be found from NHIS data. This information has been used in several epidemiological studies in Korea based on

Fig. 1. Flow chart showing selection of the study subjects. KNHI, Korean National Health Insurance.
diagnostic codes including ICD-10 code and operational definitions for hip, spine, distal radius, and humerus fractures.21-24

**Definition of osteoporotic fracture**

KNHI data of outpatient visits or hospital admissions of patients aged 50 years and older from January 1, 2002 to December 31, 2012 were analyzed. Fractures related to osteoporosis were recognized for seven processes (open reduction of fractured extremity-femur, closed pinning-femur, closed pelvis/femur fixation, closed reduction of fractured extremity-pelvis/femur, bone traction, skin traction, and hemiarthroplasty-hip) and the ICD-10 codes S72.0 (femoral neck fracture), S72.1 (pertrochanteric fracture), S22.0 (traumatic spine fracture), S22.1 (traumatic spine fracture), S32.0 (traumatic spine fracture), M48.4 (traumatic vertebra fracture), M48.5 (traumatic vertebra fracture), S52.5 (traumatic distal fracture), S52.6 (traumatic distal radius/ulna fracture), S42.2 (proximal humerus fracture), and S42.3 (humerus shaft fracture), as well as fractures in general.4,21,25

**Definition of refracture and survival duration**

Refracture was classified as a fracture of bone in one of four initial components (hip, humerus, spine, and wrist) that occurred after 6 months (180 days) based on the last claim date.26 The re-fracture was defined after a 6-month untreated period using the same operational definition as described previously.27,28 Survival duration was defined as the length from the first fracture date to the date of death between 2007 and 2012.

**Mortality after osteoporotic fractures in patients**

NHIS data were combined with National Statistical Office domestic mortality data to determine survival for each patient during the follow-up period after osteoporotic fracture. From the index date of the first refracture event, the mortality rate of patients with refracture was calculated.

**Adjustment of comorbidity index and disability**

Medical comorbidity was based on the modified Charlson’s Comorbidity Index, which was calculated as the amount of points given for disease circumstances conditions as follows: one point for myocardial infarction, deep vein thrombosis, congestive heart failure, peripheral vascular disease, dementia, arthritis, chronic obstructive pulmonary disease, diabetes mellitus, or ulcer; two points for stroke or cancer; and three points for liver cirrhosis. Thus, possible total scores ranged from 0 to 15, with higher scores indicating poorer health status.29

In terms of disability, its class (physical disability or all-cause disability) and severity (grade 1: ordinary, grade 1–2: serious, grade 3–6: mild) were obtained from the NHIS database. Disability was assessed by the accountable physician according to particular guidelines developed by the Korean government.

**Statistical analyses**

To evaluate the relationship between recurrence of osteoporotic fracture and death, the time from incidence to death was calculated, and recurrence from incidence of the final episode to death was calculated. A life table was used to calculate the cumulative incidence of refracture. Cumulative incidence was described as the likelihood of a specific case occurring, such as the occurrence of a specific disease. It was calculated as the amount of topics at the start of the research, separating the amount of new refractures over a period of time. The risk of mortality was calculated using Cox proportional hazards regression. A life table was also used to calculate the rate of survival. All data analyses were performed using SAS statistical package version 9.4 (SAS Institute, Cary, NC, USA).

**RESULTS**

A total of 18956 first-time instances of osteoporotic fracture were reported between 2007 and 2012, with a median follow-up of 3.1 years (range, 1 to 7 years). Demographic features of each fracture site and the refracture states of patients are summarized in Table 1.

There were 4641 (24.50%) male patients and 14315 (75.50%) female patients. A total of 724 (3.80%) patients showed serious impairment related with the severity of the disease, and 2999 (15.80%) patients died during the follow-up period. Of 18956 patients, 2941 (15.50%) had at least one refracture. There were statistically significant differences in sex, age, and mortality between the refracture group and the non-refracture group (Table 1, Fig. 1). Osteoporotic fracture in the spine had the highest number of cases (n=8600, 45.40%), followed by wrist fracture (n=6243, 32.90%), fracture in the humerus (n=829, 4.40%), and hip fracture (n=3284, 17.30%). Of 2941 patients with refractures, 1116 (37.95%), 815 (27.71%), 677 (23.02%), and 333 (11.32%) events were associated with the spine, hip, wrist, and humerus, respectively. The incidences of re-fracture according to the first fracture site were 12.83% (1103/8600) in spine and 22.50% (739/3284) in hip. The incidence of wrist re-fracture in a previous wrist fracture was 6.63% (414/6243), and the frequency of humeral re-fracture involving a previous humeral fracture was 35.83% (297/829) (Table 2).

Mortality in the re-fracture group (63.5/1000 person-years) was higher than that in the non-refracture group (44.5/1000 person-years) during the study period (Table 3). After adjusting for age, sex, income, and comorbidity index, the mortality rate in patients with re-fracture was 1.4 times [hazard ratio (HR): 1.4, 95% confidence interval (CI): 1.26–1.55, p<0.001] higher than that in patients without re-fracture over a median follow-up of 3 years (Fig. 2).

According to the site of first fracture, mortality risk was decreased in the order of hip (HR: 1.68, p<0.001), humerus (HR: 1.41, p<0.001), spine (reference), and wrist (HR: 0.52, p<0.001).
In addition, the mortality risks according to the site of first re-fracture (reference=non-refracture) were decreased in the order of hip (HR=1.52, \( p<0.001 \)), spine (HR=1.09, \( p=0.329 \)), humerus (HR=0.93, \( p=0.722 \)), and wrist (HR=0.69, \( p=0.072 \)) (Table 4).

Adults >85 years of age showed greater danger of re-fracture than those aged between 50 and 54 years (HR: 1.43, 95% CI: 1.17–1.76, \( p<0.001 \)). The risk of re-fracture was higher in female (HR: 1.37, 95% CI: 1.30–1.44, \( p<0.001 \)) than in male.

### Table 1. Demographic Characteristics in Terms of Osteoporotic Fracture Pattern

| Variables | Total | Recurrence | First fracture location |
|-----------|-------|------------|-------------------------|
|           | n %   | n %        | Spine | Humerus | Wrist | Hip     | p value | p value |
| Total     | 18956 | 16015 84.50 | 2941 15.50 | 8600 45.40 | 829 4.40 | 6243 32.90 | 3284 17.30 |
| Sex       |       | <0.001    |        |        |        | 0.046   |         |
| Male      | 4641  4105 88.45 | 536 11.55 |       | 2262 48.74 | 222 4.78 | 1044 22.50 | 1113 23.98 |
| Female    | 14315 | 11910 83.20 | 2405 16.80 | 6338 44.28 | 607 4.24 | 5199 36.32 | 2171 15.16 |
| Age (yr)  |       | <0.001    | <0.001 | <0.001 |        | <0.001 |         |
| 50–54     | 1770  1617 91.36 | 153  8.64 |       | 534 30.17 | 111 6.27 | 946 53.45 | 179 10.11 |
| 55–59     | 2109  1932 91.61 | 177  8.39 |       | 634 30.06 | 110 5.22 | 1176 55.76 | 189 8.96 |
| 60–64     | 2192  1935 88.28 | 257 11.72 |       | 819 37.36 | 107 4.88 | 1040 47.45 | 226 10.31 |
| 65–69     | 2914  2436 83.60 | 478 16.40 |       | 1362 46.75 | 133 4.56 | 1052 36.10 | 367 12.59 |
| 70–74     | 3336  2678 80.28 | 658 19.72 |       | 1754 52.58 | 132 3.96 | 916 27.46 | 534 16.00 |
| 75–79     | 2976  2417 82.83 | 559 18.78 |       | 1670 56.12 | 115 3.86 | 572 19.22 | 619 20.80 |
| 80–84     | 2025  1619 79.95 | 406 20.05 |       | 1064 52.54 | 67 3.31 | 328 16.20 | 566 27.95 |
| ≥85       | 1634  1381 84.52 | 253 15.48 |       | 763 46.70 | 54 3.30 | 213 13.04 | 604 36.96 |
| Income quintile |       | 0.322     | <0.001 | <0.001 |        |        |         |
| 0         | 1073  920 85.74 | 153 14.26 |       | 548 51.07 | 55 5.13 | 212 19.76 | 258 24.04 |
| 1         | 2867  2433 84.86 | 434 15.14 |       | 1281 44.68 | 117 4.08 | 991 34.57 | 478 16.67 |
| 2         | 2291  1932 84.33 | 359 15.67 |       | 1020 44.52 | 106 4.63 | 782 34.57 | 373 16.28 |
| 3         | 2917  2463 84.44 | 454 15.56 |       | 1310 44.91 | 120 4.11 | 1034 35.45 | 453 15.53 |
| 4         | 3887  3142 85.22 | 545 14.78 |       | 1612 43.72 | 168 5.56 | 1296 35.15 | 611 16.57 |
| 5         | 6121  5125 83.73 | 996 16.27 |       | 2829 46.22 | 263 4.30 | 1918 31.33 | 1111 18.15 |
| Disability severity classification |       | 0.037     | <0.001 |         |        |        |         |
| Normal    | 15628 | 13239 84.71 | 2389 15.29 | 7014 44.88 | 686 4.39 | 5568 35.63 | 2360 15.10 |
| Mild      | 2604  2157 82.63 | 447 17.17 |       | 1262 48.46 | 81 3.11 | 582 22.35 | 679 26.08 |
| Severe    | 724   619 85.50 | 105 14.50 |       | 324 44.75 | 62 8.56 | 93 12.85 | 245 33.84 |
| Charlson comorbidity score |       | <0.001    | <0.001 |         |        |        |         |
| 0         | 8303  7212 86.86 | 1091 13.14 |       | 3523 42.43 | 360 4.34 | 3309 38.85 | 1111 13.38 |
| 1         | 6151  5049 82.08 | 1102 17.92 |       | 2915 47.39 | 256 4.16 | 1815 29.51 | 1165 18.94 |
| 2         | 2474  2058 83.19 | 416 16.81 |       | 1150 46.48 | 116 4.69 | 693 28.01 | 515 20.82 |
| ≥3        | 2028  1696 83.63 | 332 16.37 |       | 1012 49.90 | 97 4.78 | 426 21.01 | 493 24.31 |

### Table 2. Refracture Rate according to First Osteoporotic Fracture Site

| Number of subject | Total | Spine | Humerus | Wrist | Hip     |
|------------------|-------|-------|---------|-------|---------|
|                  | n %   | n %   | n %     | n %   | n %     |
| Total            | 18956 | 2941 15.50 | 1424 7.51 | 297 1.57 | 467 2.46 | 753 3.97 |
| Location of first fracture |
| Spine            | 8600 1116 12.98 | 1103 12.83 | 0 0 | 5 0.06 | 8 0.09 |
| Humerus          | 829 333 40.17 | 4 0.48 | 297 35.83 | 30 3.62 | 2 0.24 |
| Wrist            | 6243 677 10.84 | 259 4.15 | 0 0 | 414 6.63 | 4 0.06 |
| Hip              | 3284 815 24.82 | 58 1.77 | 0 0 | 18 0.55 | 739 22.50 |
DISCUSSION

Although attempts have been made to prevent secondary fractures in patients with osteoporotic fracture over the past several centuries, information about the incidence, morbidity, mortality, and financial burden associated with secondary fractures is still limited for patients with osteoporotic fractures. Thus, this study determined the incidence and mortality of osteoporotic refractures based on information from domestic claims for health insurance. During the study period with a median follow-up of 3 years (range, 1 to 7 years), the incidence of refractures among complete osteoporotic fractures was 15.5% (2941/18956 patients). Incidences rates of refractures in the spine, hip, wrist, and humerus were 37.95%, 27.71%, 23.02%, and 11.32%, respectively. Cumulative mortality rates for non-refracture and re-fracture groups at 1 year of follow up were 7.2% and 9.1%, respectively. During the study period, cumulative mortality was higher in the re-fracture group than that in the non-refracture group. After adjusting for age, sex, income, and comorbidity, the mortality rate was 1.2 times greater in patients with re-fracture than that in patients without re-fracture (Model 2, HR: 1.20, 95% CI: 1.08–1.34, \(p < 0.001\)). Risk ratios for hip, humerus, and wrist refractures were 1.68, 1.41, and 0.52, respectively. Adults >85 years of age had a greater risk of re-fracture than those aged between 50 and 54 years (HR: 1.43, 95% CI: 1.17–1.76, \(p<0.001\)), and the risk of refracture was greater in females (HR: 1.37, 95% CI: 1.30–1.44, \(p<0.001\)) than in males.

Hsiao, et al.\(^3\) determined the incidence of osteoporotic fracture in patients over 65 years of age using the National Health Insurance Database. They indicated that within the first year of original fracture, 45% experienced complete refractures. Although the overall incidence of secondary fracture depended on follow-up periods, 50% of cases showed refractures within 3 years after the primary fracture.\(^2\),\(^7\),\(^3\) In the present study, the incidence of re-fracture during follow up corresponded with the results of other studies. The incidence of refracture improved significantly up to 2 years in this research, and it decreased gradually to a plateau. Of all refractures, 21% and 55% occurred at 1 and 2 years, respectively. Considering such trends in patients with primary osteoporotic fractures, early prevention appears mandatory to minimize the incidence of refracture.

Nakayama, et al.\(^3\) performed a historical cohort study of all patients aged at least 50 years who had a 6-month history of minimal trauma fracture and presented to the emergency departments of a tertiary hospital with and without a fracture liaison service. They reported a 30% reduction in the rate of re-fracture at the fracture liaison service hospital and a 40% reduction in major refractures (hip, spine, femur, pelvis, or humerus).

Klotzbuecher, et al.\(^3\) performed a meta-analysis and revealed that past history of wrist fracture not only increases the risk of subsequent wrist fracture [odds ratio (OR): 3.3], but also increases the risk of hip fracture (OR: 1.9). Similarly, past history of hip fracture increased the risk of subsequent hip fracture (OR: 2.3) in peri- or post-menopausal females. A common fracture, irrespective of its location, reduced the danger of subsequent fracture, including pooled vertebral and non-

### Table 3. Mortality Rates during Follow Up (2007 to 2012)

| Year | Non-refracture* | Refracture* |
|------|-----------------|-------------|
| 2007 | 44.0            | 74.1        |
| 2008 | 46.6            | 65.8        |
| 2009 | 41.7            | 52.6        |
| 2010 | 42.7            | 69.9        |
| 2011 | 45.9            | 60.9        |
| 2012 | 47.0            | 66.3        |
| Average | 44.5          | 63.5        |

*1000 person-years.

### Table 4. Mortality Risk for Each Refracture Site in Refracture Patients, Compared to Non-Refracture Patients

| Fracture location | Original fracture | Hazard ratios | 95% CI | \(p\) value | Refracture (reference: non-refracture) |
|-------------------|-------------------|---------------|--------|-------------|----------------------------------------|
| Spine             | Reference         | 1.09          | 0.92–1.28 | 0.329       | 1.52                                   | 1.31–1.76 | <0.001       |
| Humerus           | 1.41              | 1.18–1.69     | <0.001  | 0.93        | 0.69                                   | 0.45–1.03 | 0.072       |
| Wrist             | 0.52              | 0.46–0.58     | <0.001  | 0.69        | 0.69                                   | 0.45–1.03 | 0.072       |
| Hip               | 1.68              | 1.55–1.82     | <0.001  | 1.52        | 1.52                                   | 1.31–1.76 | <0.001       |

CI, confidence interval.

Adjusted for age, sex, income, and Charlson Comorbidity Index.
vertebrae fractures (OR: 2).34

van Staa, et al.35 used British cohort information to evaluate the incidence of subsequent fractures. They found that a previous tibia, fibula, ankle, femur, hip, radius, ulna, rib, or humerus fracture increased the risk of subsequent fracture, with corresponding ORs ranging from 2 to 3. Specifically, patients with a history of radius or ulna fracture had the highest risk of humerus fracture (OR: 5.8, 95% CI: 5.5–6.1).35

Overall, patients with osteoporotic fracture reported greater hip, spine, proximal humerus, and distal radius mortality. These results often matched secondary fractures in main fractures. Bliuc, et al.36 performed a long-term follow-up cohort study to investigate the mortality of osteoporotic fractures in patients above 60 years of age. They reported 2.99-fold and 1.91-fold increases in mortality in male and female patients with refractions, respectively. Refraction within 5 years of an initial fracture significantly increased the mortality. Furthermore, mortality was moderately increased within 10 years. In the present study, the mortality rate in patients with refraction was 1.2 times higher than that in the non-refraction group (HR: 1.20, 95% CI: 1.08–1.34, p<0.001) after adjusting for age, sex, income, and comorbidity index. During a follow-up duration of 4 years, risks of mortality rate (HR: 1.27 at 1 year, 1.25 at 2 years, 1.29 at 3 years, 1.10 at 4 years, and 0.99 at 5 years) were higher in the re-fracture group than those in the non-refraction group.

Hsiao, et al.37 found that important risk factors are hip (HR= 1.45), spine (HR=1.59), female sex (HR=1.41), and age over 85 years (HR=1.26). Our findings also showed that advanced age and female sex were risk factors for refraction. However, the frequency of refraction in this study was the highest at the humerus and hip joints depending on the primary fracture site. The incidence of humerus-related refraction was 3.7 times greater than in the hip and 2 times greater than in the spine.

This study has several limitations. First, bone mineral density data or laboratory data, such as vitamin D, calcium, body mass index, smoking/alcohol status, or caffeine use, were not considered because this study was based on the National Claims Registry database. Second, although the age and sex of the predominant fractures were considered, it was impossible to clinically diagnose any disease associated fractures. Therefore, fracture incidence might have been underestimated. Third, mortality due to a specific medical condition or non-medical usage was not analyzed. Additional research studies investigating refraction and mortality based on large-scale registry data are needed. Fourth, trends in refraction could be compared to other studies. The secular trend of re-fracture in this study cannot be generalized due to the study period and the characteristics of the database. Finally, cox-regression analysis was used to analyze the effect of refraction on mortality. However, competing risk analysis was not performed. In addition, statistical processing was difficult due to the use of claim data. Nevertheless, cohort data from the NHIS were used to analyze refraction patterns for a nationally representative population. Reporting the incidence according to different scenarios of major osteoporotic refractions would be meaningful.

In summary, in this nationwide study, the incidence of osteoporotic re-fracture was 15.5%. The mortality rate in re-fracture patients was found to be 1.2 times higher than that in non-refracture patients over a median follow-up of 3 years.

ACKNOWLEDGEMENTS

This study used National Health Insurance Service (NHIS)-National Sample Cohort data (REQ0000016926) provided by NHIS. This research was supported by a grant (HC15C1189) from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI) funded by the Ministry of Health & Welfare, Republic of Korea.

AUTHOR CONTRIBUTIONS

Conceptualization: Jun-Il Yoo and Yong-Chan Ha. Data curation: Rock-Beum Kim and Sung-Hyo Seo. Formal analysis: Ki Soo Park. Funding acquisition: Jun-Il Yoo and Yong-Chan Ha. Investigation: Kyung-Hoi Koo. Methodology: Rock-Beum Kim, Sung-Hyo Seo, and Ki Soo Park. Project administration: Kyung-Hoi Koo. Resources: Rock-Beum Kim and Sung-Hyo Seo. Software: Rock-Beum Kim and Sung-Hyo Seo. Supervision: Jun-Il Yoo and Yong-Chan Ha. Validation: Rock-Beum Kim and Sung-Hyo Seo. Visualization: Jun-Il Yoo. Writing—original draft: Jun-Il Yoo and Yong-Chan Ha. Writing—review & editing: Jun-Il Yoo, Yong-Chan Ha, and Ki Soo Park.

ORCID iDs

Jun-Il Yoo https://orcid.org/0000-0002-3575-4123
Yong-Chan Ha https://orcid.org/0000-0002-0069-3797
Ki Soo Park https://orcid.org/0000-0001-5571-3639
Rock-Beum Kim https://orcid.org/0000-0001-5868-0465
Sung-Hyo Seo https://orcid.org/0000-0003-3327-5425
Kyung-Hoi Koo https://orcid.org/0000-0001-5251-2911

REFERENCES

1. Lems WF, Raterman HG. Critical issues and current challenges in osteoporosis and fracture prevention. An overview of unmet needs. Ther Adv Musculoskelet Dis 2017;9:299–316.
2. Kontis V, Bennett JE, Mathers CD, Li G, Foreman K, Ezzati M. Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble. Lancet 2017;389:1323–35.
3. Doherty DA, Sanders KM, Kotowicz MA, Prince RL. Lifetime and five-year age-specific risks of first and subsequent osteoporotic fractures in postmenopausal women. Osteoporos Int 2001;12:16-23.
4. Dennison E, Mohamed MA, Cooper C. Epidemiology of osteoporosis. Rheum Dis Clin North Am 2006;32:617–29.
5. Lee YK, Kim JW, Lee MH, Moon KH, Koo KH. Trend in the age-adjusted incidence of hip fractures in South Korea: systematic re
view. Clin Orthop Surg 2017;9:420–3.
6. Teng GG, Curtis JR, Saag KG. Mortality and osteoporotic fractures: is the link causal, and is it modifiable? Clin Exp Rheumatol 2008; 26(5 Suppl.51):S125–37.
7. Nazrún AS, Tzar MN, Mohktar SA, Mohamed IN. A systematic re-
view of the outcomes of osteoporotic fracture patients after hospital discharge: morbidity, subsequent fractures, and mortality. Ther Clin Risk Manag 2014;10:937-48.
8. Jung HJ, Park YS, Seo HY, Lee JC, An KC, Kim JH, et al. Quality of life in patients with osteoporotic vertebral compression fractures. J Bone Metab 2017;24:187-96.
9. Wu CH, Chen CH, Chen PH, Yang JJ, Chang PC, Huang TC, et al. Identifying characteristics of an effective fracture liaison service: systematic literature review. Osteoporos Int 2018;29:1023-47.
10. Noordin S, Allana S, Masri BA. Establishing a hospital based fracture liaison service to prevent secondary insufficiency fractures. Int J Surg 2018;54(Pt B):328-32.
11. Chang YI, Huang CJ, Hwang JS, Kuo JF, Lin KM, Huang HC, et al. Fracture liaison services for osteoporosis in the Asia-Pacific region: current unmet needs and systematic literature review. Osteoporos Int 2018;29:779-92.
12. Binkley N, Blank RD, Leslie WD, Lewiecki EM, Eisman JA, Bilezikian JP. Osteoporosis in crisis: it’s time to focus on fracture. J Bone Miner Res 2017;32:1391-4.
13. Stolnicki B, Oliveira LG. For the first fracture to be the last. Rev Bras Ortop 2016;51:121-6.
14. Dreinhöfer KE, Féron JM, Herrera A, Hubé R, Johnell O, Lidgren L, et al. Orthopaedic surgeons and fragility fractures. A survey by the Bone and Joint Decade and the International Osteoporosis Foundation. J Bone Joint Surg Br 2004;86:958-61.
15. Johnell O, Kanis JA, Odén A, Sernbo I, Redlund-Johnell I, Pettersson C, et al. Fracture risk following an osteoporotic fracture. Osteoporos Int 2004;15:175-9.
16. Lauritzen JB, Lund B. Risk of hip fracture after osteoporosis fractures. 451 women with fracture of lumbar spine, olecranon, knee or ankle. Acta Orthop Scand 1993;64:297-300.
17. Kanis JA, Johnell O, De Laet C, Johansson H, Oden A, Delmas P, et al. A meta-analysis of previous fracture and subsequent fracture risk. Bone 2004;35:375-82.
18. Park YG, Jang S, HaYC. Incidence, morbidity and mortality in patients older than 50 years with second hip fracture in a Jeju cohort study. Hip Pelvis 2014;26:250-5.
19. Cheung CL, Ang SB, Chadha M, Chow ES, Chung YS, Hew FL, et al. An updated hip fracture projection in Asia: The Asian Federation of Osteoporosis Societies study. Osteoporos Sarcopenia 2018;4:16-21.
20. Kim L, Kim JA, Kim S. A guide for the utilization of Health Insurance Review and Assessment Service National Patient Samples. Epidemiol Health 2014;36:e2014008.
21. Yoon HK, Park C, Jang S, Jang S, Lee YK, HaYC. Incidence and mortality following hip fracture in Korea. J Korean Med Sci 2011;26:1087-92.
22. Park C, HaYC, Jang S, Jang S, Yoon HK, Lee YK. The incidence and residual lifetime risk of osteoporosis-related fractures in Korea. J Bone Miner Metab 2011;29:744-51.
23. Choi HJ, Shin CS, HaYC, Jang S, Jang S, Park C, et al. Burden of osteoporosis in adults in Korea: a national health insurance database study. J Bone Miner Metab 2012;30:54-8.
24. Lee YK, Jang S, Jang S, Lee HJ, Park C, HaYC, et al. Mortality after vertebral fracture in Korea: analysis of the National Claim Registry. Osteoporos Int 2012;23:1859-65.
25. Lee YK, HaYC, ParkC, YooJJ, Shin CS, Koo KH. Bisphosphonate use and increased incidence of subtrochanteric fracture in South Korea: results from the National Claim Registry. Osteoporos Int 2013;24:707-11.
26. Kang HY, Yang KH, Kim YN, Moon SH, Choi JG, Kang DR, et al. Incidence and mortality of hip fracture among the elderly population in South Korea: a population-based study using the national health insurance claims data. BMC Public Health 2010;10:230.
27. Lee YK, HaYC, Yoon BH, Koo KH. Incidence of second hip fracture and compliant use of bisphosphonate. Osteoporos Int 2013;24:2099-104.
28. Brozek W, Reichardt B, Zwerina J, Dimai HP, Klaushofer K, Zvetter E. Antiresorptive therapy and risk of mortality and re-fracture in osteoporosis-related hip fracture: a nationwide study. Osteoporos Int 2016;27:387-96.
29. Kim KH. Comorbidity adjustment in health insurance claim database. Health Policy Manag 2016;26:71-8.
30. Hsiao PC, Chen TJ, Li CY, Chu CM, Su TP, Wang SH, et al. Risk factors and incidence of repeat osteoporotic fractures among the elderly in Taiwan: a population-based cohort study. Medicine (Baltimore) 2015;94:e532.
31. Center JR, Bluc D, Nguyen TV, Eisman JA. Risk of subsequent fracture after low-trauma fracture in men and women. JAMA 2007;297:387-94.
32. Ruan WD, Wang P, Ma XL, Ge RP, Zhou XH. Analysis on the risk factors of second fracture in osteoporosis-related fractures. Chin J Traumatol 2011;14:74-8.
33. Nakayama A, Major G, Holliday E, Attia J, Bogduk N. Evidence of effectiveness of a fracture liaison service to reduce the re-fracture rate. Osteoporos Int 2016;27:873-9.
34. Klotzbuecher CM, Ross PD, Landsman PB, Abbott TA 3rd, Berger M. Patients with prior fractures have an increased risk of future fractures: a summary of the literature and statistical synthesis. J Bone Miner Res 2000;15:721-39.
35. van Staa TP, Leufkens HG, Cooper C. Does a fracture at one site predict later fractures at other sites? A British cohort study. Osteoporos Int 2002;13:624-9.
36. Bluc D, Nguyen ND, Nguyen TV, Eisman JA, Center JR. Compound risk of high mortality following osteoporotic fracture and re-fracture in elderly women and men. J Bone Miner Res 2013;28:2317-24.