BMJ Open

Effect of dementia on all-cause mortality in hip fracture surgery: a retrospective study on a nationwide Korean cohort

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To cite: Jeong SH, Lee HJ, Kim SH, *et al*. Effect of dementia on all-cause mortality in hip fracture surgery: a retrospective study on a nationwide Korean cohort. *BMJ Open* 2023;**13**:e069579. doi:10.1136/bmjopen-2022-069579

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-069579).

Received 27 October 2022
Accepted 24 April 2023

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ABSTRACT

Objectives We aimed to evaluate the effect of dementia on the 1-year all-cause mortality in elderly patients who underwent hip fracture surgery, using a nationwide cohort in Korea.

Design, setting, and participants This was a nationwide, retrospective study. Elderly patients (≥60 years) with and without dementia who underwent hip fracture surgery between January 2005 and December 2012 were distinguished using the data from the Korean National Health Insurance Service-Senior cohort.

Interventions None.

Primary and secondary outcome measures The mortality rates with 95% CIs and the impact of dementia on all-cause mortality were calculated using a generalised linear model with Poisson distribution and a multivariable-adjusted Cox proportional hazards model, respectively.

Results Among the 10 833 patients who underwent hip fracture surgery, 13.4% were diagnosed with dementia. During the 1-year follow-up period, 1586 patients with hip fracture without dementia died in 8356.5 person-years (incidence rate (IR)=189.2 per 1000 person-years, 95% CI 179.91 to 198.99), while 340 deaths were confirmed in patients with hip fracture with dementia in 1240.8 person-years (IR, 273.1 per 1000 person-years, 95% CI 244.94 to 304.58). Patients with hip fracture and dementia were 1.23 times more likely to die than those in the control group in the same period (HR=1.23, 95% CI 1.09 to 1.39).

Conclusion Dementia is a risk factor for 1-year all-cause mortality after hip fracture surgery. To improve the postoperative outcomes of patients with dementia who have undergone hip fracture surgery, effective treatment models such as multidisciplinary diagnosis and strategic rehabilitation should be established.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is one of the few studies using country-level data to investigate the relationship between dementia status and mortality after hip fracture in an Asian population.
⇒ Using a large-scale nationwide database, we examined the mortality incidence rate in elderly hip fracture patients and presented the mortality risk after hip fracture surgery.
⇒ It was not possible to classify the severity of dementia due to the data limitations.
⇒ Although national insurance claims data were used, the disease code may not match the patient's actual disease status.

INTRODUCTION

Hip fracture is a serious injury and frequently occurs in elderly patients.[1] Hip fractures are also associated with increased morbidity and mortality in the elderly population and are a major public health threat, placing a significant clinical and economic burden on the healthcare system.[2–4] More than 1.6 million people sustain hip fractures each year. By 2025, 2.6 million people are predicted to sustain hip fractures, and this number is predicted to increase to 4.5 million by 2050.[5]

The prevalence of dementia is significantly increasing owing to the ageing of the global population.[6] The number of patients with dementia is expected to reach 67.5 million by 2030 and 115.4 million by 2050.[7] Dementia is characterised by a gradual decline in cognitive function and is accompanied by behavioural and psychological symptoms.[8] Trauma is one of the most common causes of hospitalisation in patients with dementia.[6] Older adults with dementia are at an increased risk of falls owing to their reduced safety awareness, body awareness and attention span.[9] Previous epidemiological and pathophysiological studies have demonstrated that owing to the strong association between dementia and osteoporosis, patients with dementia are more likely to sustain hip fractures.[4 10] Furthermore, dementia is considered an independent risk factor that increases the risk of fractures in the spine, distal iliac bone, proximal humerus and hip joints, even after considering the demographic factors such as sex, age and region and the associated comorbidities such as rheumatism, diabetes and cardiovascular disease.[11 12] Moreover, it is difficult to manage patients with dementia before surgery, after surgery and during rehabilitation owing to the presence of behavioural and psychological

disturbances.[13] Therefore, the incidence of postoperative complications and risk of mortality are relatively high.[14 15]

However, whether the mortality rate is higher among elderly patients with dementia after surgery for the management of hip fractures has not been extensively investigated. Most of these studies were conducted on Western populations, and most of them used a small sample of patients; hence, the scope of study participants was limited.[15] Furthermore, previous studies in Korea have been conducted on a small specific group,[16] and only a few studies have been conducted in the same Asian population.[4 6 15] In our study, we aimed to investigate the impact of dementia on the 1-year all-cause mortality in patients undergoing primary hip fracture surgery using the data from the Korea National Health Insurance Service-Senior (NHIS-Senior) cohort.

MATERIALS AND METHODS

Patient and public involvement

The participants or the public were not involved in the design, conduct, reporting or dissemination of our study.

Data collection and participants

The NHIS-Senior cohort of South Korea was used to select patients with or without dementia who had undergone hip fracture surgery. The NHIS-Senior is a representative administrative dataset used for establishing health policies and conducting biomedical research.[17] The NHIS-Senior database was established to represent the older adults residing in Korea; a total of 558 147 individuals (10% of the 5.5 million enrollees aged 60 years or older) were randomly selected and enrolled through simple random sampling.[17] All individuals included in NHIS-Senior were followed up until 31 December 2013, unless death or disqualification from the National Health Insurance coverage due to certain factors such as emigration occurred.[17 18] NHIS is the only payer under the single-insurer system of the nationwide health insurance in Korea. Almost all Korean citizens are enrolled in NHIS and are classified as insured, self-employed and medical benefit recipients.[17 18] The key variables for NHIS-Senior include inpatient and outpatient billing data, such as treatment procedure codes, prescriptions and diagnoses.[18 19]

Patients who had undergone primary hip fracture surgery and were participants in NHIS-Senior survey were included in the study. Patients who underwent total hip arthroplasty (International Statistical Classification of Disease and Related Health Problems, 10th Revision (ICD-10): N0711), hemiarthroplasty (N0715) and open reduction with internal fixation (N0611) were also included. The study participants were defined as those who underwent primary hip fracture surgery in 2002–2013 (N=13 655). Patients (1) who underwent primary hip fracture surgery before 31 December 2003 (to ensure a minimum follow-up of 2 years after obtaining a diagnosis of dementia (N=1274)) and (2) with hip fractures that occurred less than 1 year before the end of the observation period (31 December 2015) (to ensure a minimum follow-up of 1 year (N=1548)) were excluded. Ultimately, 10 833 individuals were enrolled in our study.

All the data are available in the Korean National Health Insurance Sharing Service database (https://nhiss.nhis.or.kr/bd/ab/bdaba000eng.do) and can be accessed on reasonable request.

One-year all-cause mortality

In the NHIS-Senior study, the unique deidentified number of each participant was linked to the mortality data from the Korean National Statistical Office.[18] Thus, all participants who died were identified, and the interval between the index date and the date of death was used to define the survival time.

Definition of dementia

The criteria used in previous studies for identifying patients with dementia were applied[4 6]; therefore, comparison was possible. An ICD-10 code was used to confirm whether the first diagnosis of dementia was a primary or secondary diagnosis within 2 years prior to the primary hip fracture surgery; then, the patients were divided into the non-dementia group and the dementia group. The ICD-10 codes used to confirm the diagnosis were F01, F02 and F03 for dementia and F00 and G30 for Alzheimer's disease.[6 20]

Control variables

The variables that might influence the mortality risk and dementia prevalence in patients who underwent hip fracture surgery were considered potential confounders in this study. These variables included sex, age, type of insurance coverage, region, income level, registered disability, Charlson comorbidity index (CCI), type of surgery, principal diagnosis and year of hip fracture surgery.

Statistical analysis

The patients' baseline characteristics were identified at the time of primary hip fracture surgery (time zero). The survival time used in the survival analyses was defined as the period from the index date (primary hip fracture surgery) to the date of death or 31 December 2012, whichever came first. The survival rates between the dementia and non-dementia groups were compared using the Kaplan-Meier survival curve and log-rank test. The denominators of incidence rate (IR) were defined as the unit of days divided by an IR of 365.25; the 1-year all-cause mortality (and 95% CI) was calculated using a generalised linear model with a Poisson distribution and expressed as the number of all-cause mortalities per 1000 person-years. A multivariable-adjusted Cox proportional hazards model was used to investigate the effects of dementia on all-cause mortality.[21] The effect sizes were presented as HRs and 95% CIs. Additionally, the same method was used to analyse the effects of dementia types on the mortality risks in patients who underwent primary hip fracture surgery by subdividing dementia types based

on the diagnosis code (other dementia types (ICD-10: F01, F02 and F03) and Alzheimer's disease (ICD-10: F00 and G30)).

This study aimed to investigate the all-cause mortality within 1 year after hip fracture surgery in dementia and non-dementia groups. However, based on previous studies, the effect of death from hip fracture surgery after a diagnosis of dementia was considered relatively important even within a period of less than 1 year.[22] Therefore, further survival analysis was performed in several time points (90 days[4 6] and 180 days[4 22]), which were defined as the follow-up periods. Stratified analyses by sex, age and CCI of the disorder were also performed to investigate the relationship between dementia and all-cause mortality in patients undergoing primary hip fracture surgery. A p value of <0.05 was considered significant. All data analyses were performed using SAS V.9.4 software (SAS Institute).

RESULTS

Table 1 presents the general characteristics of the study population. Of the 10 833 patients, 1451 (13.4%) were diagnosed with dementia within 2 years prior to primary hip fracture surgery, while 9382 (86.6%) were not diagnosed with dementia. High proportions of participants with dementia were older age group. In addition, no difference was found in the CCI or type of surgery between the dementia group and non-dementia group; however, differences were observed in sex, age, types of insurance coverage, region, income level, major diagnosis, registered disability and year of surgery between the two study groups.

Figure 1 shows the Kaplan-Meier survival curves and log-rank test results of the study population. The period from survival to death from all causes within 1 year after surgery was shorter in patients with dementia compared with that in patients without dementia (p for log-rank test ≤0.0001) (figure 1).

Table 2 presents the results of a multivariate-adjusted Cox proportional hazard regression analysis of all-cause mortality within 1 year in non-dementia and dementia patients who underwent primary hip fracture surgery. During the 1-year follow-up period, 340 deaths in 1240.8 person-years (IR, 273.1 patients/1000 person-years) were reported among 1451 patients with dementia who underwent primary hip fracture surgery. Among the 9382 patients without dementia who underwent primary hip fracture surgery, 1586 deaths were reported in 8356.5 person-years (IR, 189.2 per 1000 person-years). In the same period, the risk of mortality was 1.23 times higher in dementia patients who underwent primary hip fracture surgery compared with that in non-dementia patients who underwent primary hip fracture surgery (HR=1.23, 95% CI 1.09 to 1.39).

Table 3 shows the results of a multivariate-adjusted Cox proportional hazard regression analysis of all-cause mortality at 0-90, 91-180 and 181-365 days in patients with and without dementia who underwent primary hip fracture surgery. Patients with dementia who underwent primary hip fracture were 1.30 times more likely to die within 91–180 days compared with those without dementia who underwent primary hip fracture (HR=1.30, 95% CI 1.02 to 1.67). Moreover. Patients with dementia who underwent primary hip fracture were also 1.40 times more likely to die at 181–365 days (HR=1.40, 95% CI 1.13 to 1.73).

Table 4 presents the results of the multivariate-adjusted Cox proportional hazard regression analysis of the 1-year all-cause mortality by dementia type. Of the 793 patients diagnosed with Alzheimer's disease, 196 died in 674.2 person-years (IR, 290.7 per 1000 person-years). Among the 658 patients diagnosed with other types of dementia, 143 died in 566.6 person-years (IR, 252.4 patients/1000 person-years). Among patients who underwent primary hip fracture surgery at 1-year follow-up, patients with Alzheimer's disease had a 1.28 times higher risk of mortality compared with that patients without dementia (HR=1.28, 95% CI 1.10 to 1.49). Moreover, patients with other types of dementia had a 1.17 times higher risk of mortality (HR=1.17, 95% CI 0.98 to 1.39); however, mortality was only significant in patients with Alzheimer's disease.

Table 5 presents the relationship between dementia and all-cause mortality in patients who underwent hip fracture surgery using a subgroup analysis by sex, age and CCI. In both men and women, patients with dementia who underwent primary hip fracture surgery had a higher risk of mortality; however, this effect was more prominent in men (male: HR=1.32, 95% CI 1.05 to 1.65; female: HR=1.18, 95% CI 1.02 to 1.37). The younger the age, the stronger the HR for the association between mortality and dementia status (60–69 years: HR=4.87, 95% CI 2.51 to 9.43; 70–74 years: HR=2.31, 95% CI 1.63 to 3.28). In terms of CCI, the mortality rate after primary hip fracture surgery was stronger in patients with dementia in the absence of multimorbidity (HR=1.28, 95% CI 1.07 to 1.54).

DISCUSSION

Hip fractures are associated with significant mortality and place a considerable burden on society and healthcare systems.[23 24] Patients with neurodegenerative disorders are more likely to fall, resulting in sustained fractures and making it challenging to perform rehabilitation after hip fracture surgery.[25 26] In this large nationally representative population-based cohort, after adjusting for multiple confounding factors, the risk of all-cause mortality after hip fracture surgery was higher in patients with dementia compared with that in patients without dementia. The main results of this study are as follows. First, dementia patients were identified by diagnosing dementia 2 years prior to primary hip fracture surgery, and about 13% of the patients who underwent hip fracture surgery were confirmed to have dementia. Second,

Table 1 Baseline characteristics of the study population

	Without dementia		With dementia		
	N	%	N	%	P value
Total	9382	86.6	1451	13.4	
Sex					<0.0001
Male	2826	30.1	298	20.5	
Female	6556	69.9	1153	79.5	
Age					<0.0001
60–69	1205	12.8	41	2.8	
70–74	2244	23.9	195	13.4	
75–79	2240	23.9	331	22.8	
80–84	2998	32.0	720	49.6	
≥85	695	7.4	164	11.3	
Types of insurance coverage					<0.0001
Regionally insured	2825	30.1	363	25.0	
Workplace insured	5516	58.8	777	53.5	
Medical aid	1041	11.1	311	21.4	
Region					0.0324
Urban	5574	59.4	819	56.4	
Rural	3808	40.6	632	43.6	
Income level					<0.0001
Low	2777	29.6	548	37.8	
Mid	2423	25.8	291	20.1	
High	4182	44.6	612	42.2	
CCI					0.1844
0	4272	45.5	637	43.9	
1	2980	31.8	447	30.8	
2	1308	13.9	228	15.7	
≥3	822	8.8	139	9.6	
Type of surgery					0.3221
Total hip arthroplasty (THA, HA)	5068	54.0	804	55.4	
Open reduction and internal fixation (ORIF)	4314	46.0	647	44.6	
Major diagnosis					<0.0001
Hip-fracture	7989	85.2	1380	95.1	
Other	1393	14.8	71	4.9	
Registered disability*					0.0468
No	9160	97.6	1404	96.8	
Yes	222	2.4	47	3.2	
Year of surgery					<0.0001
2004	813	8.7	41	2.8	
2005	956	10.2	60	4.1	
2006	1043	11.1	115	7.9	
2007	1015	10.8	126	8.7	
2008	1041	11.1	161	11.1	
2009	1025	10.9	216	14.9	
2010	1204	12.8	251	17.3	
2011	1081	11.5	222	15.3	
2012	1204	12.8	259	17.8	

*Participants who were registered as disabled under the Korean welfare of persons with disabilities act.
CCI, Charlson comorbidity index.

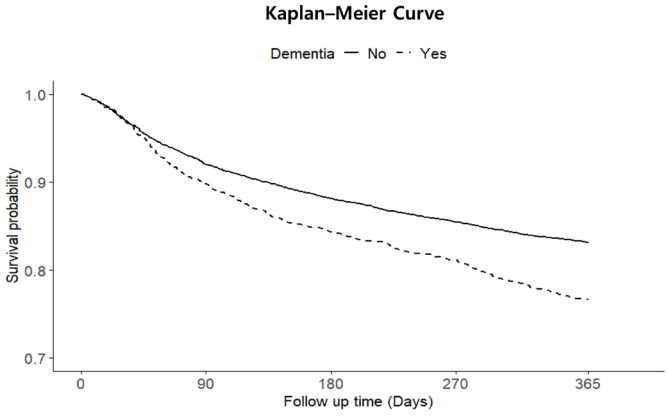

Figure 1 One-year Kaplan-Meier survival curves and log-rank test results comparing the survival rates between patients with hip fracture surgery according to dementia type (p<0.001 for the entire period; log-rank test).

the all-cause mortality after primary hip fracture surgery in dementia patients were 273.1/1000 person-years at 1-year follow-up, 258.3/1000 person-years at 91–180 days and 189.8/1000 person-years at 181–365 days. Third, patients with dementia after primary hip fracture surgery had all-cause mortality rate of 1.23 times higher at year, 1.30 times higher at 91–180 days and 1.40 times higher at 181–365 days after hip fracture surgery, compared with patients without dementia. Our results can support those of previous studies conducted in Taiwanese and Australian populations.[4 6 27]

The group with dementia had a higher risk of all-cause mortality 1 year after hip fracture surgery compared with the group without dementia. However, when the groups were divided into Alzheimer's disease and other dementia types groups, only Alzheimer's disease demonstrated an effect on mortality. Although Alzheimer's disease is a type of dementia, its effect on mortality after hip surgery is more substantial. Since most previous studies compared the effects of mortality after hip surgery in dementia and non-dementia groups or between the Alzheimer's and non-Alzheimer's groups, further studies are warranted to understand the mechanisms supporting our results.[4 28]

Our findings of an increase in dementia-related mortality after hip fracture surgery are consistent with those in previous literature reporting the risk factors for mortality after hip fracture. Previous studies have also reported an increased risk of mortality within 90–180 days and 1 year after hip surgery in patients with dementia compared with that in patients without dementia. According to previous studies, the all-cause mortality rate was 1.16 times higher (HR=1.16; 95% CI 1.11 to 1.23) 1 year after hip fracture surgery compared with that in patients without dementia in Australia and 1.45 times higher (HR=1.45, 95% CI 1.17 to 1.79) in those in Taiwan.[2 4]

The effects of dementia on the progression of hip fracture surgery to death among elderly individuals can be explained as follows. First, people with dementia tend to be less active and have fewer self-management skills,[22] which could contribute to the difficulties in following instructions after surgery, difficulties in rehabilitation or occurrence of malnutrition.[29 30] Therefore, people with dementia typically endure less rehabilitation following hip fracture surgery.[31] Participation in the course of treatment, such as rehabilitation following surgery, may help prevent the development of fatal complications.[32] This difference in postoperative treatment course could partially explain the stronger relationship between dementia and mortality in the hip surgery group.[32] Furthermore, dementia is an independent risk factor for respiratory complications, urinary tract infections, surgical site infections and delirium, which are major risk factors for postoperative mortality.[11 12 26] In particular, one of the most common complications after hip fracture surgery in patients with dementia is delirium.[26 33 34] Delirium episodes after hip fracture surgery are strongly associated with an increased risk of mortality, especially in emergency situations.[34] Therefore, the complications that occurred after hip fracture surgery in patients with dementia, such as delirium, may have contributed to the increased mortality risk in patients with dementia. Therefore, further studies are needed to explore these mechanisms.

In our subgroup analysis, the impact of dementia-related mortality in patients who underwent hip fracture surgery was more prominent in men. These results were similar to those of previous studies.[4 22 35] The reason for the different effects of dementia in men and women remains unclear. However, men with hip fractures sustain more complex injuries while performing their daily activities and exercises than women, resulting in a more significant loss of physiological functioning and reserve.[36] In addition, the effect of dementia-related mortality in patients who underwent hip fracture surgery was particularly pronounced in the group without CCI and the relatively young group, especially in those aged 60 and 69 years old and the 70–74 years old. Previous studies have identified lung, heart or circulatory system diseases, which are part of the CCI, and comorbidities such as pneumonia as major factors contributing to the high mortality rate in the early postoperative period.[16] Nonetheless, our findings may require careful interpretation as the CIs for men and women significantly overlap. Therefore, the effect of these factors in our study in the group without a CCI can be interpreted as the effect of dementia, which was the most pronounced. The age factor can be interpreted in the same context. The younger the age, the lesser tendency to develop complex diseases; hence, the effect of dementia can be considered particularly pronounced. However, these results have not been extensively investigated, and further studies are required. Therefore, our results indirectly support those of previous studies.

To the best of our knowledge, this is one of the few studies to use country-level data to examine the relationship between dementia status and mortality following hip fracture in an Asian population and is the first large-scale cohort study using a Korean population. Nevertheless, our study has several limitations. First, our

Table 2 Results of the Cox proportional hazard regression analysis of the association between dementia and risk of all-cause mortality after hip fracture surgery

Variables	Subjects (n)	Deaths (n)	Person-year	Incidence rate (95% CI) per 1000 person-years	95% CI	Crude HR	95% CI	Adjusted HR*	95% CI
0–365 days									
Diagnosis of dementia									
No	9382	1586	8356.5	189.2	(179.91 to 198.99)	1.00		1.00	
Yes	1451	340	1240.8	273.1	(244.94 to 304.58)	1.44	(1.28 to 1.63)	1.23	(1.09 to 1.39)
Sex									
Male	3124	674	2696.8	249.1	(230.54 to 269.22)	1.00		1.00	
Female	7709	1252	6900.5	180.9	(170.92 to 191.43)	0.73	(0.66 to 0.80)	0.62	(0.57 to 0.68)
Age									
60–69	1246	111	1174.1	94.5	(78.09 to 113.80)	1.00		1.00	
70–74	2439	259	2282.7	113.5	(100.04 to 127.94)	1.20	(0.96 to 1.50)	1.30	(1.04 to 1.63)
75–79	2571	406	2323.2	174.8	(157.84 to 192.33)	1.83	(1.48 to 2.26)	2.04	(1.64 to 2.53)
80–84	3718	896	3126.0	286.6	(266.92 to 305.79)	2.97	(2.44 to 3.61)	3.36	(2.73 to 4.12)
≥85	859	254	691.4	367.4	(321.93 to 416.44)	3.78	(3.02 to 4.72)	4.49	(3.56 to 5.66)
Types of insurance coverage									
Regionally insured	3188	595	2802.2	212.3	(194.92 to 229.88)	1.00		1.00	
Workplace insured	6293	1046	5630.4	185.8	(174.10 to 197.03)	0.88	(0.79 to 0.97)	0.88	(0.80 to 0.98)
Medical aid	1352	285	1164.7	244.7	(216.38 to 274.98)	1.15	(1.00 to 1.32)	1.12	(0.95 to 1.32)
Region									
Urban	6393	1079	5701.1	189.3	(177.51 to 200.56)	1.00		1.00	
Rural	4440	847	3896.2	217.4	(202.25 to 232.21)	1.15	(1.05 to 1.26)	1.11	(1.02 to 1.22)
Income level									
Low	3325	641	2903.9	220.7	(203.19 to 238.30)	1.00		1.00	
Mid	2714	480	2412.9	198.9	(181.01 to 217.29)	0.91	(0.80 to 1.02)	1.03	(0.90 to 1.19)
High	4794	805	4280.5	188.1	(174.71 to 201.20)	0.86	(0.77 to 0.95)	0.98	(0.86 to 1.11)
CCI									
0	4909	837	4359.4	192.0	(178.56 to 205.19)	1.00		1.00	
1	3427	602	3044.4	197.7	(181.67 to 213.91)	1.03	(0.93 to 1.14)	1.10	(0.99 to 1.22)
2	1536	298	1349.3	220.9	(196.03 to 247.27)	1.14	(1.00 to 1.30)	1.26	(1.10 to 1.43)
≥3	961	189	844.2	223.9	(192.95 to 258.15)	1.16	(0.99 to 1.36)	1.37	(1.17 to 1.61)
Type of surgery									

Continued

Table 2 Continued

Variables	Subjects (n)	Deaths (n)	Person-year	Incidence rate (95% CI) per 1000 person-years	95% CI	Crude HR	95% CI	Adjusted HR*	95% CI
Total hip arthroplasty (THA, HA)	5872	1031	5212.1	197.8	(185.26 to 209.91)	1.00		1.00	
Open reduction and internal fixation (ORIF)	4961	895	4385.3	204.1	(190.25 to 217.59)	1.03	(0.94 to 1.13)	1.00	(0.92 to 1.10)
Major diagnosis									
Hip-fracture	9369	1734	8270.3	209.7	(199.19 to 219.33)	1.00		1.00	
Other	1464	192	1327.0	144.7	(124.73 to 166.83)	0.69	(0.59 to 0.80)	0.97	(0.83 to 1.14)
Registered disability†									
No	10564	1873	9362.3	200.1	(190.40 to 208.91)	1.00		1.00	
Yes	269	53	235.0	225.5	(170.51 to 296.41)	1.13	(0.86 to 1.48)	0.78	(0.59 to 1.02)
Year of surgery									
2004	854	154	759.5	202.8	(172.11 to 237.42)	1.00		1.00	
2005	1016	198	889.4	222.6	(192.39 to 256.02)	1.10	(0.89 to 1.35)	1.12	(0.91 to 1.39)
2006	1158	236	1000.9	235.8	(206.02 to 268.18)	1.16	(1.16 to 1.42)	1.14	(0.93 to 1.40)
2007	1141	201	1013.6	198.3	(171.64 to 227.69)	0.98	(0.98 to 1.21)	0.95	(0.77 to 1.18)
2008	1202	220	1062.9	207.0	(180.26 to 236.21)	1.02	(1.02 to 1.26)	0.98	(0.79 to 1.20)
2009	1241	211	1107.8	190.5	(165.45 to 217.92)	0.94	(0.94 to 1.16)	0.85	(0.69 to 1.05)
2010	1455	262	1281.7	204.4	(179.93 to 230.81)	1.01	(1.01 to 1.23)	0.94	(0.77 to 1.15)
2011	1303	214	1162.6	184.1	(159.96 to 210.53)	0.91	(0.91 to 1.12)	0.85	(0.69 to 1.05)
2012	1463	230	1319.0	174.4	(152.40 to 198.30)	0.88	(0.88 to 1.07)	0.76	(0.61 to 0.93)

*Adjusted for other covariates (sex, age, types of insurance coverage, region, income level, CCI, type of surgery, major diagnosis, registered disability and year of surgery).
†Participants who were registered as disabled under the Korean welfare of persons with disabilities act.
CCI, Charlson comorbidity index.

Table 3 Comparative analysis of the association between dementia and the risk of all-cause mortality according to the period after hip fracture surgery

Exposure	Subjects (n)	Deaths (n)	Person-year	Incidence rate (95% CI) per 1000 person-years	95% CI	Crude HR	95% CI	Adjusted HR*	95% CI
0–90 days									
Diagnosis of dementia									
No	9382	752	2217.1	339.2	(312.17 to 360.13)	1.00		1.00	
Yes	1451	148	339.4	436.1	(367.00 to 506.21)	1.29	(1.08 to 1.53)	1.09	(0.91 to 1.31)
91–180 days									
Diagnosis of dementia									
No	8630	362	2079.8	174.1	(155.25 to 190.79)	1.00		1.00	
Yes	1303	80	309.7	258.3	(204.93 to 318.21)	1.48	(1.16 to 1.89)	1.30	(1.02 to 1.67)
181–365 days									
Diagnosis of dementia									
No	8268	472	4053.0	116.5	(105.81 to 126.75)	1.00		1.00	
Yes	1223	112	590.2	189.8	(156.84 to 227.04)	1.63	(1.33 to 2.00)	1.40	(1.13 to 1.73)

*Adjusted for sex, age, types of insurance coverage, region, income level, Charlson comorbidity index, type of surgery, major diagnosis, registered disability and year of surgery.

Table 4 Results of subgroup analysis stratified by dementia types

	1-year all-cause mortality								
	Subjects (n)	Deaths (n)	Person-year	Incidence rate (95% CI) per 1000 person-years	95% CI	Crude HR	95% CI	Adjusted HR*	95% CI
Diagnosis of dementia type†									
None	9382	1589	8356.5	189.6	(179.68 to 334.36)	1		1	
Alzheimer's disease	793	196	674.2	290.7	(251.12 to 334.36)	1.52	(1.30 to 1.75)	1.28	(1.10 to 1.49)
Other dementia	658	143	566.6	252.4	(212.54 to 297.80)	1.32	(1.12 to 1.57)	1.17	(0.98 to 1.39)

*Adjusted for sex, age, types of insurance coverage, region, income level, Charlson comorbidity index, type of surgery, major diagnosis, registered disability and year of surgery.
†Among patients who underwent primary hip fracture surgery, those with dementia were divided into the Alzheimer's disease group (International Classification of Diseases External 10th Revision (ICD-10): F00 and G30) and other dementia type group (ICD-10: F01, F02 and F03) based on the ICD-10 code applied.

Table 5 Results of subgroup analysis stratified by independent variables

	1-year all-cause mortality			
	Diagnosis of dementia			
	No	Yes		
Variable	HR	HR*	95% CI	P value
Sex				
Male	1.00	1.32	(1.05 to 1.65)	0.0159
Female	1.00	1.18	(1.02 to 1.37)	0.0235
Age				
60–69	1.00	4.87	(2.51 to 9.43)	<0.0001
70–74	1.00	2.31	(1.63 to 3.28)	<0.0001
75–79	1.00	1.09	(0.81 to 1.47)	0.5641
80–84	1.00	1.10	(0.93 to 1.30)	0.2794
≥85	1.00	0.80	(0.58 to 1.11)	0.1857
CCI				
0	1.00	1.28	(1.07 to 1.54)	0.0072
1	1.00	1.26	(1.02 to 1.56)	0.0364
2	1.00	1.21	(0.89 to 1.66)	0.2301
≥3	1.00	0.85	(0.55 to 1.32)	0.4687

Stratified analysis results according to sex, age and Charlson comorbidity index to investigate the relationship between dementia and 1-year all-cause mortality in patients who underwent primary hip fracture surgery.
*Adjusted for other covariates (sex, age, types of insurance coverage, region, income level, Charlson comorbidity index, type of surgery, major diagnosis, registered disability and year of surgery).
CCI, Charlson comorbidity index.

study attempted to fill the data gap in the current literature; however, it only included information that was available in the cohort. The disease codes used in the inclusion criteria may not correspond to the patient's actual disease status, which is a fundamental limitation of insurance databases. However, almost all hospitals operate under a reimbursement system, and all surgical procedures and treatments are recorded in the billing database; therefore, the incidence of hip fracture and dementia can be verified. Unlike previous studies, this study presented the risk of mortality over time after sustaining a fracture by investigating the mortality IR of elderly patients with hip fractures. Second, owing to data limitations, we did not classify the severity of dementia, which may have influenced the outcome. People with severe dementia are at higher risk of developing complications. However, despite these limitations, the information was obtained from the national databases and relied on correct coding. Third, as this was a retrospective observational study, some of the data may have been missing or not recorded. In the National Health Insurance Corporation database, all details of medical usage are recorded without missing data. In addition, as national insurance is required by law, almost all Korean individuals can be accurately tracked in the NHIS database. The use of the NHIS database may increase the value of the results obtained in this study. Therefore, the results of this study can be generalised to other individuals as well as the Korean society. Finally, participants were selected to control for various conditions and confounding variables to avoid bias. However, selection bias and unmeasured bias could exist.

Conclusion

Our study confirms that dementia is a risk factor for 1-year all-cause mortality after sustaining a hip fracture. Considering the unique characteristics of patients with dementia, treatment models such as multidisciplinary diagnosis and strategic rehabilitation exercises, should be established to improve the postoperative outcomes of patients with dementia after undergoing hip fracture surgery.

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Acknowledgements We would like to thank our colleagues at Yonsei University's Health Research Institute for their advice in writing the manuscript.

Contributors S-YJ accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish. Concept and design: SHJ, S-YJ and HJL. Acquisition, analysis or interpretation of data: SHJ, HJL and S-YJ. Drafting of the manuscript: SHJ. Critical revision of the manuscript for important intellectual content: SHJ, HJL, SHK, E-CP and S-YJ. Supervision: S-YJ. The manuscript was reviewed by all authors.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval We assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the 1975 Declaration of Helsinki, as revised in 2008. As the NHIS-NSC data do not contain any identifying information, the study was exempted for review by the Institutional Review Board of Yonsei University's Health System (4-2021-0833). Since we used deidentified data, the need for informed consent was waived by the Institutional Review Board of Yonsei University's Health System (4-2021-0833).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The data can be accessed on the National Health Insurance Data Sharing Service homepage of the National Health Insurance Service (http://nhiss.nhis.or.kr). Applications to use the NHIS data will be reviewed by the inquiry committee of research support and, once approved, raw data will be provided to the applicant for a fee. Contact information for a data access committee is listed as follows: National Health Insurance Sharing Service, Tel: 82–33–736–2432; Official internet site: https://nhiss.nhis.or.kr/bd/ay/bdaya001iv.do

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