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Reoperation rates after posterior lumbar spinal fusion surgery according to preoperative diagnoses: A national population-based cohort study

Moon Soo Park[a,*], Young-Su Ju[b], Seong-Hwan Moon[c], Tae-Hwan Kim[a], Jae Keun Oh[d], Paul S. Sung[e], Chi Heon Kim[f,g,h,i,j], Chun Kee Chung[f,g,h,i,j], Ho Guen Chang[a]

[a] Department of Orthopaedic Surgery, Hallym University Sacred Heart Hospital, Medical College of Hallym University, 22 Gwanpyeong-ro 170 beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14068, Republic of Korea
[b] Department of Occupational and Environmental Medicine, Hallym University Sacred Heart Hospital, Medical College of Hallym University, 22 Gwanpyeong-ro 170 beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14068, Republic of Korea
[c] Department of Orthopaedic Surgery, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul, 03722, Republic of Korea
[d] Department of Neurosurgery, Hallym University Sacred Heart Hospital, Medical College of Hallym University, 22 Gwanpyeong-ro 170 beon-gi, Dongan-gu, Anyang-si, Gyeonggi-do, 14068, Republic of Korea
[e] Department of Physical Therapy/Motion Analysis Center, Herbert H. and Grace A. Dow College of Health Professions, Central Michigan University, Health Professions Building, 1220, Mt. Pleasant, MI 48859, USA
[f] Department of Neurosurgery, Seoul National University Hospital, 101 Daehak-ro, Jongno-gu, Seoul 03080, Republic of Korea
[g] Department of Neurosurgery, Seoul National University College of Medicine, 103 Daehak-ro, Jongno-gu, Seoul 03080, Republic of Korea
[h] Neuroscience Research Institute, Seoul National University Medical Research Center, 103 Daehak-ro, Jongno-gu, Seoul 03080, Republic of Korea
[i] Clinical Research Institute, Seoul National University Hospital, 101 Daehak-ro, Jongno-gu, Seoul 03080, Republic of Korea
[j] Department of Brain and Cognitive Sciences, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea

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ABSTRACT

Objective: The reoperation rate after lumbar degenerative disease surgery is low. It is difficult to find statistical differences in reoperation rates according to the different diagnoses of lumbar degenerative diseases. National population-based database overcomes the statistical problem by its large cohorts with longitudinal follow-up in a nation. The purpose was to compare the reoperation rates after single-level lumbar spinal posterior decompression and fusion surgeries depending on different preoperative diagnoses of lumbar degenerative disease.

Patients and methods: We used the Korean Health Insurance Review & Assessment Service national database. The study population was the patients with a diagnosis of a degenerative lumbar disease who underwent single-level decompression and fusion from January 1, 2011, to June 30, 2016. We classified the patients into one of three groups based on diagnosis codes of lumbar disc herniation, spondylolisthesis, or spinal stenosis. A reoperation was defined as repeated decompression and fusion. We considered age, sex, the presence of diabetes, osteoporosis, associated comorbidities, and hospital types as potential confounding factors.

Results: The reoperation rate was higher in patients with spinal stenosis than in those with lumbar disc herniation. However, there was no difference in the reoperation rate between the patients with lumbar disc herniation and those with spondylolisthesis. Male gender and hospital type were risk factors for reoperation.

Conclusion: The incidence of reoperation was dependent on the diagnostic subgroups of lumbar degenerative diseases. This information can help surgeons accurately communicate with their patients and enhance the preoperative informed consent process.

1. Introduction

Surgical interventions have been performed for numerous lumbar degenerative diseases. Reoperations after primary surgeries were evaluated in patients with specific diagnoses in the family of lumbar degenerative diseases. Among the patients treated surgically for lumbar disc herniation, the reoperation rate at a follow-up of five years was 13.4% [1]. Among the patients treated surgically for lumbar degenerative spondylolisthesis, the reoperation rate at a follow-up of four to five years was 14% to 17% [2,3]. Among the patients treated surgically for spinal stenosis, the reoperation rate at a follow-up of eight to ten years was 11% to 18% based on the data from SPORT trial [4,5].

* Corresponding author.
E-mail address: amhangpark@gmail.com (M.S. Park).

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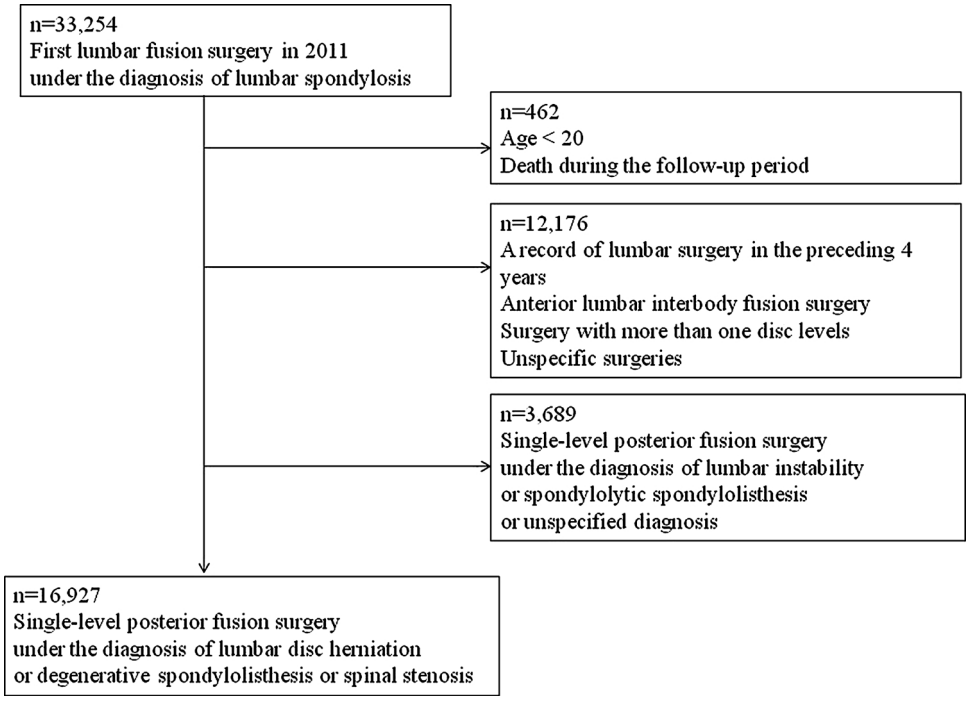

Fig. 1. Cohort definition.

A few studies have compared the differences in clinical outcomes after surgery to treat the different preoperative subgroups of lumbar degenerative diseases. In a retrospective study of 165 patients, Buttermann et al. [6] found that the patients with high grade (grade III-IV) spondylolytic spondylolisthesis had better clinical outcomes after lumbar fusion than those who underwent lumbar fusion after a prior discectomy or decompression at the follow-up of three years. Bhalla et al. [7] performed a meta-analysis to determine the influence of diagnosis on clinical outcomes after lumbar fusion for degenerative diseases of the lumbar spine. Clinical improvements were different for each preoperative diagnosis, with degenerative spondylolisthesis showing the greatest amount of improvement and non-specified degenerative disc disease showing the lowest improvement [7]. In contrast, Gehrchen et al. [8] conducted a retrospective study of 112 patients and found comparable clinical outcomes after lumbar fusion between patients with spondylolytic spondylolisthesis and those with a lumbar disc herniation at the follow-up of four years.

It has been evident that reoperation is one of the key factors affecting postoperative clinical outcomes [9]. However, the reoperation incidence following surgical intervention for lumbar degenerative diseases has been relatively low. It would be helpful to detect differences in reoperation rates according to different lumbar diagnoses based on the national population-based databases. The results of such a study could improve quality of care due to the statistical strength of retrospective research using a large population. National population-based databases provide large cohorts that may help overcome this challenge, and they provide the complete follow-up after reoperations without losses to follow-up, even after the patients were discharged from the hospital. However, few studies have evaluated the difference in reoperation rates between the different preoperative diagnostic subgroups of the lumbar degenerative diseases.

The purpose of this study was to compare the reoperation rates after single-level posterior fusion surgeries according to the different preoperative diagnoses in the family of lumbar degenerative diseases.

2. Material and methods

This study was approved by the institutional review board at the corresponding author's institution (IRB number: 2016-I106).

2.1. Data source

The source of the data is the Korean Health Insurance Review & Assessment Service (HIRA) database. This is a national and prospective dataset and is targeted at 51 million patients enrolled in the Republic of Korea. It contains all inpatient and outpatient data reported by diagnosis and procedure codes. The diagnosis codes are standardized according to the Korean Classification of Disease, 6th version, which follows the International Classification of Disease, 10th edition (ICD-10). The Korean HIRA database provides complete information about reoperations without losses to follow-up because the patients underwent reoperations in hospitals in Korea, even after they were discharged from the initial hospital after the index operation. In addition, a claim-based approach for reporting reoperations was accurate compared to medical record abstraction because the fee-for-service reimbursement system in Korea requires procedure codes for every surgical fee [10].

2.2. Study population selection & design

We searched the HIRA national database to identify patients who had a primary diagnosis of lumbar disc herniation (diagnosis codes : M4720, M4721, M4722, M4723, M4724, M4725, M4726, M4727, M4728,M4729, M5410, M5412, M5413, M5419, M511), degenerative spondylolisthesis (diagnosis codes : M4310, M4311, M4312, M4313, M4314, M4315, M4316, M4317, M4318, M4319) or degenerative spinal stenosis (diagnosis codes : M4800, M4801, M4802, M4803, M4804, M4805, M4806, M4807, M4808, M4809, M9920, M9921, M9922, M9923, M9924, M9951, M9952, M9953, M9954). Patients were included if they had any of the following primary posterior fusion procedures combined with posterior decompression between January 1, 2011, and June 30, 2016: first, lumbar posterolateral fusion (procedure code: N0469, N1469) with lumbar laminectomy (procedure code: N1499, N2499) or lumbar discectomy (procedure code: N1493); second, lumbar posterior interbody fusion (procedure code: N2470, N1460) with lumbar laminectomy (procedure code: N1499, N2499) or

lumbar discectomy (procedure code: N14930). The patients' resident registration numbers were encrypted for privacy. We have adopted the study design of the current study from previous studies because it is most effective to elucidate the reoperation rate after surgeries [1,11].

In 2011, 33,254 patients were diagnosed with the lumbar spinal degenerative disease and underwent lumbar fusion surgeries (Fig. 1). Among them, 462 patients under the age of 20 were excluded. Also, 12,176 patients who underwent anterior fusion surgeries, unidentified surgery, or surgeries in more than one disc level were excluded. In addition, 3,689 patients who underwent single disc level posterior fusion under the diagnosis of lumbar instability or spondylolytic spondylolisthesis or under unidentified diagnosis were excluded. Finally, 16,927 patients who underwent single disc level posterior fusion surgeries under the diagnosis of lumbar disc herniation or spondylolisthesis or spinal stenosis were hereby determined for the final study population (Fig. 1).

All patients included in the study cohort were evaluated during the four and half year follow-up period from January 1, 2012, to June 30, 2016. Therefore, the minimal follow-up period was four and a half years.

The patients were separated into three groups based on their respective preoperative diagnosis codes: lumbar disc herniation (Group 1), degenerative spondylolisthesis (Group 2), or spinal stenosis (Group 3). Our goal was to compare the reoperation rates among the patients with lumbar disc herniation, degenerative spondylolisthesis, and spinal stenosis while adjusting for confounding variables.

2.3. Surgical indications

Nearly all hospitals in Korea follow the surgical treatment requirements according to the Korean National Health Insurance Corporation in order to receive reimbursement. The surgical standard of care for patients with lumbar disc herniation in Korea is lumbar discectomy in case of the patients with intractable pain or neurologic deficits despite non-surgical treatment that lasted for at least 12 weeks. Regarding lumbar fusion for lumbar disc herniation, these regulations additionally require recurrent lumbar disc herniation, foraminal lumbar disc herniation, or lumbar instability combined with lumbar radiculopathy. The surgical standard of care for patients with degenerative spondylolisthesis and spinal stenosis in Korea is posterior lumbar decompression in case of the patients with no improvement of symptoms despite non-surgical treatment that lasted for at least 12 weeks. With respect to lumbar fusion for degenerative spondylolisthesis and spinal stenosis, these regulations additionally require findings of foraminal stenosis or lumbar instability combined with degenerative spondylolisthesis or spinal stenosis. Therefore, these Korean National Health Insurance Corporation requirements were considered as the surgical indications for the patients in this cohort.

2.4. Confounding factors

Age, sex, the presence of diabetes, osteoporosis, medical comorbidities, and hospital types were considered potential confounding factors in our analysis. Medical comorbidities were assessed according to the "International Classification of Disease, Ninth Edition, Clinical Modification (ICD-9-CM) and ICD-10 coding algorithms for Charlson Comorbidities" proposed by Quan et al [12]. If there were more than four distinct primary or secondary diagnoses in 2009, the patients were regarded as having associated medical comorbidities [1,13]. Diabetes was analyzed separately since it is a known risk factor for reoperation that increases complication rates and inhibits functional recovery [1,14,15].

In Korea, hospital types are classified by the health care law and regulations [1]. General hospitals have at least seven departments, such as internal medicine, general surgery, obstetrics and gynecology, pediatrics, diagnostic radiology, anesthesiology, pathology, and laboratory medicine. They must also have at least one board-certified doctor in each department with more than 99 beds. Tertiary-referral hospitals are distinguished from general hospitals because they have at least 20 departments. In addition to the characteristics of the general hospitals, tertiary-referral hospitals also have residency training programs, a minimum of 5 operating rooms, and a variety of diagnostic tools including computed tomography, magnetic resonance imaging, electromyography, angiography, gamma camera radiography, and Holter cardiac monitoring. Hospitals are healthcare systems that do not have essential departments or those that have between 30 and 99 beds. Private clinics have fewer than 30 beds.

2.5. Statistical analysis

A time to event (reoperation) survival analysis was performed. The primary endpoint was any posterior lumbar fusion reoperation during the follow-up period. Reoperations were identified by the presence of any of the aforementioned primary posterior fusion procedures combined with posterior decompression recorded after the index procedure code. Therefore, reoperation included lumbar operations performed at both the original or new levels. Reoperations included reoperations for revision of the original levels and reoperations for the adjacent segmental disease at a different level. We excluded the third and subsequent reoperation events from the cumulative operation rates since those later interventions may not have portrayed the natural history after lumbar operations. If the latter date was not available, we used January 1, 2011, which is the first date in our data collection period, and June 30, 2016, which is the last date.

Chi-square test and ANOVA were used to compare baseline characteristic in the diagnosis groups. Statistical analysis for comparison among the three diagnosis groups was performed using Cox proportional hazards regression modeling. We analyzed the data using SAS software (ver.6.1; SAS Institute, Inc., Cary, NC, USA). The statistical significance level was set at $p < 0.05$.

3. Results

Spinal stenosis was more commonly encountered in our cohort than degenerative spondylolisthesis or lumbar disc herniation as baseline characteristics (51.20% *vs.* 37.50% and 11.31%, respectively) (Table 1). The mean patient age was 62.35 ± 10.43 years and 65.30% were women (Table 1). Age, sex, the presence of diabetes, associated comorbidities, and hospital types were different among the three groups (Table 1).

During the entire follow-up period, 3.18% of the study population underwent reoperations. The cumulative reoperation rate was 3.18% at the end of the study period. The cumulative incidence of reoperations at the end of the study period was higher in the patients with spinal stenosis (3.98%) than in the patients with degenerative spondylolisthesis (2.16%) and those with lumbar disc herniation (2.93%).

The unadjusted reoperation rate was significantly higher in patients with spinal stenosis and lower in patients with spondylolisthesis than in those with lumbar disc herniation based on the hazard ratio (Table 2). Sex, the presence of diabetes, associated comorbidities, and hospital types were significant confounding factors according to the Cox regression analysis (Table 2). After controlling for these confounders, the adjusted reoperation rate was significantly higher in patients with spinal stenosis than in those with lumbar disc herniation based on the hazard ratio (p = 0.0302, hazard ratio = 1.374, 95% confidence interval 1.031–1.831, Fig. 2, Table 3). Gender, and hospital types were found to significantly affect the risk of reoperation (female sex: p = 0.0054, hazard ratio = 0.783, 95% confidence interval 0.658-0.930; General hospital: p = 0.0041, hazard ratio = 1.392, 95% confidence interval 1.110–1.744) (Table 3).

Table 1
Characteristics of the study population.

	All patients	Lumbar disc herniation	Degenerative spondylolisthesis	Spinal stenosis	P
Number (%)	16,927	1,914 (11.31%)	6347 (37.50%)	8666 (51.20%)	
Age (years)					< **0.0001**
20-29	117 (0.69%)	48 (2.51%)	47 (0.74%)	22 (0.25%)	
30-39	334 (1.97%)	168 (8.78%)	94 (1.48%)	72 (0.83%)	
40-49	1,348 (7.96%)	299 (15.62%)	586 (9.23%)	463 (5.34%)	
50-59	4,349 (25.69%)	503 (26.28%)	2024 (31.89%)	1822 (21.02%)	
60-69	6,215 (36.72%)	518 (27.06%)	2304 (36.30%)	3393 (39.15%)	
≥70	4,564 (26.96%)	378 (19.75%)	1292 (20.36%)	2894 (33.39%)	
Mean age (SD)	62.35 ± 10.43	57.06 ± 13.07	60.86 ± 9.97	64.62 ± 9.44	< **0.0001**
Sex, women, n	11,054 (65.30%)	994 (51.93%)	4474 (70.49%)	5586 (64.46%)	< **0.0001**
Diabetes, n	6,982 (41.25%)	820 (42.84%)	2410 (37.97%)	3752 (43.30%)	< **0.0001**
Osteoporosis, n	132 (0.78%)	8 (0.05%)	45 (0.27%)	79 (0.47%)	0.0609
Comorbidity, n	8631 (50.99%)	975 (50.94%)	2970 (46.79%)	4686 (54.07%)	< **0.0001**
Hospital types					< **0.0001**
Tertiary-referral hospital	4125 (24.37%)	207(10.82%)	1,119 (17.63%)	2799 (32.30%)	
General hospital	5127 (30.29%)	542 (28.32%)	1722 (27.13%)	2863 (33.04%)	
Hospital	7372 (43.55%)	1,117 (58.36%)	3.385 (53.33%)	2870 (33.12%)	
Clinic	303 (1.79%)	48 (2.51%)	121 (1.91%)	134 (1.55%)	

Table 2
Comparison of the diagnosis groups based on an unadjusted value in the Cox regression analysis.

	Entire period (n = 16,927)		
	p	HR	95% CI
Diagnosis			
Lumbar disc herniation		1.000	
Degenerative spondylolisthesis	**0.0498**	0.733	(0.537, 1.000)
Spinal stenosis	**0.0300**	1.367	(1.031, 1.813)
Age (years)			
20-29		1.000	
30-39	0.7645	1.398	(0.156, 12.506)
40-49	0.7067	1.473	(0.196, 11.067)
50-59	0.2470	3.196	(0.447, 22.891)
60-69	0.1421	4.354	(0.611, 31.043)
≥70	0.1378	4.429	(0.620, 31.624)
Sex			
Men		1.000	
Women	**0.0008**	0.746	(0.628, 0.886)
Diabetes			
Yes	**0.0003**	1.369	(1.156, 1.621)
No		1.000	
Osteoporosis			
Yes	0.3650	1.450	(0.649, 3.238)
No		1.000	
Comorbidities			
Yes	< **0.0001**	1.441	(1.213, 1.712)
No		1.000	
Hospital types			
Tertiary-referral hospital		1.000	
General hospital	**0.0030**	1.401	(1.121, 1.751)
Hospital	0.2967	0.886	(0.707,1.112)
Clinic	0.7607	1.105	(0.580, 2.106)

HR: hazard ratio; CI: confidence interval.

4. Discussion

The reoperation rates between the preoperative diagnostic subgroups in the family of lumbar degenerative diseases might be different due to the different anatomic reasons that led to surgical intervention. However, few studies have evaluated the difference in reoperation rates between the preoperative diagnostic subgroups of lumbar degenerative diseases. The purpose of this study was to compare the reoperation rates after single-level posterior fusion surgeries according to different preoperative diagnoses of lumbar degenerative diseases.

The reoperation rate was higher in patients with spinal stenosis than in those with lumbar disc herniation. However, it was not different between the patients with lumbar disc herniation and those with

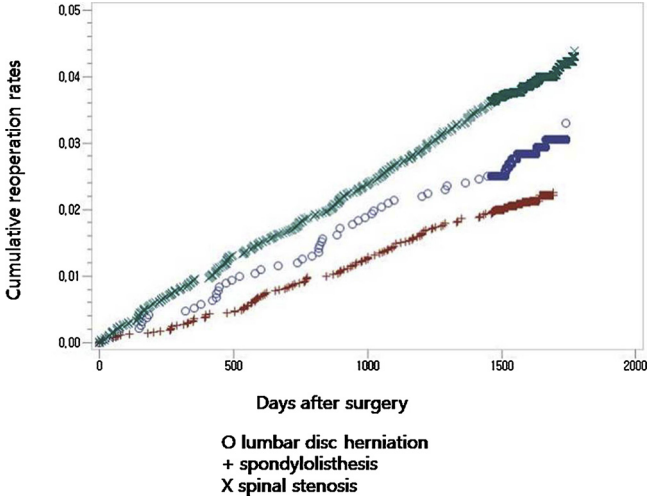

Fig. 2. Cumulative reoperation rate of surgical procedures according to diagnosis during the entire follow-up period.

Table 3
Comparison of the different diagnosis groups based on adjusted values of the Cox proportional hazards regression modeling.

	Entire period (n = 16,927)		
	p	HR	95% CI
Diagnosis			
Lumbar disc herniation		1.000	
Degenerative spondylolisthesis	0.1223	0.781	(0.517, 1.068)
Spinal stenosis	**0.0302**	1.374	(1.031, 1.831)
Sex			
Men		1.000	
Women	**0.0054**	0.783	(0.658, 0.930)
Diabetes			
Yes	0.7045	1.056	(0.796, 1.401)
No		1.000	
Comorbidities			
Yes	0.1111	1.266	(0.947, 1.691)
No		1.000	
Hospital types			
Tertiary-referral hospital		1.000	
General hospital	**0.0041**	1.392	(1.110, 1.744)
Hospital	0.9108	0.987	(0.782, 1.245)
Clinic	0.4673	1.271	(0.666, 2.427)

HR: hazard ratio; CI confidence interval.

degenerative spondylolisthesis. Male gender and hospital type were risk factors for reoperation.

De la Garza-Ramos et al. stratified 275 patients who underwent posterolateral fusion of the lumbar spine by preoperative diagnoses (post-laminectomy revision, spondylolisthesis, or spinal stenosis) and followed them for an average time of 59 months [16]. Preoperative diagnosis was not associated with reoperation rates for adjacent segment disease [16]. However, their conclusion did not provide the statistical power to detect differences because of the small number of the study population.

Martin et al. evaluated the reoperation rates following decompressive or fusion lumbar surgeries recorded in the Washington state administrative database of 26,675 patients [9]. They found that the cumulative incidence of reoperation was 19.0% in the follow-up period of 11 years [9]. There was no difference of reoperation rates among the patients with herniated disc, spondylolisthesis, spinal stenosis or degenerative disc [9]. Hu et al. evaluated reoperation rates after lumbar surgery from 1994 to 1996 from the administrative database of the Canadian Institute for Health Information including the information of 4722 patients [13]. They reviewed the reoperation rates according to the specific diagnoses in the family of lumbar degenerative diseases, which included lumbar disc herniation, spinal stenosis, possible instability, and degenerative change [13]. They found that the incidence of reoperation after lumbar surgery was independent of the diagnosis [13].

Both of the above studies are opposite to the findings of this study. These differences might be explained by the different primary endpoints of reoperations. The differing definitions of reoperation were as follows: any lumbar surgery including fusion or decompression surgery in both of the above studies *versus* repeat fusion surgery in the current study. In addition, the study population in their study included the patients who underwent lumbar fusion surgeries, laminectomies, or discectomies as the index operations, compared to the study population in this study which comprised those who underwent lumbar fusion only surgeries as the index operations. In addition, Martin et al. found that among the patients with spondylolisthesis, the incidence of reoperation was lower with fusion than with decompression alone [9]. Among the patients with the other diagnoses of herniated disc, spinal stenosis or degenerative disc, the incidence of reoperation was higher with fusion than with decompression alone [9]. However, they did not compare the reoperation rate following fusion procedures in the patients with different diagnoses.

Malter et al. evaluated the reoperation rates after lumbar surgery from 1989 to 1993 which were obtained from the administrative database of the Washington Department of Health's computerized Commission Hospital Abstract Reporting System [17]. This study included the information of 6376 patients in the specific diagnostic subgroups of the lumbar degenerative diseases, which included lumbar disc herniation, spinal stenosis, instability including spondylolisthesis, and degenerative disc disease [17]. They found that the reoperation rate was comparable between those that underwent fusion surgery and those that underwent non-fusion surgery in all four specific diagnostic subgroups. Unfortunately, they did not compare the reoperation rates among the specific diagnostic subgroups [17].

The patients with spinal stenosis in this study experienced a higher reoperation rate than those with lumbar disc herniation. This may be due to the various anatomic reasons for surgical intervention. The patients with spinal stenosis usually have stenotic lesions at multiple disc levels. In contrast, those with lumbar disc herniation usually have the pathologic lesion at a single disc level. Another possible explanation may be that the patients with spinal stenosis had impaired gait which influences the surgical outcomes related to comorbidities, and increases the risk of falling [18].

Unfortunately, our study did not elucidate why patients with the risk factors proven in the current study might have had higher reoperation rates. Male patients might possess additional risks. A possible explanation is that preoperative back pain tended to be associated with worse surgical outcomes in patients with spinal stenosis [19], and the back pain was more common in male patients than in female patients [20]. Additionally, the hospital type was a risk factor for reoperation in this study. Index operations performed in the general hospital resulted in more reoperations than those performed in the tertiary-referral hospital. This might be due to the fact that tertiary-referral hospitals were better equipped with a variety of diagnostic tools and had more of the essential departments than the general hospital.

As with any study, our investigation has several limitations. First, clinical information about pain, neurologic status, quality of life, and function was not available in the dataset. Therefore, reoperation cannot be attributed to the poor initial surgical outcome because we did not have information about the aforementioned factors in the administrative dataset. Information on radiographic findings and complexity of the surgeries was not available. There is no information on the reasons of reoperation of each diagnostic group. These restrictions are inherent to administrative database study [21]. However, the large sample size of our cohort allowed us to estimate the average reoperation rates that are generalizable to the entire population of patients with degenerative lumbar diseases. Second, the patients in the respective diagnostic subgroups of degenerative lumbar diseases were likely to be heterogeneous within the subgroup. It is possible that there is substantial overlap in terms of diagnostic categories in the study population. Fortunately, the reason for the operation was the patients' main diagnosis in the current study. Third, the primary endpoint of reoperation was repeat-posterior fusion surgery in this study. Therefore, we did not evaluate other reoperations that occurred without fusion, such as discectomies, laminectomies, incision and drainage for surgical wound infections, and anterior fusion surgeries. We may have underestimated the reoperation rates in the real clinical practice because we limited the reoperations to the fusion surgeries. Fourth, this was a study based on Koreans population operated on by Korean surgeons, so it may not be generalizable to other countries or regions. However, the Korean Healthcare system is a modern one. The surgeons use the latest surgical techniques, which are not appreciably different than those utilized in most first world countries. Finally, spinal fusion can have varying degrees of invasiveness according to the surgical procedure, such as posterolateral fusion or posterior/transforaminal interbody fusion. We plan to compare the reoperation rates according to surgical procedures in the future. Despite these limitations, to the best of our knowledge, this study represents the first population-based analysis of the reoperation rates after lumbar decompression and fusion, with comparisons of lumbar disc herniation *vs.* degenerative spondylolisthesis *vs.* spinal stenosis.

5. Conclusion

The incidence of reoperation was dependent on the diagnostic subgroups of lumbar degenerative diseases. With this understanding, we can help surgeons more accurately communicate with their patients and enhance the preoperative informed consent process.

Acknowledgment

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