The Spine Journal 22 (2022) 1983−1989

Clinical Study

Reoperations after primary and revision lumbar discectomy: study of a national-level cohort with eight years follow-up

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Received 7 March 2022; revised 19 May 2022; accepted 13 June 2022

Abstract

BACKGROUND CONTEXT: Published rates for disc reherniation following primary discectomy are around 6%, but the ultimate reoperation outcomes in patients after receiving revision discectomy are not well understood. Additionally, any disparity in the outcomes of subsequent revision discectomy (SRD) versus subsequent lumbar fusion (SLF) following primary/revision discectomy remains poorly studied.
PURPOSE: To determine the 8-year SRD/SLF rates and time until SRD/SLF after primary/revision discectomy respectively.
STUDY DESIGN: Retrospective cohort study.
PATIENT SAMPLE: Patients undergoing primary or revision discectomy, with records in the PearlDiver Patient Records Database from the years 2010 to 2019.
OUTCOME MEASURES: Subsequent surgery type and time to subsequent surgery.
METHODS: Patients were grouped into primary or revision discectomy cohorts based off of the nature of "index" procedure (primary or revision discectomy) using ICD9/10 and CPT procedure codes from 2010 to 19 insurance data sets in the PearlDiver Patient Records Database. Preoperative demographic data was collected. Outcome measures such as subsequent surgery type (fusion or discectomy) and time to subsequent surgery were collected prospectively in PearlDiver Mariner database. Statistical analysis was performed using BellWeather statistical software. A Kaplan-Meier survival analysis of time to SLF/SRD was performed on each cohort, and log-rank test was used to compare the rates of SLF/SRD between cohorts.
RESULTS: A total of 20,147 patients were identified (17,849 primary discectomy, 2,298 revision discectomy). The 8-year rates of SRD (6.1% in revision cohort, 4.8% in primary cohort, p<.01) and SLF (10.4% in revision cohort, 6.2% in primary cohort, p<.01) were higher after revision versus primary discectomy. Time to SLF was shorter after revision versus primary discectomy (709 vs. 886 days, p<.01). After both primary and revision discectomy, the 8-year rate of SLF (10.4% in revision cohort, 6.2% in primary cohort, p<.01) is greater than SRD (6.1% in revision cohort, 4.8% in primary cohort, p<.01).

FDA device/drug status: Not applicable.

Author disclosures: ***SSD***: Nothing to disclose. ***DAD***: Nothing to disclose. ***AMS***: Nothing to disclose. ***ASV***: Nothing to disclose. ***CHG***: Nothing to disclose. ***SAQ***: Royalties: Globus Medical Inc. (C). Private Investments: Tissue Differentiations Intelligence (D); HS2 LLC (D). Consulting: Stryker K2M (G); Globus Medical Inc (D). Speaking and/or Teaching Arrangements: AMOpportunities; Globous Medical Inc (E); ***DBB***: Stock Ownership: NuShoresLLC (D). Consulting: Medtronic (C). Speaking and/or Teaching Arrangements: Medtronic (B). Research Support (Investigator Salary, Staff/Materials): Medtronic (F). ***SCO***: Consulting: Globus Medical, Inc (B); Medtronic (A).

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https://doi.org/10.1016/j.spinee.2022.06.005
1529-9430/

CONCLUSIONS: Compared to primary discectomy, revision discectomy has higher rates of SLF (10.4% vs. 6.2%), and faster time to SLF (2.4 vs. 1.9 years) at 8-year follow up.

Keywords: Lumbar disc hernation; Lumbar fusion; PearlDiver; Primary lumbar discectomy; Reoperation; Revision lumbar discectomy

Introduction

Lumbar discectomy comprises of the bulk of spinal procedures performed in the United States [1−5]. Common indications for lumbar discectomy include disc herniation, lumbar spinal stenosis, and cauda equina syndrome [6]. Despite the benefits afforded by this procedure the risk of disc reherniation looms, and roughly 6% of patients will experience same-level disc reherniation regardless of the discectomy technique used [7]. The risk factors that predispose patients to disc reherniation have yet to be completely elucidated, with large defects in the annulus fibrosis being the most well-known contributor [8]. Regardless, treatment typically involves a revision discectomy or fusion procedure. Revision discectomy is often preferred to fusion as it is less invasive and costly [9]. Conversely, fusion is the treatment of choice in the setting of instability, spinal deformity, or axial low back pain [10,11].

In considering the non-insignificant rate of disc reherniation highlighted above, understanding the outcomes of surgical treatment for disc reherniation is crucial for both physicians and patients alike. Yet, there is a paucity of literature regarding the subject. Studies conducted by Findley et al. [2] and Gaston and Marshall [3] demonstrated revision rates following primary lumbar microdiscectomy of 5.1% and 7.9% respectively at 10 years follow up. Additionally, Virk et al. [5] used two national databases (HORTHO, SAF5) and calculated a rate of revision discectomy following primary discectomy of 5.6% at 5 years follow up and 6.2% at 7 years follow up. While these studies define revision discectomy rates following primary discectomy, they fail to investigate the rates of subsequent revision discectomy (SRD) or subsequent lumbar fusion (SLF) in patients following completion of a revision discectomy procedure.

In light of these findings, the objectives of this study are twofold − firstly, we determined the 8-year SLF/SRD rates, and time until SLF/SRD following primary versus revision discectomy respectively. Secondly, we analyzed the effects of variables such as patient demographics and surgical history on these outcomes.

Methods

Patient population

A retrospective cohort study was conducted using the PearlDiver Mariner Orthopaedics Database (www.pearldiverinc.com, Fort Wayne, IN, USA). The national-level administrative database from years 2010 to 2019 which collectively contained >53 million patients was queried (including all payers and geographic regions); patients from the years 2010, 2011, and 2012 were included to satisfy a minimum of 8-year follow-up, and the remaining years were queried to assess for follow-up. These data sets allowed us to follow the patients longitudinally with inpatient data, prescriptions, International Classification of Disease, Ninth and Tenth Revision, (ICD-9 and ICD-10) diagnosis codes, and Current Procedural Terminology (CPT) procedure codes. From the data, two separate cohorts were created. First, all adult patients who underwent primary discectomy were included, and these patients were identified using CPT code 63030. Second, all adult patients undergoing revision discectomy were included, and these patients were identified using CPT code 63042. Both cohorts were cross-matched with ICD9/10 diagnosis codes of lumbar disc herniation (LDH, ICD-9 772.10, ICD-10 M51.26, M51.27). Patients with less than 8 years follow-up as well as those undergoing multilevel discectomy (CPT 63035, 63044), concurrent lumbar laminectomy (CPT 63047, 63005), or concurrent lumbar fusion (CPT 22558, 22612, 22633) were excluded.

Data collection

Preoperative demographic data was collected for each patient including age, gender, Charlson Comorbidity Index, geographic region, and insurance type. Outcome measures collected included rate of SLF (CPT 22558, 22612, 22633), time to SLF, rate of SRD (CPT 63042), and time to SRD. Data on time to subsequent surgery were collected prospectively in PearlDiver Mariner database.

Statistical analysis

Statistical analysis was performed using the embedded BellWeather statistical software within the PearlDiver database. A chi-square test was used to compare age, gender, CCI, region, and insurance type. A Kaplan-Meier survival analysis of time to SLF/SRD was performed on each cohort, and log-rank test was used to compare the rates of SLF/SRD between cohorts. Multivariate logistic regression was used to identify risk factors for SLF/SRD with $p<.05$ considered to be statistically significant.

Results

A total of 20,147 patients who underwent either an isolated single level primary or revision discectomy without concurrent laminectomy or fusion between 2010 and 2012

Table 1
Demographics

	Primary discectomy	Revision discectomy	p-value
Gender			
Male	9,083 (50.9%)	1,247 (54.3%)	<.01*
Female	8,766 (49.1%)	1,051 (45.7%)	
Age			
<40	4,656 (26.1%)	522 (22.7%)	<.01*
40−49	4,541 (25.4%)	620 (27.0%)	
50−59	4,456 (25.0%)	556 (24.2%)	
60−69	2,866 (16.1%)	399 (17.4%)	
70+	1,330 (7.5%)	201 (8.7%)	
CCI			
0	12,203 (68.4%)	1510 (65.7%)	.02*
1	3,400 (19.0%)	479 (20.8%)	
2	1,251 (7.0%)	152 (6.6%)	
3	529 (3.0%)	85 (3.7%)	
4+	466 (2.6%)	72 (3.1%)	
Region			
Midwest	5,337 (29.9%)	673 (29.3%)	.45
Northeast	3,159 (17.7%)	385 (16.8%)	
South	7,235 (40.5%)	953 (41.5%)	
West	2,092 (11.7%)	286 (12.4%)	
Insurance			
Commercial	15,088 (84.5%)	1,888 (82.2%)	<.01*
Government	266 (1.5%)	33 (1.4%)	
Medicaid	599 (3.4%)	80 (3.5%)	
Medicare	1,677 (9.4%)	280 (12.2%)	
Self Pay	49 (0.3%)	3 (0.1%)	

* Indicate statistically significant difference between cohorts (p<.05).

were identified. Total duration of follow up ranged between 8 to 10 years, with the majority of patients clustering around 8 years. Of those patients, 17,849 underwent primary discectomy and 2,298 underwent revision discectomy. In the revision cohort 54.3% of patients group were male, as opposed to 50.9% of patients in primary cohort (p<.01; Table 1). In the revision cohort 8.7% of patients were 70 years or older, in comparison to 7.5% of patients in the primary cohort (p<.01). The revision cohort had a greater percentage of patients with a high CCI (3: 3.7%, 4+: 3.1%) as opposed to the primary cohort (3: 3.0%, 4+: 2.6%) (p<.02). Additionally, patients undergoing revision discectomy were more likely to have Medicaid (3.5%) in comparison to those undergoing primary discectomy (3.4%) (p<.01), with commercial insurance as the most common plan across both revision and primary cohorts (82.2% and 84.5% respectively). Although statistically insignificant, patients in both cohorts were mostly from the South (revision: 41.5%, primary: 40.5%, p=.45).

Table 2.

The 8-year rates of SRD (6.1% in revision cohort, 4.8% in primary cohort) and SLF (10.4% in revision cohort, 6.2% in primary cohort) were higher after revision discectomy as opposed to primary. There was no difference between groups in terms of time to SRD. Time to SLF was shorter after revision versus primary discectomy (709 vs. 886 days). After both primary and revision discectomy, the 8-year incidence of SLF (10.4% in revision cohort, 6.2% in primary cohort) is greater than rate of SRD (6.1% in revision cohort, 4.8% in primary cohort).

As stated above, rates of SRD and SLF are higher after revision discectomy as opposed to primary discectomy. The rate of SRD appears to level off after 4 years in both cohorts, while the rate of SLF continues to increase through year 8 (Figure).

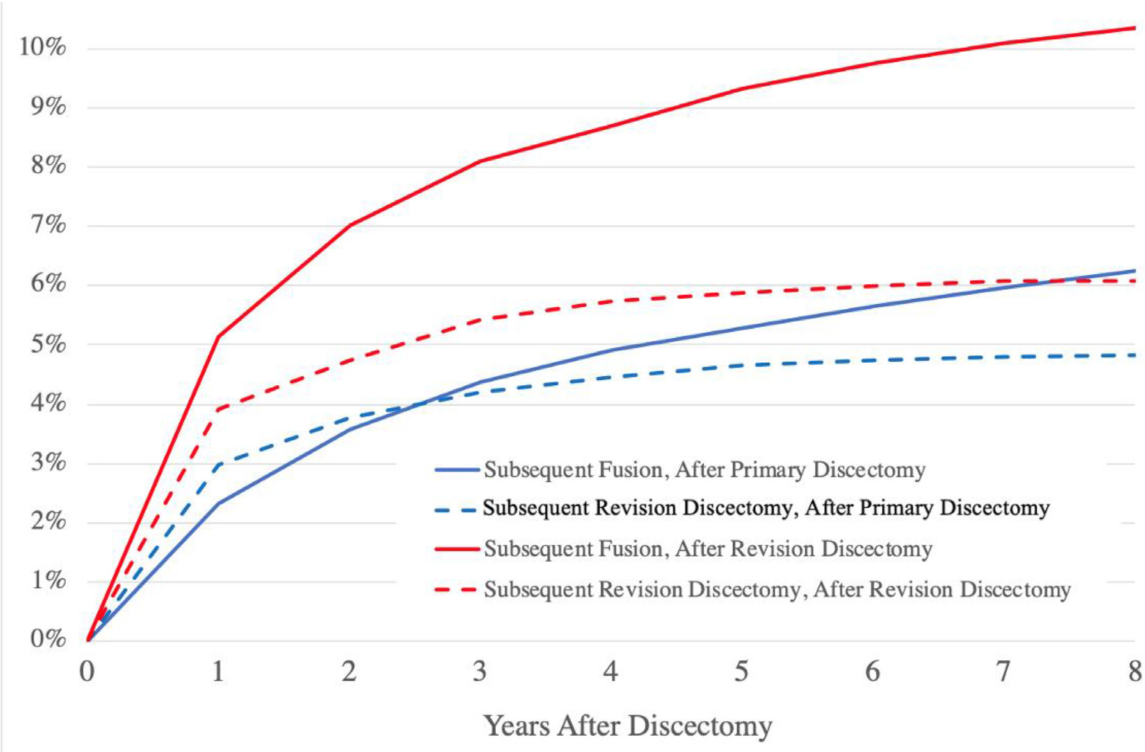
In multivariate analysis (Table 3) controlling for age, gender, CCI, geographic region, and insurance type, revision discectomy is associated with greater odds of SLF (OR: 1.78 [1.53−2.06], p<.01). Additionally, male gender was associated with lower odds of SLF (OR: 0.85 [0.76−0.96], p<.01), along with belonging to the Northeast region (OR: 0.8 [0.67−0.96], p<.01) as compared to the South (OR: 0.99 [0.87−1.14], p=.93). Self-pay insurance type (OR: 2.60, [1.06−5.43], p<.02) was associated with higher odds of SLF as compared to commercial insurance (Table 3). Medicaid (OR: 1.71 [1.30−2.20], p<.01), Medicare (OR: 1.38 [1.14−1.67], p<.01), and a higher CCI (OR: 1.07 [1.02−1.12], p<.01) were also associated with higher odds of SLF. When applying the same multivariate analysis to SRD (Table 4), only revision discectomy (OR 1.36 [1.09−1.68], p<.01) was associated with a statistically significant increase in the odds of SRD.

Discussion

The benefits of the PearlDiver database include its size (130 million patient records from 2009 to 2019) and its inclusion of patients with varying insurance coverage, allowing our study to have a larger sample size than previously published studies [2,3,5]. To our knowledge, our study is the first to determine the 8-year rate of patients undergoing SLF following primary or revision discectomy. We were also able to investigate which factors influence

Table 2
Incidence of index discectomy and reoperations

	Primary discectomy N=17,849	Revision discectomy N=2,298	p-value
8-y subsequent revision discectomy rate	4.80%	6.10%	<.01*
Time to subsequent revision discecromy, in days	493.6	432	.22
8-y subsequent lumbar fusion rate	6.20%	10.40%	<.01*
Time to subsquent fusion, in days	885.7	709.3	<.01*



Years	Primary Discectomy Number at Risk	Revision Discectomy Number at Risk
0	17849	2298
1	16867	2089
2	16528	2027
3	16421	1990
4	16153	1970
5	16100	1954
6	15992	1942
7	15921	1930
8	15886	1919

Figure. Eight years Reoperation Rates. An 8-y Kaplan-Meier survival analysis of time to subsequent lumbar fusion/subsequent revision discectomy. This analysis was performed on each cohort, and the numbers-at-risk are supplied in the figure as well.

the odds of a patient undergoing either SLF/SRD. Although the natural history of the degenerated lumbar spine lends itself to reoperation, any additional procedure required following the index surgery represents a failure of the intervention of choice; therefore, understanding the rates of reoperation of discectomy becomes imperative for surgeons if they are to comment on the clinical success of lumbar discectomy.

We found an 8-year SRD rate of 4.8% in the primary cohort and 6.1% in the revision cohort. The rate of SRD in the primary cohort was comparable to that reported by Gaston and Marshall [3], who found an overall rate of revision of 4.9% at a mean follow up of 5.25 years following primary lumbar microdiscectomy. Virk et al. [5] reported rates of revision surgery between 5.6% to 6.2% at 7 years after primary discectomy, which is consistent with the rate of SRD found in our revision cohort as opposed to the primary cohort. This discrepancy in results could be attributed to the smaller sample sizes present in their study (HORTHO and SAF5 databases yielded sample sizes of 147 and 305 patients respectively). PearlDiver includes these databases as well as others, allowing for a larger and more nationally representative sample in our study. Additionally, Virk et al. defined revision surgery as not only revision discectomy, but also more extensive decompressive procedures with or without fusion; this broader definition would partially explain the heightened rate of revision they found.

The rate of SRD across both of our cohorts has a statistically significant but small difference of 1.3%, which is likely clinically insignificant. This identically low rate in both cohorts gives rise to two opposing interpretations. The first viewpoint revolves around preventing unnecessary

Table 3
Multivariate logistic regression for odds of subsequent lumbar fusion

	Odds ratio for subsequent fusion (95% confidence interval)	p-value
Primary discectomy	Reference	-
Revision discectomy	1.78 (1.53−2.06)	<.01*
Age, by year	1.00 (0.99−1.00)	.41
CCI, by unit	1.07 (1.02−1.12)	.01*
Gender		
Male	0.85 (0.76−0.96)	.01*
Female	Reference	-
Geographic region		
Midwest	Reference	-
Northeast	0.80 (0.67−0.96)	.01*
South	0.99 (0.87−1.14)	.93
West	0.86 (0.70−1.05)	.13
Insurance Type		
Commercial Insurance	Reference	-
Self Pay	2.60 (1.06−5.43)	.02*
Government Insurance	1.18 (0.73−1.80)	.48
Medicaid	1.71 (1.30−2.20)	<.01*
Medicare	1.38 (1.14−1.67)	<.01*

* Indicate statistically significant difference between cohorts (p<.05).

healthcare resource use; the similar rate of SRD across both revision and primary discectomy cohorts implies that a revision discectomy does not protect against patients necessitating further interventions in the form of SRD. To avoid a patient receiving a potentially ineffective and costly second/third discectomy, it may be prudent for clinicians to advise non-operative alternatives. Kim et al. found that all adjusted PROMs significantly improved after both non-operative and operative treatment for LDH. The non-operative cohort showed less immediate improvement at 1 month in certain surveys, but the authors observed no difference between cohorts thereafter for 24 months [12]. The second consideration is that an SRD rate between 4.6% and 6.1% amounts to an acceptably low anticipated reoperation rate following primary or revision discectomy, and is therefore acceptable course of treatment; moreover, due to the inherent long-term drawbacks of fusion such as adjacent segment disease and decreased mobility, an additional discectomy may be inherently more desirable than opting for fusion. Ultimately, in the context of disc reherniation, selecting between conservative care or a subsequent discectomy necessitates a combination of clinical judgement and shared decision making with patients, as physicians must assess a wide variety of factors at play before settling on a course of treatment.

Heindl et al. also used the PearlDiver database and found that patients underwent lumbar fusion at a rate of 5.9% within 4 years after primary single-level discectomy. Furthermore, they stated that patients receiving a re-exploratory discectomy within 2 years of the index procedure went on to undergo lumbar fusion at a rate of 38.4% within 4 years of the re-exploration procedure [13]. We found the 8-year SLF rate to be 6.2% in the primary cohort and 10.4% in the revision cohort. While the subsequent fusion rate following primary discectomy in the Heindl et al. study is comparable to our findings, there is a large difference in the rate of subsequent fusion following revision discectomy (38.4% vs. 10.4%). The higher rate found in Heindl et al.'s study could partially be attributed to their cohort criteria, as patients were sorted into fusion, laminectomy, or discectomy cohorts solely from last procedure they received within a pre-defined follow up period; this could also lead to an underestimation of the number of patients undergoing revision laminectomy or discectomy, while inflating the observed rate of fusion. Despite the statistical significance of a 4.2% difference in the rate of fusion of our two cohorts, the clinical implications are more nuanced; in the case of a reherniated post-primary discectomy patient, this difference may not be large enough to warrant opting for a fusion over a second discectomy with the anticipation of a fusion as the likely outcome even after a second discectomy, especially when considering the aforementioned limitations of fusion. Conversely, the higher rate of SLF versus SRD in the revision discectomy cohort could suggest that when faced with the potential for a third discectomy, either surgeons or patients to prefer to opt for fusion. Lakkol et al. in their study on lumbar interbody fusion as a treatment for patients with recurrent symptoms after discectomy also found that patients are less likely to experience subsequent lumbar surgeries if fusion is their first operation as opposed to discectomy [14]. This could potentially reflect the inadequacy of discectomy for addressing lumbar spine pathology in a subset of patients who have already received discectomy. Aspects of their pathology such as the size of annular defect

Table 4
Multivariate logistic regression for odds of subsequent revision discectomy

	Odds ratio for subsequent fusion (95% confidence interval)	p-value
Primary discectomy	Reference	-
Revision discectomy	1.36 (1.09−1.68)	.01*
Age, by year	0.99 (0.98−0.99)	<.01*
CCI, by unit	1.00 (0.94−1.06)	.97
Gender		
Male	0.89 (0.78−1.02)	.09
Female	Reference	-
Geographic region		
Midwest	Reference	-
Northeast	0.95 (0.78−1.16)	.64
South	0.97 (0.83−1.13)	.7
West	1.07 (0.86−1.33)	.55
Insurance type		
Commercial insurance	Reference	-
Self Pay	0.00 (0.00−0.01)	.95
Government insurance	1.23 (0.73−1.94)	.4
Medicaid	1.28 (0.92−1.73)	.12
Medicare	0.90 (0.68−1.16)	.42

* Indicate statistically significant difference between cohorts (p<.05).

and the type of herniation could contribute to this resistance to treatment [15,16]. For these patients, a fusion procedure could avoid the costs associated with a potentially ineffective SRD while also providing more satisfactory treatment. However, guidance on determining which patients are more suitable or resistant to discectomy is beyond the scope of our study.

We found males had lower odds of experiencing SLF. While several studies have found that gender does not influence rate of recurrent herniation after discectomy [17−19], it has been shown that males have a lower incidence of degenerative spine disease compared to females [20,21]. This could potentially be due to the increased incidence of osteoporosis in women, as compared to men. Osteoporosis is associated with degenerative changes in the spine, fractures, spinal stenosis, and progressive spinal deformities [22]; any of these pathologies may contribute to increased spinal instability post discectomy and necessitate an instrumented approach [23]. Additionally, literature suggests that men and women experience differential satisfaction with lumbar spine procedures, so perhaps after a failed index discectomy women were more amenable to alternative procedures [24]. Ultimately the underlying cause for this difference remains unknown and is suitable for investigation by future studies.

Revision discectomy was associated with greater odds of SLF. The greater odds of SLF in this scenario may demonstrate a preference for fusion as a follow up to failed revision discectomy by patients and physicians alike. Fusion potentially forms a more definitive treatment option [25]. Yao et al. found in patients requiring revision for a recurrent LDH that despite yielding greater satisfaction in the 3-month postoperative period, percutaneous endoscopic lumbar discectomy was associated with a higher rate of disc reherniation in a 12 month period as opposed to MIS-TLIF.

Our study also identified a higher CCI as a factor that increases the odds of SLF. Huang et al. identified several factors which influence the rate of recurrent lumbar herniation including smoking, disc protrusion, and diabetes mellitus [18]. These findings suggest that the influence of CCI on SLF could be due to patients with more comorbidities experiencing reherniation at a greater rate, leading to reoperation. However, this would not explain the absence of any effect of CCI on the odds of SRD. This differential effect may pertain to the specific nature of the comorbidities a patient has; surgeons may opt for one treatment over another while considering these concomitant conditions. Our study does not investigate the indications for choosing discectomy or fusion in either cohort, so we are unable to comment on the etiology of this further.

Virk et al. reported no differences in revision discectomy rate in varying geographic regions. In contrast, we found patients in the Northeast had lower odds of SLF [5]. While it is possible patients in this region fare better following primary discectomy, it is more likely physicians and patients in this region prefer SRD as opposed to SLF following failure of primary surgery. Even though clear indications and guidelines exist for determining whether a fusion or discectomy is appropriate, studies indicate that spine surgeons display marked variability in decisions to operate or perform a fusion [26,27]. Additionally, self-pay insurance, Medicaid, and Medicare were all associated with higher odds of SLF. Deyo et al. may explain this, as they concluded that Medicare patients in the years 2002 to 2007 were experiencing increasing rates of superfluous complex spinal procedures, resulting in inflated complication rates, resource use, and 30-day mortality [28]. Lopez et al. found from 2012 to 2017 that the Medicare population experienced an increase in the volume of lumbar fusions, whereas the volume of lumbar discectomy and microdiscectomy had fallen [29]. Our odds ratio analysis potentially captured the increasing popularity of lumbar fusion in these insurance populations. Regardless, the interplay between socioeconomic factors and insurance type in relation to fusion and discectomy outcomes is sparsely studied and requires further investigation.

Our study has several limitations. Relying on physician or hospital billing of ICD and CPT codes allows for incongruities between claims databases and chart reviews. However, to be adequately compensated and avoid fraud, both physicians and hospitals must accurately bill and code to third party payers. Due to the limitations of PearlDiver and patient selection via CPT codes, more granular information such as the specific type of discectomy (microdiscectomy or endoscopic discectomy etc.) is unavailable. Our study does not contain data regarding the indication for reoperation nor the reasoning for selecting SRD or SLF, as this data is not available in the PearlDiver database (a limitation common to many insurance database studies). A plethora of factors could influence this choice, including the nature of the recurrent lumbar herniation, progression of degenerative disease, or other comorbid conditions. Therefore, we can only make inferences as to why certain risk factors influence SLF or SRD rates. While our study population is relatively large, it is only representative of the United States and may not be applicable to other nations or communities.

Declarations of competing interests

The authors report no conflicts of interest relevant to the topic of this study.

Acknowledgment

This study was not supported by any kind of funding.

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