Title

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Journal

Global spine journal, 12(8)

ISSN

2192-5682

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Publication Date

2022-10-01

DOI

10.1177/2192568220986148

Original Article

AO SPINE

Global Spine Journal
2022, Vol. 12(8) 1708–1714

DOI: 10.1177/21925682209861 48
journals.sagepub.com/home/gsj

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Reoperation and Mortality Rates Following Elective 1 to 2 Level Lumbar Fusion: A Large State Database Analysis

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Abstract

Study Design: Retrospective cohort.

Objective: Reoperation to lumbar spinal fusion creates significant burden on patient quality of life and healthcare costs. We assessed rates, etiologies, and risk factors for reoperation following elective 1 to 2 level lumbar fusion.

Methods: Patients undergoing elective 1 to 2 level lumbar fusion were identified using the Health Care Utilization Project (HCUP) state inpatient databases from Florida and California. Patients were tracked for 5 years for any subsequent lumbar fusion. Cox proportional hazard analyses for reoperation were assessed using the following covariates: fusion approach type, age, race, Charlson comormidity index, gender, and length of stay. Distribution of etiologies for reoperation was then assessed.

Results: 71,456 patients receiving elective 1 to 2 level lumbar fusion were included. A 5-year reoperation rate of 13.53% and mortality rate of 2.22% was seen. Combined anterior-posterior approaches (HR = 0.904, $p < 0.05$) and TLIF (HR = 0.867, $p < 0.001$) were associated with reduced risk of reoperation compared to stand-alone anterior approaches and non-TLIF posterior approaches. Age, gender, and number of comorbidities were not associated with risk of reoperation. From 1 to 5 years, degenerative disease rose from 43.50% to 50.31% of reoperations; mechanical failure decreased from 37.65% to 29.77%.

Conclusions: TLIF and combined anterior-posterior approaches for 1 to 2 level lumbar fusion are associated with the lowest rate of reoperation. Number of comorbidities and age are not predictive of reoperation. Primary etiologies leading to reoperation were degenerative disease and mechanical failure. Mortality rate is not increased from baseline following 1 to 2 level lumbar fusion.

Keywords

humans, retrospective studies, spinal fusion, reoperation, inpatients, risk factors, quality of life, lumbar vertebrae, length of stay, health care costs

Introduction

Lumbar spinal fusion procedures are a potential treatment option for the increasingly common degenerative spinal pathologies affecting the population.[1,2] Since surgical treatment of degenerative pathology is performed on an elective basis, it is important to counsel patients on potential risks to surgery, including reoperation, morbidity, and mortality.[3,4] Failed lumbar fusion requiring reoperation may cause persistent low back pain, physical disability, and depression.[5,6] Revision surgery often presents additional technical challenges to surgeons,[6] and has a reported direct financial cost consistently over $50,000 per revision, adding significant cost to that of index fusion[7,8] While many studies have attempted to quantify the rate and causes of reoperation, there has yet to be a large cohort analysis

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of reoperation rates and etiologies of reoperation following elective 1 to 2 level lumbar fusions (LF).

Of the studies that have looked at risk factors for reoperation, many of them have been underpowered or have a mixed patient population (decompression alone versus fusion). With a sample size of only 163, Sato et al. found a reoperation rate of 23.2% for surgical treatment of degenerative spondylolisthesis at minimum 5-year follow-up, with male gender and facet degeneration identified as independent risk factors.[9] Gerling et al. found that presenting without a neurological deficit was a risk factor for reoperation in the setting of lumbar stenosis, although only 11% of their 417 included patients had undergone initial fusion.[10] In a study of 22,151 elective lumbar posterior spinal fusion (PSF) patients, Durand et al. found BMI >35, multilevel fusion, bleeding disorders, weight loss >10% in 6 months prior to surgery and disseminated cancer to be risk factors for reoperation; however these patients were only followed for 30-days post-surgery.[11] Furthermore, these studies did not quantify the predominant etiologies leading to reoperation. Thus, there remains a need for well-powered studies with long-term outcomes focused specifically on risk factors and associated etiologies of reoperation after lumbar fusion.

The purpose of this study is to identify the rate of reoperation, etiologies, and potential risk factors for reoperation at a minimum of 5-year follow-up after elective 1 to 2 level lumbar fusion. **We hypothesize that patient-specific factors such as age and number of comorbidities will play a significant role in determining risk for reoperation following primary lumbar fusion.**

Methods

Data Collection

In this retrospective cohort study, data for adult patients undergoing 1 to 2 level lumbar fusions in Florida (2005-2014) and California (2005-2011) were extracted from the **Health Care Utilization Project (HCUP) state inpatient databases. These databases collectively encompass diagnostic and procedural data from all inpatient hospital discharges in included states, regardless of insurance payer.** Included cases were identified via International Classification of Diseases, ninth Reoperation Clinical Modification (ICD-9 CM) diagnosis codes. Patients receiving 1 to 2 level lumbar fusion with subsequent elective hospital admission were included. Patients who were admitted for trauma or had emergency, urgent, or unknown admission status were excluded. The patients were followed for 5 years and any subsequent reoperation thoracolumbar fusions were identified.

Informed Consent and IRB Approval

The data used for analysis did not include personal identifier information at any point, and thus is considered non-human subjects research by the UCSF Human Research Protection Program (HRPP). This study was therefore exempt from need for approval by an institutional review board (IRB) and exempt from need for direct informed consent.

Statistical Analysis

Reoperation rate was calculated by the percentage of patients in the stated cohort who received reoperation surgery within 5 years. Statistical significance was performed with the R software using the "coxph" function in the "Survival" package to obtain multivariate Cox proportional hazard ratios (https://cran.r-project.org/web/packages/survival/survival.pdf). The following covariates were included: fusion approach type, age at fusion, race, Charlson comormidity index (CCI), gender, and length of stay for fusion surgery. **Fusion approach included transforaminal lumbar interbody fusion [TLIF], all other posterior lumbar fusions without TLIF [PLF], anterior approach lumbar fusions [ALF], and combined anterior and posterior approaches [ALF_PLF]). Lateral lumbar interbody fusions (LLIF), oblique lumbar interbody fusions (OLIF), and anterior lumbar interbody fusions (ALIF) were included within** 1 **category of anterior approaches (ALF) due to grouping in HCUP. The Charlson comorbidity index is the most widely-used method to quantify comorbidities using ICD9 coding data, as was assessed in this study.**[12] Age, length of stay, and comorbidites were included as continuous variables, while fusion type and self-identified race were categorical variables. First, inital Cox proportional hazard analysis for overall reoperation rate was performed, right-censoring for mortality. Second, we assessed the distribution of causes for reoperation surgery, including the following causes.

Reoperation due to:

1. Degenerative Disease (Proximal Junction Kyphosis, Adjacent Segment Disease, Spondylosis, or Degenerative Disc Disease)
2. Infection
3. Mechanical Failure (Including pseudarthrosis)
4. Postlaminectomy Syndrome
5. Stenosis
6. Other

Classification of cause for reoperation surgery was performed using categorization of ICD9 diagnoses coded at time of reoperation surgery.

Results

The overall patient cohort included 77,349 patients receiving 1 to 2 level lumbar fusion, including 71,456 with elective admission for fusion that were included in analysis. In the 5 years following fusion, 9,670 revisons were recorded and 1,585 deaths for a 5-year reoperation rate of 13.53% and mortality rate of 2.22%. **When grouped by decade of life at fusion, reoperation rate at** 5 **years was greatest for those 60-69 years at index fusion (16.44%)** [Table 1, Figure 1]. Age was not associated with risk of all-cause reoperation on univariate or multivariate analysis.

Gender was also not associated with signficant difference in reoperation rate. Asian ancestry was associated with significantly decreased risk of reoperation compared to Black (HR = 1.586, 95% CI = 1.217-2.066, p < 0.001), Hispanic (HR = 1.485, 95% CI = 1.148-1.922, p = 0.003), and White ancestry (HR = 1.742, 95% CI = 1.360-2.233, p < 0.0001) (Figure 2).

Combined anterior and posterior approach, ALF with PLF (HR = 0.904, 95% CI = 0.819-0.999, p < 0.05) and TLIF (HR = 0.867 95% CI = 0.803-0.935, p < 0.001) were associated with reduced risk of reoperation compared to stand-alone anterior approach (ALF) and other posterior approaches (PLF) [Figure 3].

Length of stay for fusion surgery was associated with increased risk of reoperation (HR = 1.007, 95% CI = 1.000-1.013, p = 0.039). Number of comorbidities at fusion was not associated with increased risk of reoperation, although a peak in reoperation rate was seen with a moderate number of comorbidites (2), rather than absent or higher number of comorbidities (Table 2, Figure 4).

In order to ascertain the predominant etiologies of reoperation among patients receiving 1 to 2 level lumbar fusions, we performed a competing-risks analysis with the aforementioned causes of reoperation. Of the 7 competing risks, the most prevalent outcomes were (percent of the 9,670 reoperations at 1 and 5 years):

1. Degenerative disease reoperation (1 year = 43.50%, 5 years = 50.31%)
2. Mechanical failure reoperation (1 year = 37.65%, 5 years = 29.77%)
3. Stenosis reoperation (1 year = 7.17%, 5 years = 10.18%)

Reoperation distribution for post-laminectomy syndrome was 2.71%, infection 2.14%, and for an uncategorized reason, "Other" 4.89% (Table 3, Figure 5). Additionally, a mortality rate of 2.2% was seen within 5 years (Table 4).

Table 1. Overall 5-Year Reoperation and Mortality Rate.

Reoperation Period	1 Year	2 Year	3 Year	4 Year	5 Year
Total Reoperations	2956	5482	7202	8655	9670
Reoperation Rate (%)	4.14	7.67	10.08	12.11	13.53
Mortalities	340	624	896	1227	1585
Mortality Rate (%)	0.48	0.87	1.25	1.72	2.22

Discussion

Our study found a 13.5% reoperation rate and 2.2% mortality rate in adult patients undergoing elective 1 to 2 level primary lumbar fusion. Notably, isolated anterior or non-TLIF posterior fusion approaches, increased length of stay, and self-identified ancestry of Black, White and Hispanic (compared to Asian ancestry), were found to be independent risk factors for reoperation within 5 years of surgery. As expected, increased age, comorbidities, and length of stay for fusion were independently associated with mortality on multivariate analysis. Furthermore, the mortality rate of 2.2% by 5 years from index fusion is approximately representative of mortality rate across the U.S. population for the age distribution of this study (median 58 years, mean 57.09 years).[13] **It is notable that lumbar fusion surgery does not significantly raise risk of long-term mortality (within 5 years).**

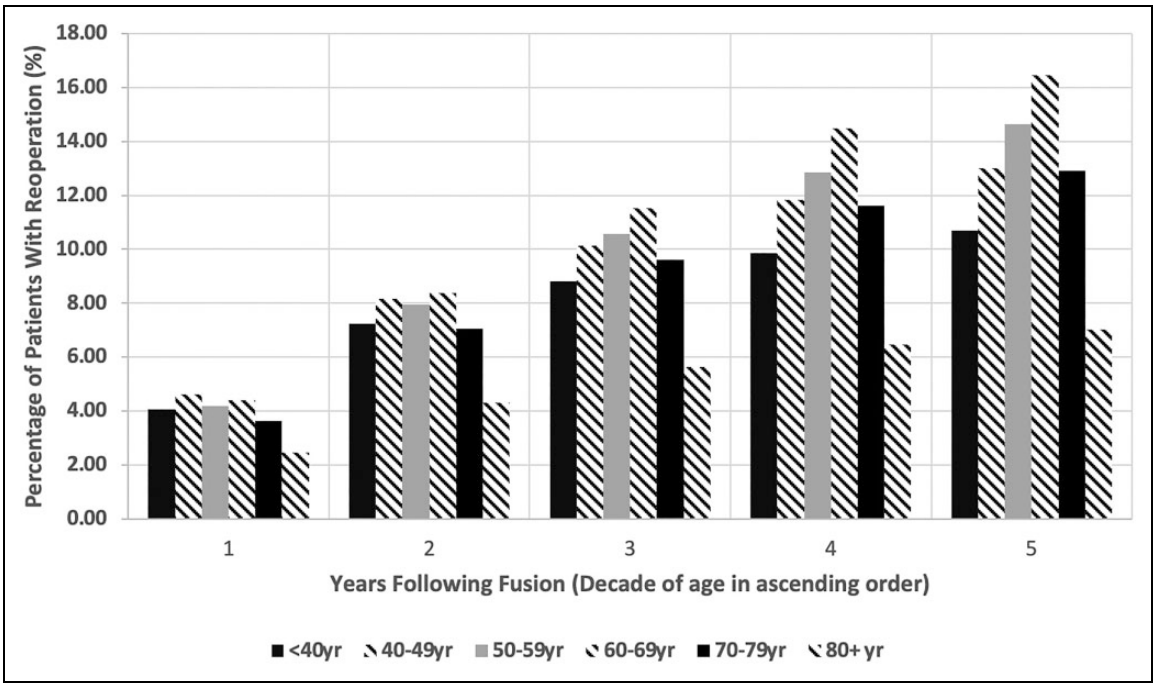

Figure 1. Age and reoperation rate for 1 to 2 level lumbar fusion.

Previous work has shown reduced fusion rate by stand-alone anterior approaches (ALF) compared to combined ALF with PLF. Combining ALIF with pedicle screw fixation for 1 to 2 level lumbar fusion has been shown to raise fusion rate from 65% to 100% at mean follow-up of 19 months,[14] and similarly high fusion rate (97%) in patients with stand-alone ALIF using posterior pedicle fixation with a follow-up of 2 years.[15] This analysis may confirm these findings, showing stand-alone anterior approaches are associated with increased reoperation rate—particularly within the first year following fusion. However, interpretation is limited by including other anterior approaches with ALIF. It is notable that, in this study, anterior approaches (ALF) have the highest reoperation risk at 1 year, while reoperation rate for non-TLIF posterior approaches (PLF) seem to approach that of ALF with increased time. By 5 years, combined anterior and posterior approaches and TLIF have lower reoperation risk compared to stand-alone ALF or PLF (Figure 3).

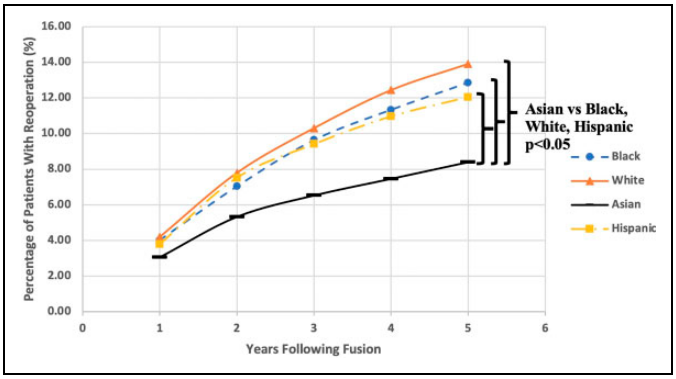

Figure 2. Race/ancestry and reoperation rate for 1 to 2 level lumbar fusion.

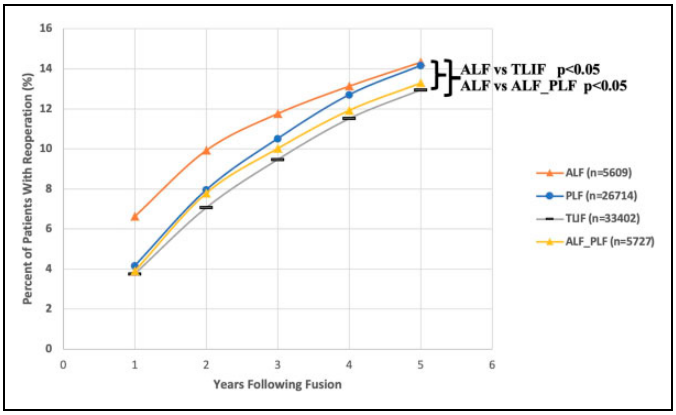

Figure 3. Fusion case type and reoperation rate for 1 to 2 level lumbar fusion.

While there is literature showing higher patient satisfaction following stand-alone anterior approaches compared to anterior and posterior approaches, this study and recent literature point toward improved fusion rates and decreased rate of reoperation with combined interbody and posterior fusion.[16,17] Long-term prospective study and meta-analysis has demonstrated superiority of circumferential fusion over posterolateral fusion (PLF) by lower reoperation rate, in addition to metrics such as quality-adjusted life years (QALYs).[18,19] This work suggests possible superiority of circumferential fusion, and TLIF, compared to stand-alone anterior lumbar fusion approaches (ALF) or other posterior approaches (PLF).

Beyond fusion approach, hospital length of stay (LOS) for primary fusion was associated with increased risk of all-cause reoperation. **The relationship between LOS and reoperation risk may be due to factors not included in multivariate analysis, such as greater complexity of surgical cases and level of disability.** Race also had a significant effect on reoperation rate, with Black, Hispanic and White patients having markedly elevated risk of reoperation compared to Asian

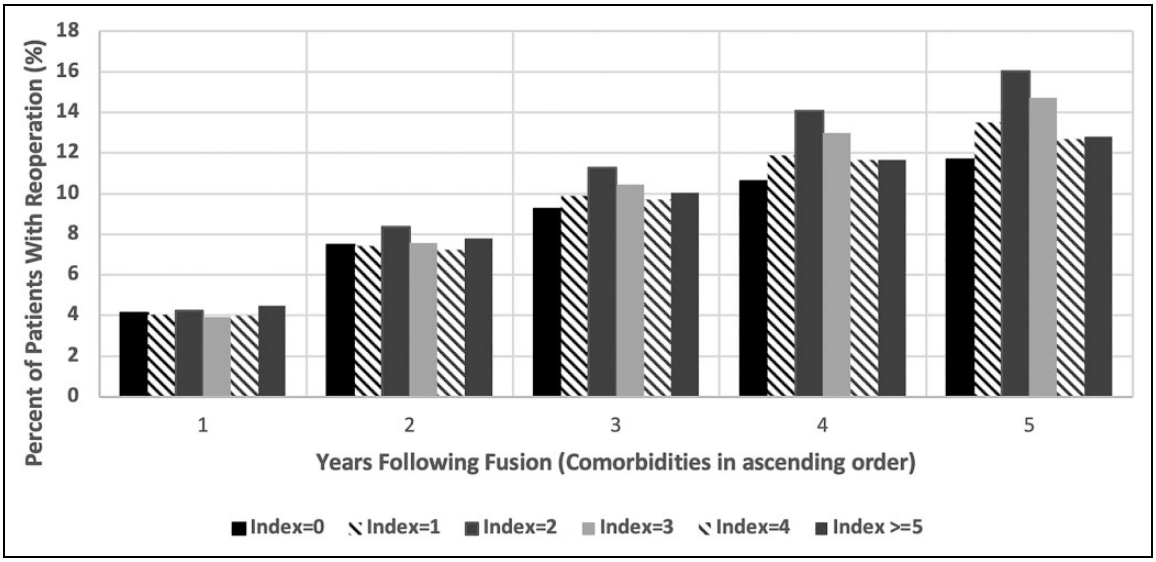

Figure 4. Charleston cormorbidity index and reoperation rate for 1 to 2 level lumbar fusion.

Table 2. Cox Proportional Hazard Ratios for Overall Reoperation Over 5 Years.

	Hazard Ratio	Lower 95% CI	Upper 95% CI	p-value
Fusion Case Type ALF	Reference	Reference	Reference	Reference
Fusion Case Type ALF_PLF	0.904	0.819	0.999	0.047
Fusion Case Type Other	0.000	0.000	1.76E+158	0.958
Fusion Case Type PLF	0.956	0.884	1.033	0.254
Fusion Case Type TLIF	0.867	0.803	0.935	2.223E-04
AGE	1.000	0.997	1.002	0.664
Charlson Comorbidity Index	1.013	0.996	1.030	0.129
Gender Female	Reference	Reference	Reference	Reference
Gender Male	0.973	0.935	1.014	0.190
Gender Undetermined	1.055	0.645	1.725	0.831
Race/Desc Asian	Reference	Reference	Reference	Reference
Race/Desc Black	1.586	1.217	2.066	0.001
Race/Desc Hispanic	1.485	1.148	1.922	0.003
Race/Desc Native American	1.647	0.754	3.596	0.210
Race/Desc Other	1.318	0.974	1.784	0.074
Race/Desc White	1.742	1.360	2.233	1.149E-05
Length of Stay	1.007	1.000	1.013	0.039

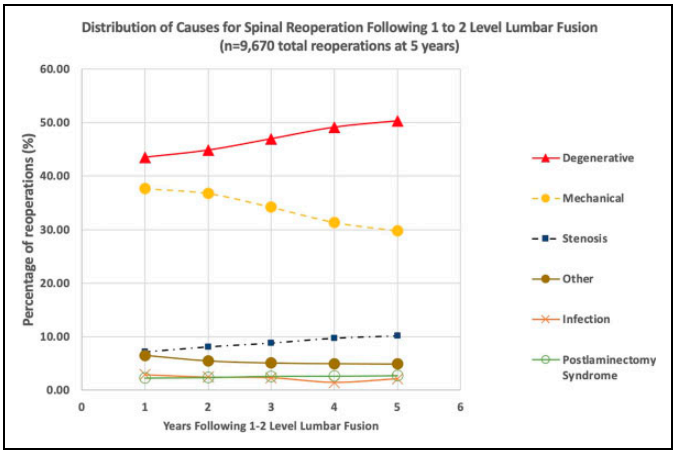

Figure 5. Distribution of causes for spinal reoperation following 1 to 2 level lumbar fusion (n = 9,670 total reoperations at 5 years).

patients. While racial disparities in lumbar spine surgery have been previously reported, reduced risk of reoperation with Asian ancestry has not yet been reported, to the best of our knowledge.[20] As this study did not incorporate socioeconomic factors into analysis, these and other confounding variables may explain variation in reoperation outcome by race.

Distribution of etiologies for reoperation following 1 to 2 level lumbar fusion demonstrated degenerative disease, mechanical failure, and stenosis as primary factors leading to reoperation surgery, with very few patients receiving reoperation surgery for infectious complications (2.14% of reoperations). This result holds despite infection contributing to a large amount rehospitalizations in the post-operative period following elective lumbar fusion.[21] Within 30 days of elective fusion, as many as 4.5% of patients may be hospitalized for infection, but infectious complication will very rarely lead to procedural intervention such as instrumentation removal or reoperation fusion.[22,21] It is promising that reoperation for infectious cause is largely limited in the setting of elective spinal fusion, although infectious complication remains a significant complication of interest.

The low rate of reoperation seen for post-laminectomy syndrome (PLS = 2.71% of reoperations) should be expected with correct selection of patients. Cases of PLS requiring reoperation surgery would likely have a more identifiable degenerative or mechanical cause, while psychosomatic causes of PLS—with no spinal anatomic cause identified—would not be appropriate candidates for reoperation surgery.[23] The relatively high proportion of reoperations for degenerative disease, mechanical failure, and stenosis compared to infrequent reoperation for PLS therefore indicate appropriate selection of patients for reoperation surgery following 1 to 2 level lumbar fusion. Reoperation cases due to degenerative disease or stenosis both may be associated with adjacent segment disease (ASD).[24] **Notably, the proportion of reoperations from degenerative disease rose from 1 to 5 years (43.50% to 50.31%), as for stenosis (7.17% to 10.18%), while mechanical failure declined in relative incidence from 1 to 5 years following fusion (37.65% to 29.77% of reoperations).**

While these findings present large-scale trends in risk factors and reasons for reoperation following 1 to 2 level lumbar fusion, there are several limitations of this study. As a large database study, we do not capture factors such as indication for primary fusion and patient-specific anatomy, which may limit applicability to individual patients. A further limitation is lack of granularity in operative details from HCUP, such as the inclusion of LLIF, OLIF, and ALIF procedures within ALF anterior fusion approach. Diagnoses at reoperation surgery may also be susceptible to bias in coding, which may confound results of cause-specific reoperation rates. However, to our knowledge, this is the largest study evaluating risk factors for reoperation in patients who undergo 1 to 2 level fusion.

Table 3. Cause-Specific Reoperation and Mortality Following Elective 1 to 2 Level Lumbar Fusion.

	1 Year	2 Year	3 Year	4 Year	5 Year
Overall Reoperation	2956	5482	7202	8655	9670
Overall Reoperation Rate	4.14	7.67	10.08	12.11	13.53
Degenerative Reoperations	1286	2458	3382	4252	4865
Proportion of Reoperations (%)	43.50	44.84	46.96	49.13	50.31
Infection Reoperations	86	134	168	123	207
Proportion of Reoperations (%)	2.91	2.44	2.33	1.42	2.14
Mechanical Reoperations	1113	2015	2463	2715	2879
Proportion of Reoperations (%)	37.65	36.76	34.20	31.37	29.77
Postlaminectomy Synd Reoperations	67	130	187	226	262
Proportion of Reoperations (%)	2.27	2.37	2.60	2.61	2.71
Stenosis Reoperations	212	445	636	843	984
Proportion of Reoperations (%)	7.17	8.12	8.83	9.74	10.18
Other Reoperations	192	300	366	429	473
Proportion of Reoperations (%)	6.50	5.47	5.08	4.96	6.50
Mortality	340	624	896	1227	1585
Mortality Rate (%)	0.48	0.87	1.25	1.72	2.22

Table 4. Mortality Significant Covariates.

	Hazard Ratio	Lower 95% CI	Upper 95% CI	p-value	Adjusted p-value
AGE	1.028	1.022	1.034	1.74E-21	5.69E-20
Charlson Comorbidity Index	1.334	1.301	1.369	4.47E-110	4.38E-108
Length of Stay	1.026	1.019	1.032	4.43E-15	1.08E-13

Conclusion

This large-database retrospective study confirms an approximate reoperation rate of 13.5% following elective 1 to 2 level lumbar fusion, predominantly owing to degenerative disease and mechanical failure. While degenerative disease causes progressively more reoperations over time following fusion, risk of mechanical failure reduces steadily with time. **Long-term mortality rate following 1-2 level lumbar fusion approximates that of the general population. Controlling for age, comorbidities, race, and length of stay, circumferential surgical approaches and TLIF carry reduced risk of reoperation compared to stand-alone ALF and posterior approaches without TLIF. This effect size, however, may not be clinically meaningful (from about 14% to 13% reoperation rate at 5 years).** Future work may aim to assess surgical approach with more granularity, and risk of reoperation based on factors such as indication for fusion, case complexity, and intra-operative complications. Understanding the effect of such patient-specific variables may allow improved patient counseling, risk assessment, and prevention of reoperation following elective lumbar fusion.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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