# Patient Factors Associated with Recurrent Herniation and Revision Surgery following Lumbar Microdiscectomy

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**Abstract:**

**Introduction:** Lumbar microdiscectomy is a commonly conducted surgical procedure for treating symptomatic lumbar disc herniations. Recurrence of herniation is a common cause of poor outcomes and the need for revision surgery, which occurs in as many as 21% of patients following primary discectomy. Identifying factors that are associated with the recurrence of herniation may be valuable for risk stratification and patient counseling. This study aimed to explore the relationship between various patient demographic variables and comorbidities and rates of reoperation after primary lumbar microdiscectomy.

**Methods:** The American College of Surgeons National Surgical Quality Improvement Program database was queried for patients who were undergoing single-level primary lumbar microdiscectomy between 2016 and 2022. Eligibility for inclusion was determined by age >18 years and current procedural terminology codes 63030 and 63042. Patients with preoperative sepsis or cancer were excluded. Patient demographics, including age, race, ethnicity, and body mass index (BMI), and various comorbidities were compared between cohorts. To determine factors independently associated with the need for revision microdiscectomy, multivariable Poisson regressions were utilized.

**Results:** In this study, a total of 65,121 primary discectomy patients were included, with a separate cohort of 6,971 patients undergoing revision discectomy. In comparison with primary patients, the revision cohort was older and had higher proportions of female and non-Hispanic White patients (all *c*0.001). The odds ratio for revision discectomy was greater in patients aged ≥65 years (1.577, 95% CI [1.480, 1.680]) than in those aged <45 years ($p$>0.001). The odds ratio for revision was lower in Black (0.821, 95% CI [0.738, 0.914]) and Hispanic patients (0.819, 95% CI [0.738, 0.909]) when compared with non-Hispanic White patients ($p$<0.001). Obese patients with BMI ≥35 (1.193, 95% CI [1.103, 1.290]) were at greater risk of revision than those with BMI <25 ($p$<0.001). Diabetes (1.326, 95% CI [1.242, 1.416], $p$<0.001), functional dependence (1.411, 95% CI [1.183, 1.683], $p$<0.001), chronic obstructive pulmonary disorder (1.315, 95% CI [1.137, 1.512], $p$<0.001), hypertension (1.398, 95% CI [1.330, 1.470], $p$<0.001), and smoking (1.082, 95% CI [1.018, 1.151], $p$=0.012) were associated with greater risk of revision. Poisson log-linear regression demonstrated sex ($\chi^2$=19.9, $p$<0.001), race ($\chi^2$=39.5, $p$<0.001), diabetes ($\chi^2$=10.1, $p$=0.001), smoking ($\chi^2$=18.5, $p$<0.001), hypertension ($\chi^2$=16.4, $p$<0.001), age ($\chi^2$=102.4, $p$<0.001), and BMI ($\chi^2$=4.7, $p$=0.029) as significant predictors of revision, with steroid use ($\chi^2$=3.5, $p$=0.061) and functional status ($\chi^2$=3.7, $p$=0.055) approaching significance.

**Conclusions:** Patient demographics, comorbidities, and rehabilitative status may be significantly associated with rates of reherniation and revision surgery following lumbar microdiscectomy. We found that the significant predictors of revision surgery are functional dependence, advanced age, male sex, White race, obesity, diabetes, smoking, and hypertension. Early identification and attendance to the modifiable risk factors will aid patient guidance and outcomes following primary lumbar microdiscectomy.

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## Introduction

Lumbar disc herniation is a common cause of lumbar radiculopathy[1-3]. Operative management has been associated with earlier improvement in pain and function as well as superior long-term clinical outcomes when compared with nonoperative management. Lumbar microdiscectomy is an effective procedure for lumbar disc herniation, with reported success rates of approximately 80%-90%[4-9]. Nevertheless, reherniation occurs in 5%-21% of patients following primary discectomy and is the leading cause of reoperation after primary discectomy[10-16]. Revision surgery can be associated with a higher degree of technical difficulty and increases the economic burden on the healthcare system[17].

As such, the risk factors for recurrent lumbar disc herniation must be investigated. Previous studies have determined patient characteristics including age, gender, BMI, herniation type, diabetes, and herniation level as risk factors for reherniation[14,15,18-25]. However, inconsistencies in results have been reported. For instance, in several studies, smoking was identified as a risk factor, but other studies reported no significant difference in the rate of reherniation between smokers and nonsmokers[18,21,22,24,25-27]. Meredith et al. found that obesity increases the risk of reherniation, whereas Moliterno et al. found otherwise with lower BMI increasing the risk of reherniation[20-22]. Separately, Huang et al. and Kara et al. identified no significant correlation between BMI and reherniation. However, many of these studies were single-centered and had relatively small sample sizes, and they may not be generalizable to the broader population[25,27]. Hence, a study utilizing a large, national dataset is needed, making it more generalizable to the broader population. These data would be valuable for risk stratification and patient counseling. Therefore, using a large national-scale patient dataset, this study sought to explore the potential relationship between various patient demographic variables and comorbidities and rates of reoperation following primary lumbar microdiscectomy.

## Materials and Methods

### *Study design and data source*

A retrospective observational study was conducted on patients who underwent single-level primary lumbar microdiscectomy from 2016 to 2022, using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. This outcome-based, national surgical database captures clinically significant perioperative variables and 30-day outcomes from more than 600 participating institutions, including academic settings, private practices, community hospitals, tertiary centers, and both inpatient and outpatient medical centers[28-30]. Patient demographics and 30-day perioperative outcome data are recorded directly from the electronic medical record by clinical reviewers and risk-adjusted using patient characteristics to account for differences in patient populations[30,31].

### *Study population*

Using current procedural terminology (CPT) codes 63030 and 63042, adult patients undergoing single-level primary lumbar microdiscectomy were identified. CPT code 63030 was employed to define single-level primary lumbar microdiscectomy and is defined by the American Medical Association as "Under Posterior Extradural Laminotomy or Laminectomy for Exploration/Decompression of Neural Elements or Excision of Herniated Intervertebral Disks Procedures." CPT code 63042 was utilized to define single-level revision lumbar microdiscectomy at the same level as primary surgery and is defined by the American Medical Association for revision procedures as "Under Posterior Extradural Laminotomy or Laminectomy for Exploration/Decompression of Neural Elements or Excision of Herniated Intervertebral Disks Procedures." CPT code 63042 is specific to revision discectomy for recurrent disk herniation outside the 90-day period for primary discectomy. Other causes of revision, such as wound infection, scar tissue, and facet cysts, would be included under different CPT codes, with facet cysts largely necessitating fusion rather than revision. Exclusion criteria included patients with preoperative sepsis, cancer, emergency cases, and nonelective cases. Using CPT codes, cases involving nonlumbar regions of the spine were excluded.

### *Demographics and comorbidities*

Using the reoperation variable in ACS-NSQIP, patients requiring revision microdiscectomy within 30 days were determined. Patient demographics and comorbidities including age, race, ethnicity, BMI, functional dependence, diabetes mellitus, smoking status, chronic obstructive pulmonary disease (COPD), steroid use, hypertension requiring medications, congestive heart failure (CHF), and American Society of Anesthesiologists (ASA) class were recorded. To assess differences in demographic characteristics and comorbidities, the data from the primary and revision surgery groups were analyzed.

**Table 1.** Baseline Characteristics of Patients Undergoing Primary and Revision Discectomy.

| Characteristic | Primary Discectomy | | Revision Discectomy | | *p*-value |
|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | |
| ***N* of cases** | 65,121 | | 6,971 | | |
| **Mean age±SD** | 51.37±16.0 | | 54.60±15.7 | | <0.001 |
| <45 | 24,415 | 37.5% | 2,105 | 30.2% | <0.001 |
| 45–54 | 12,499 | 19.2% | 1,337 | 19.2% | 0.977 |
| 55–64 | 12,569 | 19.3% | 1,403 | 20.1% | 0.101 |
| ≥65 | 15,638 | 24.0% | 2,126 | 30.5% | <0.001 |
| **Sex** | | | | | |
| Male | 36,384 | 55.9% | 4,099 | 58.8% | <0.001 |
| Female | 28,689 | 44.1% | 2,872 | 41.2% | <0.001 |
| **Race** | | | | | |
| Non-Hispanic White | 44,912 | 79.9% | 5,182 | 84.2% | <0.001 |
| Non-Hispanic Black | 4,159 | 7.4% | 394 | 6.4% | 0.017 |
| Hispanic | 4,637 | 8.2% | 412 | 6.7% | <0.001 |
| Asian | 1,803 | 3.2% | 118 | 1.9% | <0.001 |
| **BMI category** | | | | | |
| <25 | 13,319 | 20.5% | 1,262 | 18.1% | <0.001 |
| 25–29 | 22,064 | 33.9% | 2,304 | 33.1% | 0.022 |
| 30–34 | 16,413 | 25.2% | 1,899 | 27.2% | <0.001 |
| ≥35 | 13,325 | 20.5% | 1,506 | 21.6% | 0.025 |
| **Comorbidities** | | | | | |
| Functional dependence | 682 | 1.0% | 96 | 1.4% | 0.011 |
| ASA class ≥3 | 22,161 | 34.0% | 2,912 | 41.8% | <0.001 |
| Diabetes mellitus | 9,048 | 13.9% | 1,229 | 17.6% | <0.001 |
| Smoker | 12,540 | 19.3% | 1,430 | 20.5% | 0.012 |
| COPD | 1,532 | 2.4% | 214 | 3.1% | <0.001 |
| CHF | 254 | 0.4% | 41 | 0.6% | 0.014 |
| Hypertension | 24,269 | 37.3% | 3,163 | 45.4% | <0.001 |
| Steroid use | 2,504 | 3.8% | 323 | 4.6% | 0.001 |

ASA, American Society of Anesthesiologists. BMI, body mass index. CHF, congestive heart failure. COPD, chronic obstructive pulmonary disease. SD, standard deviation

### *Statistical analysis*

Differences in baseline characteristics between patients who required reoperation within 30 days versus those who did not require reoperation were evaluated using chi-squared tests for categorical variables (e.g., race and smoking status) and Wilcoxon rank sum test for continuous variables (e.g., age). Odds ratios were calculated to compare the relative risk for reoperation. To determine factors independently associated with the need for revision microdiscectomy, multivariable Poisson log-linear regression with a backward stepwise approach was utilized. Statistical significance was set at a p-value of <0.05. All statistical analyses were carried out using IBM Statistical Package for Social Sciences version 29.0.

## Results

A total of 65,121 primary discectomy patients were included, with a separate cohort of 6,971 patients undergoing revision discectomy. Patients in the revision cohort were older on average (54.60±15.7 vs. 51.37±16.00, $p<0.001$). The revision cohort had a greater proportion of male (58.8% vs. 55.9%, $p<0.001$), non-Hispanic White patients (84.2% vs. 79.9%, $p<0.001$) and with a BMI greater than 30 (48.8% vs. 45.7%, $p<0.001$). Rates of comorbidities were greater in the revision cohort for functional dependence (1.4% vs. 1.0%, $p=0.011$), ASA ≥3 (41.8% vs. 34.0%, $p<0.001$), diabetes (17.6% vs. 13.9%, $p<0.001$), smoking (20.5%, vs. 19.3%, $p=0.012$), COPD (3.1% vs. 2.4%, $p<0.001$), CHF (0.6% vs. 0.4%, $p=0.014$), hypertension (45.4% vs. 37.3%, $p<0.001$), and chronic steroid use (4.6% vs 3.8%, $p=0.001$). Table 1 outlines the baseline characteristics of the primary and revision discectomy cohorts.

In the univariable analysis, the odds ratio for revision discectomy was greater in patients aged 45-54 years (1.241, 95% CI [1.155, 1.333], $p<0.001$), 55-64 years (1.295, 95% CI [1.206, 1.390], $p<0.001$), and ≥65 years (1.577, 95% CI [1.480, 1.680], $p<0.001$) than those aged <45 years. The odds ratio for revision was lower in Black (0.821, 95% CI [0.738, 0.914], $p<0.001$), Asian (0.611, 95% CI [0.508, 0.736], $p<0.001$), and Hispanic patients (0.819, 95% CI

**Table 2.** Independent Risk Factors for Revision Discectomy following Reherniation Compared to Primary Discectomy.

| Characteristic | Odds Ratio | 95% Confidence Interval | *p*-value |
|---|---|---|---|
| **Age** | | | |
| <45 | Reference | - | - |
| 45–54 | 1.241 | 1.155–1.333 | <0.001 |
| 55–64 | 1.295 | 1.206–1.390 | <0.001 |
| ≥65 | 1.577 | 1.480–1.680 | <0.001 |
| **Race and ethnicity** | | | |
| Non-Hispanic White | Reference | - | - |
| Non-Hispanic Black | 0.821 | 0.738–0.914 | <0.001 |
| Hispanic | 0.819 | 0.738–0.909 | <0.001 |
| Asian | 0.611 | 0.508–0.736 | <0.001 |
| **BMI category** | | | |
| <25 | Reference | - | - |
| 25–29 | 1.102 | 1.026–1.184 | 0.008 |
| 30–34 | 1.221 | 1.133–1.316 | <0.001 |
| ≥35 | 1.193 | 1.103–1.290 | <0.001 |
| **Functional dependence** | | | |
| No | Reference | - | - |
| Yes | 1.319 | 1.183–1.683 | 0.011 |
| **Diabetes mellitus** | | | |
| No | Reference | - | - |
| Yes | 1.326 | 1.242–1.416 | <0.001 |
| **Smoker** | | | |
| No | Reference | - | - |
| Yes | 1.082 | 1.018–1.151 | 0.012 |
| **COPD** | | | |
| No | Reference | - | - |
| Yes | 1.315 | 1.137–1.512 | <0.001 |
| **Steroid use** | | | |
| No | Reference | - | - |
| Yes | 1.215 | 1.079–1.368 | 0.001 |
| **Hypertension** | | | |
| No | Reference | - | - |
| Yes | 1.398 | 1.330–1.470 | <0.001 |
| **Congestive heart failure** | | | |
| No | Reference | - | - |
| Yes | 1.511 | 1.085–2.103 | 0.014 |
| **ASA Class ≥ 3** | | | |
| No | Reference | - | - |
| Yes | 1.391 | 1.323–1.462 | <0.001 |

BMI, body mass index. COPD, chronic obstructive pulmonary disease

[0.738, 0.909], $p<0.001$) compared to non-Hispanic White patients. Patients with BMI 25-29 (1.102, 95% CI [1.026, 1.184], $p=0.008$), 30-34 (1.221, 95% CI [1.133, 1.316], $p<0.001$), and ≥35 (1.193, 95% CI [1.103, 1.290], $p<0.001$) were at greater risk of revision compared with patients with BMI <25. Diabetes (1.326, 95% CI [1.242, 1.416], $p<0.001$), functional dependence (1.411, 95% CI [1.183, 1.683], $p<0.001$), COPD (1.315, 95% CI [1.137, 1.512], $p<0.001$), CHF (1.511, 95% CI [1.085, 2.103], $p=0.014$), chronic steroid use (1.215, 95% CI [1.079, 1.368], $p=0.001$), and ASA class ≥3 (1.391, 95% CI [1.323, 1.462], $p<0.001$), hypertension (1.398, 95% CI [1.330, 1.470], $p<0.001$), and smoking (1.082, 95% CI [1.018, 1.151], $p=0.012$) were associated with greater risk of revision. Table 2 summarizes the odds ratio comparison of demographics and comorbidities between primary and revision discectomy.

**Table 3.** Poisson Log-Linear Regression with Significant Patient Demographics and Comorbidities as Predictors of Revision.

| Characteristic | Wald Chi-Square | *p*-value |
|---|---|---|
| **Age** | 102.38 | <0.001 |
| **Male sex** | 19.93 | <0.001 |
| **Race** | 39.50 | <0.001 |
| **BMI** | 4.74 | 0.029 |
| **Diabetes** | 10.13 | 0.001 |
| **Smoker** | 18.54 | <0.001 |
| **Functional dependence** | 3.67 | 0.055 |
| **Hypertension** | 16.42 | <0.001 |
| **Steroid use** | 3.50 | 0.061 |

BMI, body mass index

Poisson log-linear regression demonstrated male sex ($\chi^2=19.9$, $p<0.001$), race ($\chi^2=39.5$, $p<0.001$), diabetes ($\chi^2=10.1$, $p=0.001$), smoking ($\chi^2=18.5$, $p<0.001$), hypertension ($\chi^2=16.4$, $p<0.001$), age ($\chi^2=102.4$, $p<0.001$) and BMI ($\chi^2=4.7$, $p=0.029$) as significant predictors of revision, with steroid use ($\chi^2=3.5$, $p=0.061$) and functional status ($\chi^2=3.7$, $p=0.055$) approaching significance. Table 3 summarizes the regression model.

## Discussion

Previous studies have identified various demographic factors and comorbidities including diabetes, male sex, and BMI as predictors of revision in institutional cohorts[18,25]. However, there is a shortage of literature looking at these characteristics within the past decade and in a national database. In this retrospective analysis, we noted that (1) demographics and comorbidities differed between primary and revision discectomy cohorts and (2) functional dependence, advanced age, male sex, nonWhite race, obesity, diabetes, smoking, and hypertension are independent and significant predictors of revision surgery.

The results from our univariate analysis demonstrate several characteristics that vary between primary and revision discectomy cohorts. The revision cohort was older, with a greater proportion of male, non-Hispanic White, and obese patients. Comorbidities including functional dependence, ASA class, diabetes, smoking, COPD, CHF, hypertension, and steroid use for chronic conditions were more common in the revision cohort. In an institutional cohort, Shimia et al. found rates of smoking and higher BMI to be higher in the revision cohort[18]. Additional studies conducted by Mobbs, Miwa, and Meredith et al. similarly found an association between diabetes mellitus, smoking, and obesity and recurrent herniation[21,22,32,33]. Although functional status has

not been found as a risk factor, patient-reported function has been associated with outcome measures after lumbar microdiscectomy[34]. Our results are in agreement with these findings from the literature, besides finding greater rates of ASA class ≥3, functional dependence, hypertension, steroid use for chronic conditions, COPD, and CHF in the revision cohort.

Our multivariable regression analysis showed that advanced age, male sex, White race, obesity, diabetes, smoking, and hypertension were significant predictors of revision discectomy. Mobbs et al. found diabetes to be a significant predictor of recurrent herniation, with Robinson et al. showing fewer proteoglycans in intervertebral discs of diabetics, providing less structural support against herniation[33-35]. Although Meredith and Kim et al. found an association between elevated BMI and recurrent herniation, studies by Quah, Rihn, and Moliterno et al. did not find a significant association[20,36,37]. Studies carried out by Miwa, An, and Kelsey showed smoking as a predictor or recurrent herniation, possibly due to effects of smoking on cellular oxygenation, nutrition, and healing of the nucleus pulposus as outlined by Robinson and Stairmand et al[21,38-41]. Additionally, Shimia et al. found male sex to be associated with recurrent herniation[18]. The results of our study provide support for diabetes, obesity, smoking, and male sex as significant predictors of recurrent herniation while introducing advanced age, White race, and hypertension as previously unreported risk factors. Although the mechanism is uncertain, age and hypertension may impact the cellular integrity of the nucleus pulposus as discussed by Robinson, Stairmand, and Akmal et al., with race acting through socioeconomic factors[35,40,41].

Besides the characteristics discussed in our study, additional risk factors not included in the ACS-NSQIP database and our analysis have been discussed in the literature. This includes biomechanical factors, with Kim et al. showing patients with sagittal motion >10 degrees had significantly higher rates of recurrent herniation[26]. McGirt and Kim et al. reported disc height, larger annular defects, and smaller percentage of disc removed as additional variables that predict recurrent herniation[26-42]. Notably, a prospective study carried out by Carragee et al. found intraoperative variables of the primary lumbar microdiscectomy including herniation type, extruded disc fragments, and large annular loss to be greater predictors of recurrent herniation when compared with demographic, socioeconomic, or comorbidities[42]. As such, although demographic factors and comorbidities can be valuable predictors of recurrent herniation, they should be considered in the context of additional physiological and surgical factors.

### *Limitations*

There are a few limitations to consider in this study. First, the retrospective design of the study may introduce an element of selection bias. Additionally, CPT billing codes were utilized to identify patients in the primary and revision discectomy cohorts, which do not always accurately represent the patient population. However, this study adjusted for potential confounding variables by excluding procedures involving nonlumbar regions, cancer, and preoperative sepsis. Furthermore, because the cohorts were defined based on CPT codes for a patient encounter at a single time point, some patients included in the primary cohort may have eventually received a revision surgery in the future. This is a limitation inherent to the utilized database, which does not allow for long-term longitudinal tracking of patients. Finally, the ACS-NSQIP database does not provide a rationale or timeframe for revision microdiscectomy, limiting the causality that can be drawn. The database also does not contain socioeconomic, physiological, or intraoperative variables that have been found to predict revision discectomy in previous studies.

## Conclusion

Patient demographics, comorbidities, and rehabilitative status are associated with the recurrence of reherniation and revision surgery following lumbar microdiscectomy. Functional dependence, advanced age, male sex, nonWhite race, obesity, diabetes, smoking, and hypertension were predictive of revision surgery. Early identification and attendance of modifiable risk factors will better inform patient guidance and outcomes following primary lumbar microdiscectomy.

**Conflicts of Interest:** The authors declare that there are no relevant conflicts of interest.

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**Author Contributions:** JS and AK designed the study. RH, JS, and AK analyzed the data. RH, JS, JT, AN, TH, JC, and NN wrote the manuscript. SC, SKC, AH, DE, SV, and AK provided supervision.

**Ethical Approval:** This study utilized a deidentified national database, and no direct patient involvement occurred; hence, ethical approval was not necessary.

**Informed Consent:** This study utilized a deidentified national database, and no direct patient involvement occurred; thus, informed consent was not necessary.

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