# Research Article

# Rates of Future Lumbar Fusion in Patients with Cauda Equina Syndrome Treated With Decompression

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## ABSTRACT

**Introduction:** The long-term risk of conversion to lumbar fusion is ill-defined for patients with cauda equina syndrome (CES) treated with decompression. This study aimed to identify the rates of fusion in patients with CES and compare those rates with a matched lumbar spinal stenosis (LSS) group.

**Methods:** Patients with CES who underwent decompression were identified in a national database and matched to control patients with LSS. The rates of conversion to fusion were identified and compared. Multivariate logistic regression analysis identified independently associated risk factors. A subanalysis was conducted after stratifying by timing between CES diagnosis and decompression.

**Results:** The rate of lumbar fusion in the CES cohort was 3.6% after 1 year, 6.7% after 3 years, and 7.8% after 5 years, significantly higher than the LSS control group at all time points (1 year: 1.6%, $P = 0.001$; 3 years: 3.0%, $P < 0.001$; 5 years: 3.8%, $P < 0.001$). CES was independently associated with increased risk of conversion to fusion (odds ratio: 2.13; 95% confidence interval: 1.56 to 2.97; $P < 0.001$). Surgical timing was not associated with risk of conversion to fusion.

**Conclusions:** After 5 years, 7.8% of patients with CES underwent fusion, a markedly higher rate compared with patients with LSS. Counseling patients with CES on this increased risk of future surgery is important for patient education and satisfaction.

Cauda equina syndrome (CES) is a rare but serious condition that results from compression of the lumbar and sacral nerve roots. The most common cause is lumbar disk herniation, although a variety of etiologies, including spinal neoplasm, abscess, epidural hematoma, and trauma, have been reported.[1–6] Patients experiencing CES often present with an array of symptoms, including low back pain; lower extremity weakness; perianal hypoesthesia; and bowel, bladder, or sexual dysfunction.[7–9]

Management of CES centers around decompression of the spinal nerve roots. CES caused by disk herniation is commonly treated with laminectomy and diskectomy at the level of the herniation; however, a number of decompression techniques can be conducted, varying by the specific compressive pathology.[7,10,11] A full or wide laminectomy with generous bone removal is often conducted in patients with CES,[12,13] as compared with a partial laminectomy for uncomplicated disk herniation or lumbar spinal stenosis (LSS). The timing of decompression for CES is also of considerable interest in the literature. The generally accepted view is that decompression should be conducted within 48 hours of the onset of symptoms because multiple studies have demonstrated improved neurological outcomes when treatment occurs within this indicated window.[12,14–19] Thus, these potentially challenging operations are often conducted on an urgent basis with less-than-optimal conditions.

Although concomitant lumbar fusion may be conducted during the index decompression procedure, most patients with CES are treated with decompression alone.[20] The long-term rates of conversion to fusion in this patient population are not clear because most of the clinical studies investigating postoperative outcomes in CES have focused on the resolution of neurological deficits.[15,21–24] Requiring additional surgery may result in increased morbidity for these patients; thus, accurate prognostic information regarding the risk of conversion to lumbar fusion is important for patient counseling.

The goal of this study was to define the rates of future lumbar fusion in patients with CES managed with decompression alone at the time of initial presentation and compare those rates with a matched LSS group. Furthermore, we sought to investigate how the timing between CES diagnosis and decompression surgery affected long-term risk of conversion to fusion.

## Methods

### Database

We conducted a retrospective study of patients from the Mariner national insurance claims database, available through PearlDiver (PearlDiver), consisting of anonymized records from 53 million orthopaedic patients between the years 2010 to 2018. The Mariner database contains insurance claims from multiple payer types, including commercial insurance, Medicare, Medicaid, and self-pay. It is searchable by billing codes identified in the database with Current Procedural Terminology (CPT)

codes and International Classification of Diseases, Ninth Revision (ICD-9) and 10th Revision (ICD-10) diagnostic and procedural codes. All records in PearlDiver are Health Insurance Portability and Accountability Act (HIPAA) compliant. This study was determined exempt from additional review by our Institutional Review Board.

### Patient Selection and Outcomes

Patients who underwent decompression within 1 month of a diagnosis of CES were identified in the database using CPT, ICD-9, and ICD-10 codes (Appendix, http://links.lww.com/JG9/A244). To account for patients who changed or lost insurance or left the database for other reasons, patients were excluded if they did not have continuously active records in the database over the study period; thus, all patients had a 5-year follow up in this study. Patients in the CES cohort were matched to patients from a LSS control group. The control group underwent similar decompression procedures as the CES group but lacked a diagnosis of CES and instead had an ICD-9 or ICD-10 code specific for LSS (Appendix, http://links.lww.com/JG9/A244). To further characterize the patients in the LSS control group, we identified the percentage of patients with an associated diagnosis of facet hypertrophy or disk extrusion. This LSS control group was matched in a 1:1 ratio with the CES cohort by the matching parameters of age, sex, obesity, tobacco use, and diabetes. Patients who underwent lumbar fusion on the same day as the index decompression procedure were excluded from the CES cohort and LSS control group. The 1-year, 3-year, and 5-year rates of conversion to fusion, as defined by a CPT or ICD procedure code for lumbar fusion (Appendix, http://links.lww.com/JG9/A244), were identified for the two groups.

### Statistical Analysis

The Pearson chi squared test was used to assess the univariate differences in rates of conversion to lumbar fusion 1, 3, and 5 years after decompression surgery between the CES cohort and LSS control group. Differences between the 2 groups were determined to be notable at an alpha level of 0.05. To further investigate the independent association between CES and conversion to lumbar fusion 5 years after the index decompression surgery, a multivariate logistic regression analysis was conducted, accounting for the variables of CES diagnosis, age, sex, obesity, diabetes, and tobacco use because these are commonly investigated demographic and comorbidity risk factors associated with spinal revision

**Table 1.** Demographics and Comorbidities of Patients Compared Between the Matched CES Cohort and Non-CES LSS Control Group

| Characteristic | CES Cohort (N = 1288) | LSS Control Group (N = 1288) | P |
|---|---|---|---|
| Age, mean ± SD | 53.6 ± 15.9 | 52.0 ± 15.5 | 0.010 |
| Female, % (n) | 48.0% (618) | 48.0% (618) | 1.000 |
| Male, % (n) | 52.0% (670) | 52.0% (670) | 1.000 |
| Diabetes, % (n) | 45.1% (581) | 45.1% (581) | 1.000 |
| Obesity, % (n) | 49.5% (637) | 49.5% (637) | 1.000 |
| Tobacco use, % (n) | 32.1% (413) | 32.1% (413) | 1.000 |

CES = cauda equina syndrome, LSS = lumbar spinal stenosis

surgery procedures.[25-27] Adjusted odds ratios (ORs) and confidence intervals (CIs) were determined. Statistical analysis was conducted using the R statistical package available within PearlDiver software.

### Timing to Decompression Subanalysis

A subanalysis based on the timing of decompression was additionally conducted. Patients in the CES cohort were stratified into three subgroups: <48 hours, 48 hours— 10 days, and 10 days—30 days between CES diagnosis and decompression. The timing of these subgroups was chosen because 48 hours is the classically recommended window for intervention in patients diagnosed with CES; furthermore, previous studies have used similar timing cutoffs.[15,16,28] We identified the 5-year rates of conversion to lumbar fusion of patients from these three subgroups. Univariate logistic regression analysis was used to determine differences in the rates of conversion to lumbar fusion between the three subgroups.

## Results

### Patient Identification and Matching

A total of 1800 patients who underwent decompression surgery after a CES diagnosis with a 5-year follow-up in the database were identified. Of these patients, 1288 (71.6%) received decompression alone while 512 (28.4%) underwent lumbar fusion in addition to decompression. The patients treated with decompression alone made up the CES cohort of this study and were matched to 1288 control patients who underwent decompression for LSS. Among the patients in the LSS control group, 34.0% (438) had associated disk extrusion billing codes, 7.0% (90) had facet hypertrophy codes, 49.2% (634) had both codes, and 9.8% (126) did not have a billing code of disk extrusion or facet hypertrophy associated and underwent decompression because of another etiology of LSS. The CES cohort and LSS control groups consisted of patients with similar

### Figure 1
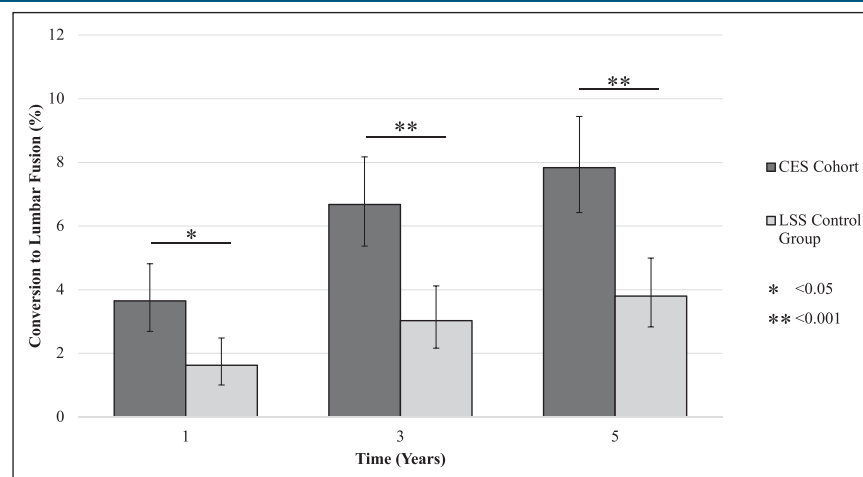


Graph showing long-term rates of conversion to fusion after index decompression surgery compared between patients with CES and patients who underwent decompression for LSS not associated with CES. Error bars represent 95% confidence intervals. CES = cauda equina syndrome, LSS = lumbar spinal stenosis

**Table 2.** Multivariate Logistic Regression Analysis of 5 Year Rate of Conversion to a Fusion Procedure After Index Decompression

| Variables | Odds Ratio (95% Confidence Interval) | P |
|---|---|---|
| Cauda equina syndrome | 2.13 (1.56-2.97) | <**0.001** |
| Sex (male) | 0.46 (0.35-0.60) | <**0.001** |
| Age older than 65 years | 0.57 (0.40-0.78) | <**0.001** |
| Obesity | 1.27 (0.97-1.66) | 0.085 |
| Tobacco use | 1.25 (0.95-1.64) | 0.103 |
| Diabetes | 1.10 (0.84-1.43) | 0.500 |

Bolded entries indicate statistical significance.

distributions of sex, diabetes and obesity comorbidity, and tobacco use (Table 1). The age of patients in the CES cohort ($53.6 \pm 15.9$) was observed to be higher than those in the LSS control group ($52.0 \pm 15.5$) even after matching because of limited availability of control patients ($P = 0.010$).

## Outcome Measures

3.6% of patients in the CES cohort required lumbar fusion after 1 year, 6.7% after 3 years, and 7.8% after 5 years (Figure 1). Patients in the LSS control group underwent conversion to lumbar fusion at the rates of 1.6% after 1 year, 3.0% after 3 years, and 3.8% after 5 years. Univariate analysis identified the rates to be significantly higher among the patients with CES at all time points ($P = 0.001$ at 1 year; $P < 0.001$ at 3 and 5 years).

## Multivariate Analysis

Multivariate logistic regression analysis identified a diagnosis of CES as independently associated with an increased risk of 5-year conversion to lumbar fusion (OR: 2.13; 95% CI: 1.56 to 2.97; $P < 0.001$; Table 2). Male sex (OR: 0.46; CI: 0.35 to 0.60; $P < 0.001$) and age 65 years or older (OR: 0.57; CI: 0.40 to 0.78; $P < 0.001$) were associated with decreased risk of conversion to lumbar fusion at 5 years after decompression surgery. Obesity, tobacco use, and diabetes were not found to be markedly associated with 5-year conversion to lumbar fusion.

## Timing to Decompression Subanalysis

Of the 1288 patients who made up the CES cohort, 1118 (86.8%) underwent decompression within 48 hours of CES diagnosis, 94 (7.3%) between 48 hours and 10 days, and 76 (5.9%) between 10 days and 1 month. The 5-year rates of conversion to lumbar fusion were 8.0%, 5.3%, and 9.2%, respectively. Although the rates trended higher in the <48 hour and 10 days—1-month groups, in univariate logistic regression analysis, the timing of decompression showed no notable effect on 5-year rate of conversion to lumbar fusion (Table 3).

## Discussion

Understanding the long-term outcomes of CES treated with decompression is important for patient counseling, setting reasonable postoperative expectations, and the future care of these patients. Although various outcomes related to CES have been reported, the risk of conversion to fusion after decompression laminectomy for CES is largely unknown. In this study, we observed the rate of conversion to lumbar fusion to be markedly higher at 1 year, 3 years, and 5 years between patients with CES and control patients with LSS who underwent decompression alone at the index procedure. In addition, in multivariate analysis, we found CES to be independently associated with a 5-year rate of conversion to lumbar fusion after controlling for patient demographic and relevant

**Table 3.** Five-Year Rates of Conversion to Fusion Stratified by Timing Between Cauda Equina Syndrome Diagnosis and Decompression Surgery

| Timing Subgroups (n) | 5-Year Conversion to Fusion, % (n) | Odds Ratio (95% Confidence Interval) | P |
|---|---|---|---|
| <48 hr (1,118) | 8.0% (89) | 1.13 (0.62-2.11) | 0.710 |
| 48 hr to 10 d (94) | 5.3% (5) | 0.65 (0.26-1.64) | 0.360 |
| 10 d to -30 d (76) | 9.2% (7) | 1.22 (0.54-2.73) | 0.629 |

comorbidity factors. In a subanalysis of timing from CES diagnosis to decompression, most of the patients (86.8%) were treated within 48 hours; however, no significance was found between the future risk of conversion to lumbar fusion compared between the timing groups.

Currently, apart from reports that decompression surgeries for CES, which often involve a wide or complete laminectomy, may result in instability, the literature is scant regarding risk of future conversion to fusion.[20,29] To the best of our knowledge, this is the largest study to date investigating the risk of future lumbar fusion after decompression alone in patients with CES. In studies not associated with CES, the reported risk of conversion to fusion is poorly defined for patients treated with decompression alone for LSS and degenerative disk disease. Most studies have sought to investigate revision surgery rates after laminectomy, which may include repeat decompression or conversion to fusion. A recent systematic review by Lang et al.[30] reported the 5-year revision surgery rate after decompression alone for degenerative lumbar disease ranged broadly from 3.6% to 34.0% across 12 studies. A few studies conducted subanalysis on revision surgeries that were specifically conversions to fusion. Chan et al.[31] reported that although 6.0% of patients in their study had revision surgery within 2 years after index decompression surgery, 2.4% (2 of 84 total patients) had a fusion procedure. Bydon et al.[32] observed that the lifetime risk (average follow-up of 46.8 months) for requiring a fusion procedure after a lumbar laminectomy was 8.0%. Modhia et al.[33] reported that the 2-year readmission rate for patients who underwent decompression alone for LSS was 13.2%, with 56% of the readmissions being for fusion procedures; thus, 7.4% of the decompression patients in their study experienced conversion to fusion. In the control group for our study, 3.8% of patients with LSS who underwent decompression alone as the index procedure required conversion to lumbar fusion after 5 years.

In the multivariate analysis, among a pooled group of the CES cohort and LSS control patients, CES was independently associated with increased 5-year risk of requiring a conversion to lumbar fusion. Although none of the other demographic and comorbidity risk factors were associated with increased risk of conversion to lumbar fusion, patients age 65 years and older and of male sex were observed to be independently associated with decreased risk of conversion to fusion. Similar to our findings, Keskimäki et al.[34] reported that elderly patients underwent revision surgery at a decreased rate after lumber disk surgery. We hypothesize that this decreased rate of conversion to lumbar fusion in elderly patients is a reflection of risk stratification because a larger proportion of this patient cohort might be less suitable candidates for surgery. Our findings also align with a subanalysis of the Spine Patient Outcomes Research Trial, which found obesity, diabetes, and smoking status to have no notable association with revision surgery rate.[27] However, neither of the aforementioned studies investigated conversion to fusion alone, instead considering risk factors associated with any revision surgery procedure. In addition, they did not include patients who underwent decompression due to CES, so our findings are difficult to compare. Ultimately, the most clinically notable finding from our multivariate analysis was that CES, independent of patient demographics and comorbidity risk factors, is associated with increased conversion to lumbar fusion with an OR of 2.13 (CI 1.56 to 2.97; $P < 0.001$).

While the subanalysis of how timing to decompression affected future conversion to lumbar fusion showed a higher trend in the patients treated within 48 hours compared with the patients treated between 48 hours and 10 days; ultimately, no statistical difference was observed between any of the timing groups. This result suggests that the emergent nature of decompression surgery for CES has minimal effect specifically on stability and risk of future conversion to fusion. Instead, we suspect that the increased rate of conversion to fusion in patients with CES compared with LSS control patients may be related to the technique of the decompression. Complete laminectomy and generous medial facetectomies may be necessary to achieve adequate decompression in some patients with CES. We speculate that this wide decompression, rather than emergent surgery, may be the driving factor for the results of our study; however, additional controlled investigation is needed to understand why this trend is observed.

There are several limitations to our study. First, with the use of a national insurance database, our study relies on the individual coding practices of physicians and hospitals. Because the nature of a national insurance database does not allow access to individual patient charts, this study depended on a coded diagnosis of CES, which may not have precisely correlated with the initial onset of symptoms if the patients were not properly diagnosed at the initial encounter; specifically, this may have added potential error to the subanalysis of time to decompression. In addition, the claims database does not capture the specific techniques used for decompression, such as full laminectomy versus partial hemilaminectomies, nor does it detail how much of the posterior elements were removed or preserved or how many levels were decompressed. Furthermore, although the

fusion codes used in this study were specific for the lumbar region, we were not able to establish whether the conversion to fusion procedure occurred at the same level as the index decompression or how many levels were fused. However, we attempted to control for this through our matched analysis. Because both the CES cohort and LSS control group experienced this limitation, the absolute rates of conversion to fusion may have been affected, but the relative rates compared between the two groups still provide a clear demonstration of the increased risk of conversion to fusion among patients with CES. Finally, although this study examined patients who underwent decompression alone, some patients treated for CES undergo concomitant fusion in addition with decompression. The indications for fusion in CES are not clearly defined but may be associated with traumatic or iatrogenic instability.[20] Although there is some limited evidence to suggest that fusion in addition to decompression may result in better outcomes,[35] the increased cost and additional risk of instrumentation-related complications cloud this topic, and no trials to study this have been conducted. Our finding that patients with CES treated with decompression alone experience higher long-term rates of conversion to lumbar fusion warrants additional investigation into the indications for concomitant fusion and how the outcomes compare with decompression alone.

## Conclusion

Ultimately, our findings provide valuable information for counseling patients regarding risk for additional surgery. Compared with patients with LSS, patients who underwent decompression for CES were at increased risk of conversion to lumbar fusion. Because these surgeries come with increased morbidity and financial implications, setting realistic postoperative expectations after decompression surgery in CES is important for patient satisfaction and well-being.

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