# Impact of Ambulatory Setting for Workers' Compensation Patients Undergoing One-Level Minimally Invasive Transforaminal Lumbar Interbody Fusion and Review of the Literature

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■ OBJECTIVE: **To compare perioperative characteristics and patient-reported outcome measures (PROMs) in workers' compensation (WC) patients undergoing minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) in either the inpatient/outpatient setting.**

■ METHODS: **Patients with WC undergoing 1-level MIS-TLIF were included. Patients were separated into inpatient/outpatient groups and demographically propensity score matched. PROMs included visual analog scale (VAS) back/VAS leg/Oswestry Disability Index (ODI)/12-item Short Form Physical Composite Score (SF-12 PCS)/Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS-PF) preoperatively and 6 weeks, 12 weeks, 6 months, and 1 year postoperatively. Results were compared preoperatively and postoperatively and between cohorts. Minimum clinically important difference (MCID) achievement was determined through comparison with values established in the literature.**

■ RESULTS: **A total of 216 patients were included (184 inpatient). The inpatient cohort (IC) showed worse perioperative outcomes in multiple measures ($P < 0.034$; all). The IC improved in all PROMs ($P < 0.038$; all), besides ODI at 6 weeks, SF-12 PCS at 6 weeks/6 months/1 year, and PROMIS-PF at 6 weeks. The outpatient cohort (OC) improved in VAS back at all time points and VAS leg at 6 months ($P < 0.033$; all). Between cohorts, the OC showed better scores with VAS leg/ODI/SF-12 PCS/PROMIS-PF at multiple time points ($P < 0.031$; all). Most of the IC achieved MCID, aside from ODI, whereas the OC achieved MCID in SF-12 PCS. MCID achievement between cohorts was higher in the IC at PROMIS-PF at 1 year and VAS back overall ($P < 0.034$; all).**

■ CONCLUSIONS: **Despite more comorbidities and worse perioperative measures, the IC showed improved PROMs from preoperative to ≥1 follow-up visit, whereas the OC had improvement with only VAS back and leg. The IC showed multiple MCID achievements, whereas the OC showed MCID in only SF-12 PCS. These findings may help guide a surgeon's decision making between inpatient/outpatient lumbar surgery in the WC population.**

## INTRODUCTION

With increasing costs and complications associated with extended hospital stays, there has been a shift toward performing spine surgery in an ambulatory setting.[1] Between 1994 and 2006, outpatient surgery for spinal stenosis

**Key words**
- Inpatient
- MCID
- MIS-TLIF
- Outpatient
- PROM
- WC
- Workers' Compensation

**Abbreviations and Acronyms**
**ASA**: American Society of Anesthesiologists
**BMI**: Body mass index
**EBL**: Estimated blood loss
**LOS**: Length of stay
**MCID**: Minimum clinically important difference
**MIS-TLIF**: Minimally invasive transforaminal lumbar interbody fusion
**ODI**: Oswestry Disability Index
**PROM**: Patient-reported outcome measure
**PROMIS-PF**: Patient-Reported Outcomes Measurement Information System Physical Function
**SF-12 PCS**: 12-item Short Form Physical Composite Score
**VAS**: Visual analog scale
**WC**: Workers' compensation

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increased by 2000%.[1,2] Further, hospital costs associated with lumbar fusion increased by 177% from 2004 to 2015, averaging more than $50,000 per admission.[3] In conjunction with an increasing emphasis on outpatient surgery, minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) has emerged as an approach suited for the ambulatory setting because of decreased blood loss, length of stay (LOS), postoperative pain, and narcotic use and decreased injury to the paraspinal muscles compared with open TLIF.[4-6]

The workers' compensation (WC) population represents a particularly vulnerable group to worse outcomes after spine surgery.[7] One meta-analysis of WC patients undergoing spine surgery found that these patients were associated with increased postoperative pain and disability, with decreased satisfaction and delayed return to work, relative to non-WC patients.[7] Furthermore, these patients have been associated with higher postoperative and chronic opioid use, increased risk of failed back syndrome and additional surgery, and worse pain and disability relative to non-WC patients.[7,8]

With this emphasis on performing outpatient surgery and increased risk in WC patients, further investigation may prove beneficial in managing expectations and considering outcomes in the ambulatory setting. Although there are previous studies examining the outcomes of performing surgery in the ambulatory setting, few articles have compared these outcomes in the WC population.[9-12] To do so, we analyzed a retrospective single-surgeon database in WC patients undergoing 1-level MIS-TLIF in the inpatient versus outpatient setting.

## METHODS

### Patient Population

Patient consent and institutional review board approval (ORA number 14051301) were acquired before the current study. To determine patients who were eligible for this study, retrospective review of a single-surgeon database at an academic institution for spinal procedures between November 2005 and December 2021 was used. Patients who were WC claimants undergoing single-level MIS-TLIF in either the ambulatory or the inpatient setting were included. Patients without the setting of surgery or with diagnosis of trauma, malignancy, or infection were excluded from the study.

### Data Collection

In WC patients undergoing 1-level MIS-TLIF, patients were grouped into inpatient and outpatient cohorts. Age, body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters), gender, ethnicity, diabetic status, smoking status, blood pressure, American Society of Anesthesiologists (ASA) score, and Charlson Comorbidity Index were demographic parameters collected in this study. After propensity score matching for demographic characteristics, perioperative characteristics of spinal diseases of degenerative and isthmic spondylolisthesis, degenerative scoliosis, recurrent herniated nucleus pulposus, and central and foraminal stenosis were collected. Further perioperative characteristics of operative time, estimated blood loss (EBL), LOS, and postoperative visual analog scale (VAS) pain, and narcotic consumption were collected on postoperative day 0. Complications collected in this study were reintubation, urinary retention, urinary tract infection, acute renal failure, altered mental status, venous thromboembolism, pneumothorax, pneumonia, atelectasis, pleural effusion, arrhythmia, ileus, nausea and vomiting, hematoma, dysphagia, and fever of unknown origin. Postoperative patient-reported outcome measures (PROMs) of VAS back and leg, Oswestry Disability Index (ODI), 12-Item Short Form Physical Component Score (SF-12 PCS), and Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS-PF) were collected at preoperative, 6 weeks, 12 weeks, 6 months, and 1 year time points.

### Statistical Analysis

Using Stata 17.0 (StataCorp LLC, College Station, Texas, USA), data were analyzed with a significance of $P < 0.05$. Inferential statistics for demographic parameters were calculated, and propensity score matching was used to account for differences in demographics and comorbidities between cohorts. After propensity score matching, perioperative characteristics and complications were determined through a Student t test for continuous variables and $\chi^2$ for categorical variables. A paired t test was used for preoperative improvement of PROMs, whereas a Student t test was used for comparing mean PROMs between cohorts. Minimum clinically important difference (MCID) achievement was determined by comparing ΔPROM between preoperative and postoperative time point scores to predetermined values in the literature of VAS back = 2.1,[13] VAS leg = 2.8,[13] ODI = 14.9,[13] SF-12 PCS = 2.5,[14] and PROMIS-PF = 4.5.[15]

### Review of the Literature: Search Strategy, Selection Criteria, Data Extraction, and Findings

Studies examining WC claimants or comparing between WC and non-WC claimants were focused in this review. Embase and PubMed databases were searched through the PIO format of patient (P), intervention (I), and outcome (O) from January 2005 to July 2022. The starting year 2005 was selected to coincide with the start of data collection of the single-surgeon database used in this study. This review aimed to answer the following question: how are PROMs (O) affected in WC claimants (P) undergoing spine surgery (I)? The full search string is in the **Appendix**. Inclusion criteria included peer-reviewed randomized controlled trials, prospective cohort, retrospective cohort, case series, and case-control studies. Patients undergoing any type of elective spine surgery, such as cervical/lumbar decompression, cervical disc replacement, cervical fusion, and lumbar fusion, were included. Additional inclusion criteria included clinical outcomes of PROMs and MCID. Exclusion criteria included any conference abstracts, conference papers, reviews, notes, editorials, non–journal articles, and studies unrelated to spine surgery. The initial search was conducted independently by 2 reviewers (J.W.N. and T.J.H.). In cases of disagreements, the 2 reviewers discussed the article until a consensus was reached. Titles and abstracts were first examined, followed by examination of the full-text articles. In reports comparing WC versus non-WC claimants, the effect of WC on

**Table 1.** Unmatched Patient Demographics

| Characteristic | Inpatient (N = 240) | Outpatient (N = 33) | *P* Value* |
|---|---|---|---|
| Age (years), mean ± SD | 46.5 ± 10.5 | 44.4 ± 7.8 | 0.285 |
| Body mass index (kg/m$^2$), mean ± SD | 31.8 ± 6.1 | 29.2 ± 4.1 | **0.019** |
| Gender | | | 0.910 |
| Female | 22.1 (53) | 21.2 (7) | |
| Male | 77.9 (187) | 78.8 (26) | |
| Ethnicity | | | 0.062 |
| African American | 18.3 (44) | 6.5 (2) | |
| Asian | 1.3 (3) | 0.0 (0) | |
| Hispanic | 27.1 (65) | 51.6 (16) | |
| White | 50.4 (121) | 38.7 (12) | |
| Other | 2.9 (7) | 3.2 (1) | |
| Diabetic status | | | 0.662 |
| Nondiabetic | 88.3 (212) | 90.9 (30) | |
| Diabetic | 11.7 (28) | 9.1 (3) | |
| Smoking status | | | 0.068 |
| Nonsmoker | 73.2 (175) | 87.9 (29) | |
| Smoker | 26.8 (64) | 12.1 (4) | |
| Blood pressure | | | **0.020** |
| Normotensive | 63.6 (152) | 84.4 (27) | |
| Hypertensive | 36.4 (87) | 15.6 (5) | |
| American Society of Anesthesiologists score | | | **0.034** |
| ≤2 | 81.2 (194) | 96.7 (29) | |
| >2 | 18.8 (45) | 3.3 (1) | |
| Charlson Comorbidity Index (mean ± SD) | 1.5 ± 1.4 | 0.9 ± 1.2 | 0.059 |

Values are % (number) except where indicated otherwise. Bold values indicate significance.
SD, standard deviation.
*$P$ value calculated using $\chi^2$ analysis for categorical variables or Student $t$ test for continuous variables.

**Table 2.** Matched Patient Demographics

| Characteristic | Inpatient (N = 184) | Outpatient (N = 32) | *P* Value* |
|---|---|---|---|
| Age (years), mean ± SD | 45.0 ± 10.5 | 44.4 ± 7.9 | 0.769 |
| Body mass index (kg/m$^2$), mean ± SD | 30.2 ± 5.1 | 29.3 ± 4.2 | 0.304 |
| Gender | | | 0.875 |
| Female | 20.7 (38) | 21.9 (7) | |
| Male | 79.4 (146) | 78.1 (25) | |
| Ethnicity | | | 0.126 |
| African American | 16.3 (30) | 6.7 (2) | |
| Asian | 1.6 (3) | 0.0 (0) | |
| Hispanic | 29.9 (55) | 53.3 (16) | |
| White | 48.9 (90) | 36.7 (11) | |
| Other | 3.3 (6) | 3.3 (1) | |
| Diabetic status | | | 0.645 |
| Nondiabetic | 92.9 (171) | 90.6 (29) | |
| Diabetic | 7.1 (13) | 9.4 (3) | |
| Smoking status | | | 0.451 |
| Nonsmoker | 82.1 (151) | 87.5 (28) | |
| Smoker | 17.9 (33) | 12.5 (4) | |
| Blood pressure | | | 0.511 |
| Normotensive | 79.4 (146) | 84.4 (27) | |
| Hypertensive | 20.7 (38) | 15.6 (5) | |
| American Society of Anesthesiologists score | | | 0.134 |
| ≤2 | 86.9 (159) | 96.6 (28) | |
| >2 | 13.1 (24) | 3.5 (1) | |
| Charlson Comorbidity Index (mean ± SD) | 1.1 ± 1.2 | 0.9 ± 1.2 | 0.456 |

Values are % (number) except where indicated otherwise. Bold values indicate significance.
SD, standard deviation.
*$P$ value calculated using $\chi^2$ analysis for categorical variables or Student $t$ test for continuous variables.

clinical outcomes was recorded. In reports limiting patients to only WC claimants, the primary outcomes of the measured variables were recorded.

## RESULTS

### Demographics, Perioperative Characteristics, and Complications

Before propensity score matching, there were 240 and 33 patients undergoing single-level MIS-TLIF in the inpatient and outpatient setting, respectively, totaling 277 patients. In the unmatched patient demographics (Table 1), the outpatient cohort was associated with significantly lower BMI, diabetic status, hypertension, and decreased ASA score. After propensity matching for demographic characteristics and comorbidities, there were no significant differences between cohorts (Table 2). For perioperative outcomes, the outpatient cohort was associated with a higher proportion of patients with diagnosis of central and foraminal stenosis ($P < 0.021$; all) and decreased EBL, LOS, and postoperative VAS pain score and narcotic consumption ($P < 0.034$; all) relative to the inpatient cohort (Table 3). However, no significant differences were noted with diagnosis of degenerative and isthmic spondylolisthesis, degenerative scoliosis, and degenerative scoliosis and mean operative time

**Table 3.** Matched Perioperative Characteristics

| Characteristic | Inpatient (N = 184) | Outpatient (N = 32) | *P* Value* |
|---|---|---|---|
| Spinal disease | | | |
| Degenerative spondylolisthesis | 34.2 (63) | 43.8 (14) | 0.300 |
| Isthmic spondylolisthesis | 17.4 (32) | 31.3 (10) | 0.068 |
| Degenerative scoliosis | 1.1 (2) | 0.0 (0) | 0.554 |
| Recurrent herniation of the nucleus pulposus | 27.2 (50) | 28.1 (9) | 0.911 |
| Central stenosis | 75.5 (139) | 93.8 (30) | **0.021** |
| Foraminal stenosis | 14.7 (27) | 81.3 (26) | **<0.001** |
| Operative time (minutes) | | | |
| Mean ± SD | 122.7 ± 35.7 | 126.1 ± 21.7 | 0.614 |
| Estimated blood loss (mL) | | | |
| Mean ± SD | 58.0 ± 27.3 | 38.0 ± 22.3 | **<0.001** |
| Length of stay (hours) | | | |
| Mean ± SD | 50.6 ± 22.6 | 4.7 ± 1.5 | **<0.001** |
| Acute postoperative visual analog scale pain | | | |
| POD 0 | 5.9 ± 1.6 | 4.9 ± 2.3 | **0.034** |
| Postoperative narcotic consumption | | | |
| POD 0 | 119.6 ± 81.7 | 23.5 ± 17.4 | **<0.001** |

Values are % (number) except where indicated otherwise. Bold values indicate significance.
SD, standard deviation; POD, postoperative day of discharge.
*$P$ value calculated using $\chi^2$ analysis for categorical variables or Student $t$ test for continuous variables.

**Table 4.** Matched Postoperative Complications

| Complication | Inpatient (N = 184), % (n) | Outpatient (N = 32), % (n) | *P* Value* |
|---|---|---|---|
| Reintubation | 0.0 (0) | 0.0 (0) | — |
| Urinary retention | 2.8 (5) | 3.3 (1) | 0.882 |
| Urinary tract infection | 0.0 (0) | 0.0 (0) | — |
| Acute renal failure | 0.0 (0) | 0.0 (0) | — |
| Altered mental status | 0.0 (0) | 0.0 (0) | — |
| Venous thromboembolism | 0.0 (0) | 0.0 (0) | — |
| Pulmonary embolism | 0.0 (0) | 0.0 (0) | — |
| Pneumothorax | 0.0 (0) | 0.0 (0) | — |
| Pneumonia | 0.0 (0) | 0.0 (0) | — |
| Atelectasis | 1.6 (3) | 0.0 (0) | 0.481 |
| Pleural effusion | 0.0 (0) | 0.0 (0) | — |
| Arrhythmia | 0.0 (0) | 0.0 (0) | — |
| Ileus | 0.0 (0) | 0.0 (0) | — |
| Nausea/vomiting | 17.9 (33) | 0.0 (0) | **0.012** |
| Hematoma | 0.0 (0) | 0.0 (0) | — |
| Dysphagia | 0.0 (0) | 0.0 (0) | — |
| Fever of unknown origin | 6.6 (11) | 0.0 (0) | 0.148 |

Bold values indicate significance.
*$P$ values calculated using $\chi^2$ analysis.

(Table 3). For complications, the inpatient cohort was associated with a significantly higher rate of nausea and vomiting ($P = 0.012$) compared with the outpatient cohort (Table 4). There were no significant differences between cohorts for the complications reintubation, urinary retention, urinary tract infection, acute renal failure, altered mental status, venous thromboembolism, pulmonary embolism, pneumothorax, pneumonia, atelectasis, pleural effusion, arrhythmia, ileus, hematoma, dysphagia, or fever of unknown origin (Table 4).

## Primary Outcome Measures

From preoperative baseline, both cohorts were associated with significant improvement in postoperative follow-up in VAS back and leg score (Figure 1) from 6 weeks to 6 months follow-up in the inpatient cohort and 6 weeks to 1 year follow-up in the outpatient cohort ($P < 0.033$; all) (Table 5). The inpatient cohort was associated with significant preoperative improvement from preoperative baseline with ODI (Figure 2) from 12 weeks to 1 year, SF-12 PCS (Figure 3) at 12 weeks, and PROMIS-PF (Figure 3) from 12 weeks to 1 year ($P < 0.038$), whereas the outpatient cohort had no significant difference from preoperative baseline in the PROMs ODI SF-12 PCS, and PROMIS-PF at any time point (Table 5). Between cohorts, the outpatient cohort was associated with decreased VAS leg (Figure 1) scores at 1 year and ODI (Figure 2) at preoperative and 12 weeks time points ($P < 0.031$; all) (Table 5). Further, the outpatient cohort was associated with higher SF-12 PCS (Figure 3) at 6 weeks visit and preoperative PROMIS-PF (Figure 3) ($P < 0.028$; all) (Table 5). For MCID achievement, the inpatient cohort had most patients achieve overall MCID for all PROMs aside from ODI, whereas the outpatient cohort had most patients achieve MCID in only SF-12 PCS (Table 6). The inpatient cohort had more patients achieve MCID for PROMIS-PF at 1 year ($P = 0.034$) relative to the outpatient cohort (Table 6).

## Review of the Literature

A total of 150 studies were identified in the Embase and PubMed databases (Figure 4). Fifty-five records were excluded before reviewing the title or abstracts, because these records were duplicates, conference abstracts, conference papers, reviews, notes, or editorials. Ninety-five titles and abstracts were screened, with 61 exclusions. These records were excluded, because these studies

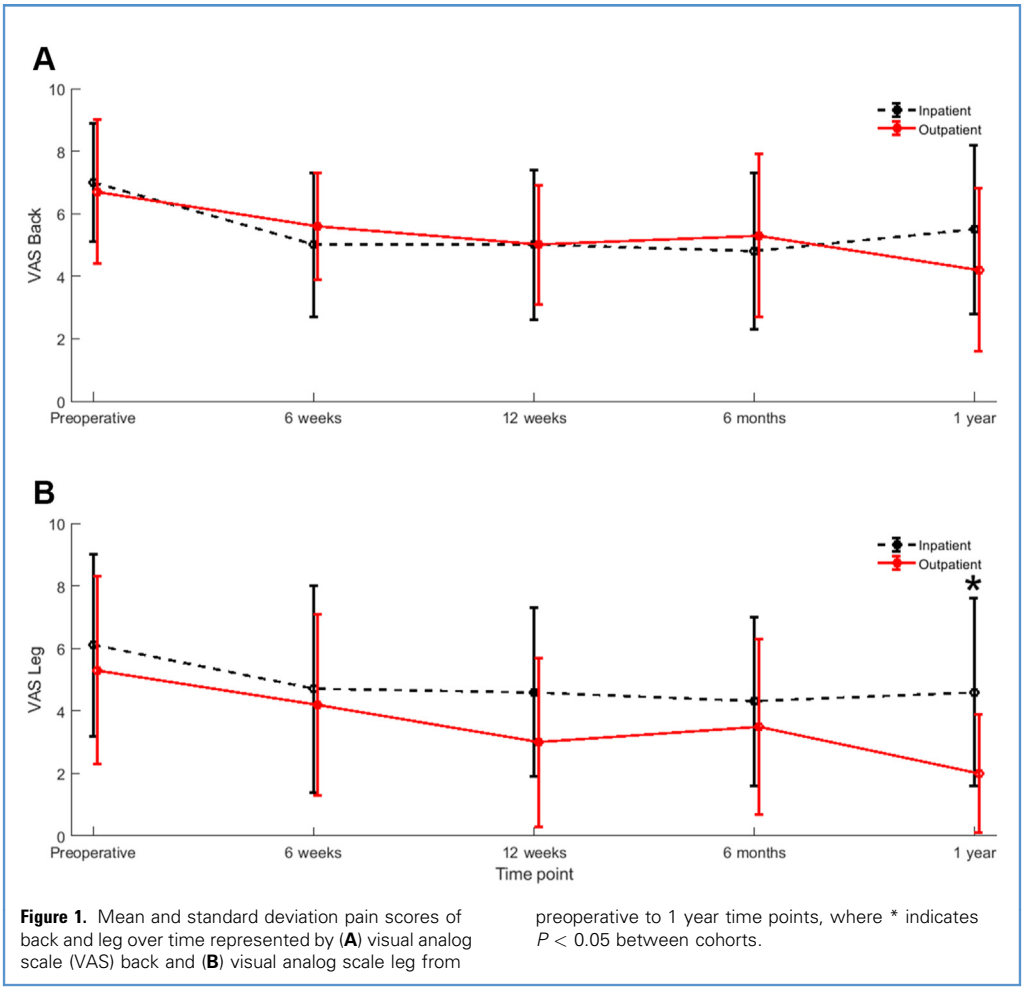


**Figure 1.** Mean and standard deviation pain scores of back and leg over time represented by (**A**) visual analog scale (VAS) back and (**B**) visual analog scale leg from preoperative to 1 year time points, where * indicates $P < 0.05$ between cohorts.

were not related to spine surgery, were not surgical, or had no PROMs. Thirty-four full-text studies were examined for eligibility, and 8 reports were excluded. These reports were excluded, because the WC claimants were accounted for only in the preoperative time point, the full-text was not available, the patient population was not WC claimants, or the study was not surgical. Of the 26 remaining studies, 3 limited the patient population to only WC claimants (Table 7). These studies examined the effect of anterior cervical discectomy and fusion versus cervical disc replacement, time to surgery and symptom duration, and the severity of obesity on clinical outcomes (Table 7).[16-18] In 23 studies, WC claimants were incorporated as a variable in regression analysis or were used to stratify patient groups to analyze the effect of WC status on clinical outcomes (Table 7).[19-41] In analyzing the effect of WC status, 1 study in patients undergoing TLIF reported that WC status did not significantly affect postoperative VAS pain score.[26] In the remaining 22 studies, WC status was either a negative predictor or had worse outcomes in physical function, pain, disability, mental function, postoperative satisfaction, or MCID achievement.[19-25,27-41]

## DISCUSSION

In this analysis, perioperative characteristics, complications, and postoperative outcomes were compared in the WC patients undergoing primary single-level MIS-TLIF in either the inpatient or the outpatient setting. After propensity score matching with respect to demographic information, the outpatient cohort was associated with a higher proportion of diagnosis for central and foraminal stenosis, whereas the inpatient cohort was associated with greater EBL, LOS, postoperative pain, postoperative narcotic use, and nausea/vomiting. The inpatient cohort was associated with improvement from preoperative baseline in all PROMs in ≥1 time point, with most patients achieving MCID, the threshold at which patients experience a noticeable clinical difference,[13-15] in all PROMs aside from ODI. The outpatient cohort was associated with improvement in VAS back score at all time points and VAS leg score at 6 months, with most WC claimants achieving overall MCID only in SF-12 PCS. Between cohorts, the outpatient cohort was associated with less leg pain at 1 year, decreased preoperative and 1-year disability, and increased preoperative and 6-week physical function, whereas the inpatient cohort was associated with higher

**Table 5.** Matched Impact of Inpatient Versus Outpatient Setting on Patient-Reported Outcome Measures

| Patient-Reported Outcome Measure | Inpatient (Mean ± SD) | *P* Value* | Outpatient (Mean ± SD) | *P* Value* | *P* Value† |
|---|---|---|---|---|---|
| VAS back | | | | | |
| Preoperative | 7.0 ± 1.9 | — | 6.7 ± 2.3 | — | 0.500 |
| 6 weeks | 5.0 ± 2.3 | **<0.001** | 5.6 ± 1.7 | **0.001** | 0.258 |
| 12 weeks | 5.0 ± 2.4 | **<0.001** | 5.0 ± 1.9 | **0.021** | 0.993 |
| 6 months | 4.8 ± 2.5 | **<0.001** | 5.3 ± 2.6 | **0.033** | 0.419 |
| 1 year | 5.5 ± 2.7 | 0.064 | 4.2 ± 2.6 | **0.017** | 0.183 |
| VAS leg | | | | | |
| Preoperative | 6.1 ± 2.9 | — | 5.3 ± 3.0 | — | 0.229 |
| 6 weeks | 4.7 ± 3.3 | **0.001** | 4.2 ± 2.9 | 0.096 | 0.550 |
| 12 weeks | 4.6 ± 2.7 | **<0.001** | 3.0 ± 2.7 | 0.114 | 0.054 |
| 6 months | 4.3 ± 2.7 | **<0.001** | 3.5 ± 2.8 | **0.010** | 0.244 |
| 1 year | 4.6 ± 3.0 | **0.022** | 2.0 ± 1.9 | 0.060 | **0.018** |
| Oswestry Disability Index | | | | | |
| Preoperative | 52.1 ± 16.4 | — | 44.2 ± 14.1 | — | **0.031** |
| 6 weeks | 51.2 ± 18.2 | 0.673 | 47.2 ± 16.2 | 0.400 | 0.390 |
| 12 weeks | 46.5 ± 16.0 | **0.002** | 36.4 ± 11.2 | 0.170 | **0.027** |
| 6 months | 40.7 ± 19.1 | **<0.001** | 37.3 ± 17.8 | 0.064 | 0.468 |
| 1 year | 44.6 ± 24.0 | **0.004** | 30.0 ± 16.3 | 0.116 | 0.075 |
| 12-item Short Form Physical Composite Score | | | | | |
| Preoperative | 27.9 ± 10.3 | — | 30.3 ± 5.9 | — | 0.298 |
| 6 weeks | 26.4 ± 6.7 | 0.900 | 31.4 ± 7.8 | 0.297 | **0.028** |
| 12 weeks | 29.3 ± 7.7 | **0.038** | 31.0 ± 7.8 | 0.550 | 0.502 |
| 6 months | 31.0 ± 7.3 | 0.064 | 33.1 ± 10.1 | 0.390 | 0.437 |
| 1 year | 32.6 ± 11.7 | 0.253 | 36.5 ± 12.3 | 0.437 | 0.489 |
| Patient-Reported Outcomes Measurement Information System Physical Function | | | | | |
| Preoperative | 31.6 ± 4.9 | — | 36.4 ± 6.4 | — | **0.012** |
| 6 weeks | 32.0 ± 5.7 | 0.135 | 32.1 ± 5.8 | 0.381 | 0.964 |
| 12 weeks | 37.5 ± 7.4 | **0.007** | 36.9 ± 7.6 | 0.869 | 0.825 |
| 6 months | 38.9 ± 7.7 | **<0.001** | 39.8 ± 8.3 | 0.211 | 0.774 |
| 1 year | 38.9 ± 8.3 | **0.002** | 41.2 ± 8.9 | 0.944 | 0.568 |

Bold values indicate significance.
SD, standard deviation; VAS, visual analog scale.
**P* values calculated using paired-samples *t* test to determine improvement in patient-reported outcome measures.
†*P* values calculated using Student *t* test for independent samples to compare patient-reported outcome measures between groups.

achievement of MCID for PROMIS-PF at 1 year and overall VAS back score. Overall, these findings suggest that the outpatient cohort was associated with improved perioperative outcomes, decreased pain and disability, and increased physical function at specific time points, whereas the inpatient cohort had most patients achieve meaningful clinical improvement in pain and physical function.

Consistently throughout the literature, WC claimants report inferior clinical outcomes in spine surgery.[19-41] WC claimants typically report worse physical function, mental function, pain, disability, and postoperative satisfaction compared with non-WC patients.[19-41] Further, WC status was generally an independent predictor of negative clinical outcomes of disability, pain, and physical function.[19-41] Because this population is susceptible to worse clinical outcomes, use of the ambulatory surgical setting for spine surgery may reduce health care use and may prove helpful in managing expectations for WC claimants.[1] Thus, it is imperative

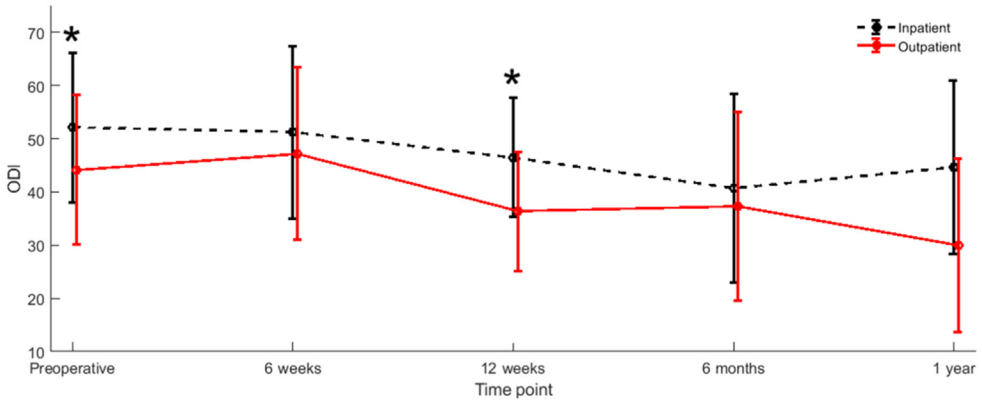


**Figure 2.** Mean and standard deviation disability scores over time represented by Oswestry Disability Index (ODI) over time from preoperative to 1 year time points, where * indicates $P < 0.05$ between cohorts.

to identify whether WC claimants undergoing ambulatory spine surgery see similar postoperative benefit to their inpatient counterparts.

### Demographics, Perioperative Characteristics, and Complications

Before propensity score matching, patients undergoing single-level MIS-TLIF in the outpatient setting were associated with decreased BMI, diagnosis of hypertension, and ASA score. Further, smoking status and Charlson Comorbidity Index trended toward significance. These findings concur with previous studies.[42-45] In 1 study of 18,689 patients undergoing lumbar decompression,[42] patients who underwent surgery in the outpatient setting were associated with decreased BMI, smoking status, ASA class, and diagnosis of diabetes and chronic obstructive pulmonary disease. The presence of these comorbidities has been associated with conversion of outpatient surgery to inpatient admission.[45] One practice[46] recommended specific criteria, such as decreased ASA class, lower BMI, clearance from a general practitioner, and close proximity to the surgical center, as recommendations before performing surgery in the ambulatory setting. Consequently, surgeons may be more cautious and may select patients with higher comorbidities to undergo surgery in the inpatient setting.

After propensity score matching, perioperative characteristics that differed significantly between cohorts were diagnosis of central and foraminal stenosis, EBL, LOS, postoperative pain, and postoperative narcotic use. Specifically, the WC outpatient cohort undergoing 1-level MIS-TLIF were associated with more patients with diagnosis of central and foraminal stenosis compared with the inpatient cohort. However, the inpatient cohort was associated with greater EBL, LOS, postoperative pain, and narcotic use. Further, these patients had a higher proportion of patients experiencing nausea and vomiting relative to the outpatient cohort. Previous articles studying ambulatory lumbar spine surgery have found similar findings with respect to increased EBL and LOS.[9,46,47] Further, postoperative pain and nausea/vomiting are the most common symptoms after surgery and have been associated factors that preclude discharge and extend LOS.[48-51] These symptoms have been also correlated with increased opioid use, suggesting that the combination of these factors may extend LOS and require further inpatient management.[52] These factors may be particularly relevant to WC claimants, because this population has previously been associated with higher rates of chronic opioid use and more severe postoperative pain, contributing to delay in return to work and worse outcomes.[7,53] Identifying WC claimants who would have decreased risk in undergoing surgery in the ambulatory setting may prove beneficial in minimizing these perioperative factors.

### Pain

VAS back and VAS leg represent a pain from 0 to 10. In VAS back, both cohorts undergoing 1-level MIS-TLIF experienced significant improvement from preoperative scores at all time points, apart from the inpatient cohort at 1 year. However, for VAS leg, the inpatient cohort was associated with improvement from preoperative leg pain, whereas the outpatient cohort had improvement only at 6 months. For MCID, most patients in the inpatient cohort achieved overall MCID for both VAS back and leg, whereas less than half of patients achieved MCID in the outpatient cohort overall. Furthermore, the inpatient cohort was associated with a significantly higher proportion of patients achieving MCID relative to the inpatient cohort. As a procedure to reduce symptoms from neural compression, MIS-TLIF has previously shown significant improvement in back and leg pain in the postoperative period.[54,55] One possible explanation for the lack of improvement in the outpatient cohort for VAS leg and differences in MCID was the lack of power in this group, because this cohort had 32 patients in the analysis relative to the 184 patients in the inpatient cohort. This finding is further supported by these VAS leg scores in the outpatient cohort trending toward significant improvement from preoperative baseline and that this cohort was associated with decreased VAS leg score at 1 year. Regardless, these findings overall suggest that WC

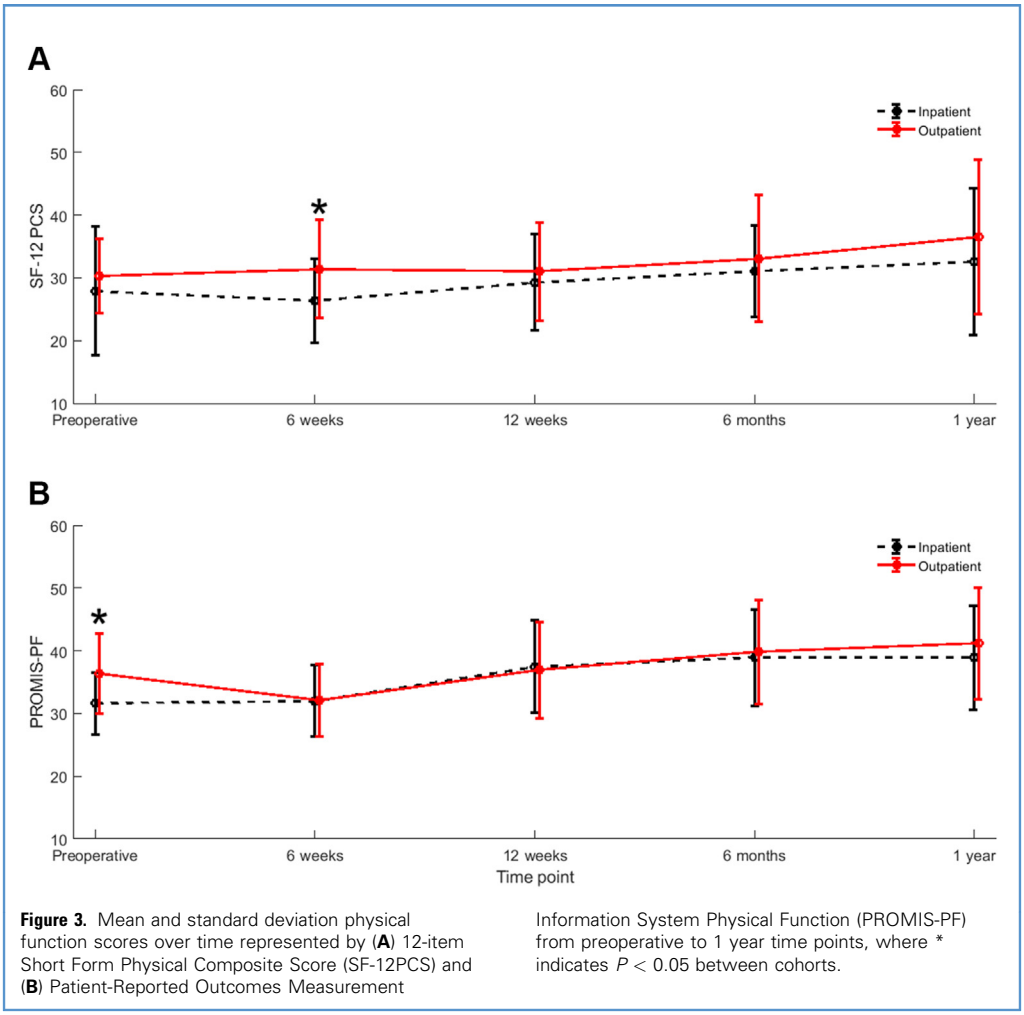


**Figure 3.** Mean and standard deviation physical function scores over time represented by (**A**) 12-item Short Form Physical Composite Score (SF-12PCS) and (**B**) Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS-PF) from preoperative to 1 year time points, where * indicates $P < 0.05$ between cohorts.

claimants undergoing 1-level MIS-TLIF in either the inpatient or the outpatient setting improve in their back and leg pain at some point in their postoperative course. However, further investigation is necessary, because WC claimants have been associated with higher postoperative pain and decreased improvement after intervention.[7,19-41]

## Disability

ODI represents a measure of disability in patients with low back pain. In the inpatient cohort, there was a significant improvement in ODI from 6 weeks to 6 months. Although the outpatient cohort trended toward improvement in disability from 12 weeks to 1 year, there was no significant improvement at these time points. However, the outpatient cohort had significantly less disability compared with the inpatient cohort at preoperative and 12-week time points. For MCID achievement, fewer than half of patients in both cohorts achieved overall MCID in ODI. Previous studies of patients undergoing lumbar spine surgery have shown similar findings in disability outcomes.[42,46] One study of 70 patients undergoing lateral lumbar interbody fusion in either the hospital or the ambulatory setting found that patients in the ambulatory cohort had no significant improvement in disability from preoperative scores, but there was an association with improved disability postoperatively between cohorts.[46] These findings suggest that WC claimants undergoing surgery in the ambulatory setting had less disability before surgery, with continuation of decreased disability postoperatively. Consequently, the outpatient cohort trended toward less clinically meaningful change in disability. In addition, this analysis may be limited because of the power of the outpatient cohort, potentially limiting the effect between surgery settings. Because the WC population has also been associated with increased disability compared with non-WC patients, further analysis may elucidate this relationship.[7,19-41]

## Physical Function

PROMIS-PF and SF-12 PCS are questionnaires to evaluate physical function in patients. In the inpatient cohort, WC claimants were associated with improved SF-12 PCS and PROMIS-PF at 6 months follow-up and from 12 weeks to 1 year follow-up, respectively, with most patients achieving overall MCID in both PROMs. For the

**Table 6.** Matched Minimum Clinically Important Difference Achievement

| Patient-Reported Outcome Measure | Inpatient, % (n) | Outpatient, % (n) | *P* value* |
|---|---|---|---|
| Oswestry Disability Index | | | |
| 6 weeks | 20.3 (12) | 5.6 (1) | 0.143 |
| 12 weeks | 27.8 (15) | 28.6 (4) | 0.953 |
| 6 months | 41.4 (24) | 36.8 (7) | 0.726 |
| 1 year | 47.8 (11) | 11.1 (1) | 0.054 |
| Overall | 43.9 (29) | 36.0 (9) | 0.493 |
| Patient-Reported Outcomes Measurement Information System Physical Function | | | |
| 6 weeks | 35.0 (7) | 16.7 (1) | 0.393 |
| 12 weeks | 44.4 (8) | 25.0 (2) | 0.347 |
| 6 months | 67.7 (12) | 42.9 (3) | 0.275 |
| 1 year | 67.7 (10) | 0.0 (0) | **0.034** |
| Overall | 70.4 (19) | 45.5 (5) | 0.149 |
| 12-item Short Form Physical Composite Score | | | |
| 6 weeks | 32.1 (9) | 33.3 (4) | 0.941 |
| 12 weeks | 51.9 (14) | 18.2 (2) | 0.057 |
| 6 months | 43.5 (10) | 45.5 (5) | 0.914 |
| 1 year | 57.1 (12) | 50.0 (2) | 0.792 |
| Overall | 66.7 (26) | 55.6 (10) | 0.419 |
| VAS back | | | |
| 6 weeks | 41.2 (63) | 38.9 (7) | 0.852 |
| 12 weeks | 42.4 (61) | 50.0 (7) | 0.582 |
| 6 months | 43.1 (62) | 29.4 (5) | 0.280 |
| 1 year | 36.4 (8) | 44.4 (4) | 0.675 |
| Overall | 64.0 (103) | 40.0 (10) | **0.022** |
| VAS leg | | | |
| 6 weeks | 36.4 (20) | 35.3 (6) | 0.936 |
| 12 weeks | 35.2 (19) | 30.8 (4) | 0.091 |
| 6 months | 38.6 (22) | 50.0 (8) | 0.413 |
| 1 year | 27.3 (6) | 55.6 (5) | 0.135 |
| Overall | 54.0 (34) | 37.5 (9) | 0.170 |

Bold values indicate significance.
VAS, visual analog scale.
*$P$ values calculated using $\chi^2$ analysis.

outpatient cohort, there was no significant improvement from baseline at any time point with either PROM, and most WC claimants achieved MCID only in SF-12 PCS. Between cohorts, the outpatient cohort was associated with significantly higher SF-12 PCS at 6 weeks compared with the inpatient cohort, and the inpatient cohort had a higher proportion of WC claimants achieve MCID at 1 year follow-up. These findings suggest that WC claimants in the outpatient setting were associated with greater physical function before their procedure, and therefore, were less likely to benefit in meaningful clinical improvement after their procedure. However, these physical function outcome measures have previously been correlated with ODI and VAS score.[56-60] Similar to pain and disability patient outcome measures, these physical function outcome measures may be limited by the number of WC claimants in the outpatient setting, prompting further investigation.[7,19-41]

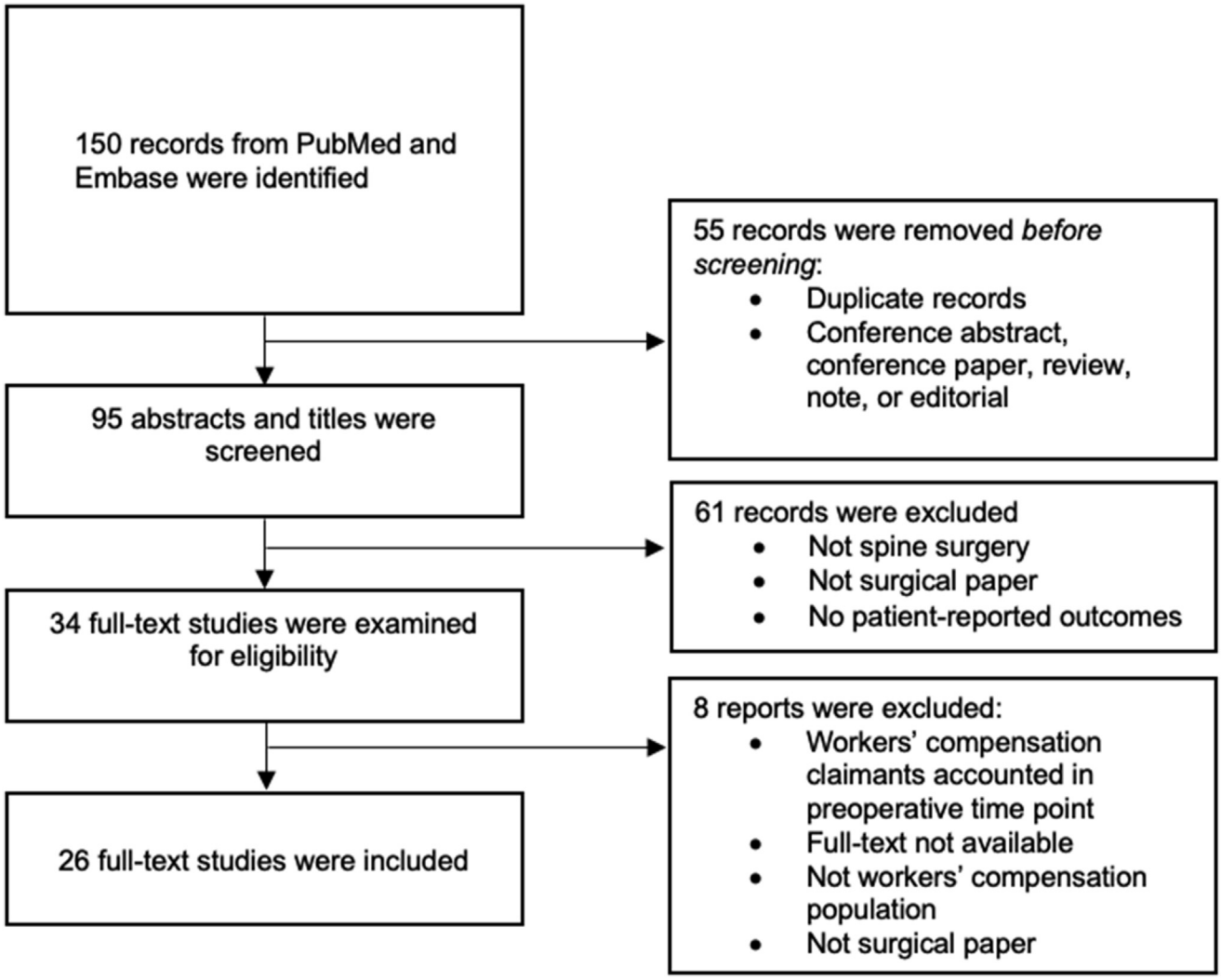


**Figure 4.** Search flow diagram.

## Limitations

This study has several limitations. Because this analysis used a retrospective, single-surgeon database undergoing 1-level MIS-TLIF, generalizability and external validity are limited. Further, retrospective analysis precludes causality for the effect of undergoing surgery in the ambulatory setting rather than the hospital. In addition, the number of WC claimants in the outpatient cohort had 32 patients after matching, compared with the 184 patients undergoing single-level MIS-TLIF as inpatients. The outpatient cohort had limited power, as noted in multiple PROMs that trended to significance. This situation is further limited through loss of patient follow-up, which may introduce selection bias. Furthermore, PROMs are inherently subjective and are susceptible to response bias. Because the effect of WC status has been associated with effects of worse mental health in addition to increased pain and decreased disability, further investigation into the effect of mental health in WC patients in this procedure may provide a more complete analysis.[7,19-41] In addition, external validity and generalizability may be improved through analysis with multiple surgeons at different centers.

## CONCLUSIONS

In WC claimants undergoing single-level MIS-TLIF in either the inpatient or outpatient setting, claimants in the inpatient setting were associated with higher BMI, diagnosis of hypertension, and higher ASA classification. After propensity score matching, this cohort was associated with higher EBL, LOS, postoperative pain, and narcotic use, decreased diagnosis of central and foraminal stenosis, and higher amounts of nausea/vomiting. The inpatient cohort was associated with significant improvement from preoperative function in back and leg pain, disability, and physical function in most time points, with meaningful clinical difference in most patients apart from disability. Outpatient WC claimants were

**Table 7.** List of Studies with Country, Study Type, Number of Patients, Follow-Up Time, Procedure, and Impact of Workers' Compensation Status or Major Finding of Workers' Compensation Study

| Study | Country | Study Type | Number of Patients | Follow-Up | Procedure | Impact of WC Status or Major Finding of WC Study |
|---|---|---|---|---|---|---|
| Trief et al., 2006[19] | United States | Prospective case-control | 160 | 2 years | Lumbar fusion | WC negatively associated with postoperative VAS pain and ODI |
| Steinmetz et al., 2008[16] | United States | Randomized controlled trial | 1004 | 2 years | CDR or ACDF | WC claimants had lower NDI scores in CDR rather than ACDF |
| Carreon et al., 2009[20] | United States | Prospective cohort | 489 | 2 years | Lumbar fusion | WC claimants had worse significantly worse ODI and had less improvement in SF-36 PCS |
| Anderson et al., 2009[21] | United States | Retrospective cohort | 488 | 2 years | ACDF | WC status was a negative predictor of overall success defined as >15-point NDI improvement, maintained/improved neurologic examination result, no serious adverse event related to the procedure, and no revision of plate/graft |
| Carreon et al., 2010[22] | United States | Retrospective case-control | 783 | 2 years | Posterolateral lumbar fusion | WC claimants had worse ODI, SF-36 PCS, and MCID achievement for SF-36 PCS |
| Kong et al., 2010[23] | Korea | Retrospective cross-sectional | 629 | <1 month to >1 year | Lumbar spinal fusion | ODI was significantly worse with presence of WC status |
| Djurasovic et al., 2011[24] | United States | Retrospective cohort | 171 | 2 years | Lumbar spinal fusion | WC claimants negatively affected MCID achievement for SF-36 PCS |
| Rouben et al., 2011[25] | United States | Retrospective cohort | 169 | 36—60 months | MIS-TLIF | WC claimants improved less in ODI and VAS pain scores compared with non-WC patients |
| Pelton et al., 2012[26] | United States | Prospective cohort | 66 | 6 months | Open transforaminal lumbar interbody fusion or MIS-TLIF | WC status did not significantly affect VAS pain scores |
| Gum et al., 2013[27] | United States | Retrospective case-control | 74 | 2 years | Lumbar fusion | WC claimants reported less improvement in back pain, leg pain, and ODI, with less substantial clinical benefit achieved in back and leg pain |
| Chatha et al., 2014[28] | Australia | Prospective cohort | 286 | 2 years | ALIF, anterior lumbar artificial disc implant, or hybrid | WC claimants reported inferior postoperative VAS back/leg pain, ODI, SF-36 PCS, and 36-Item Short Form Mental Component Score |
| Tabaraee et al., 2015[29] | United States | Retrospective cohort | 352 | 6 months | ACDF | WC claimants reported significantly inferior VAS pain scores |
| McGirt et al., 2017[30] | United States | Retrospective case-control | 7,618 | 1 year | Lumbar spine surgery | Presence of WC status predicted negative ODI, EuroQol-5D, numeric rating scale back pain, and numeric rating scale leg pain outcomes |
| Phan et al., 2017[31] | Australia | Prospective cohort | 114 | 1 year | ALIF | WC claimants reported similar improvement and MCID achievement of SF-12 PCS, 12-Item Short Form Mental Component Score, and ODI compared with non-WC claimants |
| Hijji et al., 2018[32] | United States | Retrospective cohort | 165 | 1 year | MIS-TLIF | WC status was a negative independent risk factor for MCID achievement for VAS back |
| Asher et al., 2019[33] | United States | Retrospective case-control | 4,148 | 1 year | ACDF | WC status negatively predicted 1 year North American Spine Society satisfaction |
| Sivaganesan et al., 2020[34] | United States | Retrospective case-control | 34,076 | 1 year | Elective spine surgery | WC status positively predicted 1 year dissatisfaction |
| Archer et al., 2020[35] | United States | Retrospective case-control | 4,988 | 1 year | Cervical spine surgery | WC claim predicted worse NDI, NRS neck pain, and NRS arm pain |

WC, workers' compensation; VAS, visual analog scale; ODI, Oswestry Disability Index; CDR, cervical disc replacement; ACDF, anterior cervical discectomy and fusion; NDI, Neck Disability Index; SF-36 PCS, 36-Item Short Form Physical Component Score; MCID, minimum clinically important difference; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion; SF-12 PCS, 12-Item Short Form Physical Component Score; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function.
*Follow-up from postoperative day 0 to day of discharge.

Continues

**Table 7.** Continued

| Study | Country | Study Type | Number of Patients | Follow-Up | Procedure | Impact of WC Status or Major Finding of WC Study |
|---|---|---|---|---|---|---|
| Jenkins et al., 2020[36] | United States | Retrospective case-control | 255 | * | MIS-TLIF | WC status was independently associated with greater inpatient pain after MIS-TLIF |
| Yoo et al., 2020[37] | United States | Retrospective cohort | 124 | 1 year | ACDF | WC claimants showed significantly inferior postoperative PROMIS-PF compared with non-WC claimants |
| Budiono et al., 2021[38] | Australia | Retrospective cohort | 68 | >8 months | ALIF | WC status negatively predicted probability of a clinical success, where clinical success was an ODI improvement of ≥20 points |
| Cha et al., 2021[39] (WC ACDF) | United States | Retrospective cohort | 139 | 1 year | ACDF | WC claimants reported worse VAS arm, VAS neck, NDI, SF-12 PCS, and PROMIS-PF. WC claimants had lower MCID achievement rates for VAS arm, VAS neck, and NDI |
| Karamian et al., 2022[40] | United States | Retrospective cohort | 571 | 1 year | Lumbar decompression | WC was a negative independent predictor of SF-12 PCS, VAS back, and VAS leg scores |
| Patel et al., 2022[17] | United States | Retrospective cohort | 169 | 2 years | Minimally invasive lumbar decompression | Body mass index was not a predictor of postoperative physical health, pain, or disability in WC claimants |
| Patel et al., 2022[18] | United States | Retrospective cohort | 193 | 6 months | MIS-TLIF | Time to surgery and duration of symptoms had no effect on clinical outcomes in WC claimants |
| Cha et al., 2022[41] | United States | Retrospective cohort | 121 | 1 year | MIS-TLIF | WC claimants showed worse VAS back, VAS leg, ODI, SF-12 PCS, and PROMIS-PF. MCID achievement for WC claimants for VAS back, ODI, SF-12 PCS, and PROMIS-PF was lower compared with non-WC patients |

WC, workers' compensation; VAS, visual analog scale; ODI, Oswestry Disability Index; CDR, cervical disc replacement; ACDF, anterior cervical discectomy and fusion; NDI, Neck Disability Index; SF-36 PCS, 36-Item Short Form Physical Component Score; MCID, minimum clinically important difference; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion; SF-12 PCS, 12-Item Short Form Physical Component Score; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function.
*Follow-up from postoperative day 0 to day of discharge.

associated with significant preoperative improvement in back and leg pain at certain time points, with most claimants achieving MCID in only SF-12 PCS. The outpatient cohort was associated with decreased leg pain and disability, with improved physical function, whereas the inpatient cohort noted greater meaningful clinical improvement in physical function and back pain. These findings may be useful for surgeons managing expectations in outcomes for WC claimants undergoing lumbar surgery and for selecting whether these patients would benefit from an outpatient setting.

## CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**James W. Nie:** Conceptualization, Methodology, Visualization, Formal analysis, Software, Investigation, Writing — original draft, Writing — review & editing. **Timothy J. Hartman:** Conceptualization, Methodology, Visualization, Formal analysis, Software, Investigation, Writing — original draft, Writing — review & editing. **Hanna Pawlowski:** Project administration, Data curation, Investigation, Writing — review & editing. **Michael C. Prabhu:** Project administration, Data curation, Investigation, Writing — review & editing. **Nisheka N. Vanjani:** Project administration, Data curation, Investigation, Writing — review & editing. **Omolabake O. Oyetayo:** Project administration, Data curation, Investigation, Writing — review & editing. **Kern Singh:** Conceptualization, Methodology, Supervision, Resources, Investigation, Writing — review & editing.

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## APPENDIX

('compensation, workman'/exp OR 'compensation, workman' OR 'worker compensation'/exp OR 'worker compensation' OR 'workers compensation'/exp OR 'workers compensation' OR 'workers` compensation'/exp OR 'workers` compensation' OR 'workman compensation'/exp OR 'workman compensation' OR 'workmen compensation'/exp OR 'workmen compensation' OR 'workmen`s compensation'/exp OR 'workmen`s compensation') AND ('cervical spine surgery'/exp OR 'cervical spine surgery' OR 'spinal surgery'/exp OR 'spinal surgery' OR 'spine surgery'/exp OR 'spine surgery' OR 'lower lumbar spinal cord'/exp OR 'lower lumbar spinal cord' OR 'lumbar canal'/exp OR 'lumbar canal' OR 'lumbar spinal segment'/exp OR 'lumbar spinal segment' OR 'lumbar spine'/exp OR 'lumbar spine' OR 'lumbar vertebral column'/exp OR 'lumbar vertebral column' OR 'spina lumbalis'/exp OR 'spina lumbalis' OR 'spine, lumbar'/exp OR 'spine, lumbar' OR 'acapella one'/exp OR 'acapella one' OR 'axialif'/exp OR 'axialif' OR 'axle (intervertebral body 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