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Long-term Outcomes of Lumbar Fusion Among Workers' Compensation Subjects

An Historical Cohort Study

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Study Design. Historical cohort study.

Objective. To determine objective outcomes of return to work (RTW), permanent disability, postsurgical complications, opiate utilization, and reoperation status for chronic low back pain subjects with lumbar fusion. Similarly, RTW status, permanent disability, and opiate utilization were also measured for nonsurgical controls.

Summary of Background Data. A historical cohort study of workers' compensation (WC) subjects with lumbar arthrodesis and randomly selected controls to evaluate multiple objective outcomes has not been previously published.

Methods. A total of 725 lumbar fusion cases were compared to 725 controls who were randomly selected from a pool of WC subjects with chronic low back pain diagnoses with dates of injury between January 1, 1999 and December 31, 2001. The study ended on January 31, 2006. Main outcomes were reported as RTW status 2 years after the date of injury (for controls) or 2 years after date of surgery (for cases). Disability, reoperations, complications, opioid usage, and deaths were also determined.

Results. Two years after fusion surgery, 26% (n = 188) of fusion cases had RTW, while 67% (n = 483) of nonsurgical controls had RTW ($P \leq 0.001$) within 2 years from the date of injury. The reoperation rate was 27% (n = 194) for surgical patients. Of the lumbar fusion subjects, 36% (n = 264) had complications. Permanent disability rates were 11% (n = 82) for cases and 2% (n = 11) for nonoperative controls ($P \leq 0.001$). Seventeen surgical patients and 11 controls died by the end of the study ($P = 0.26$). For lumbar fusion subjects, daily opioid use increased 41% after surgery, with 76% (n = 550) of cases continuing opioid use after surgery. Total number of days off work was more prolonged for cases compared to controls, 1140 and 316 days, respectively ($P < 0.001$). Final multivariate, logistic regression analysis indicated the number of days off before surgery odds ratio [OR], 0.94 (95% confidence interval [CI], 0.92–0.97); legal representation OR, 3.43 (95% CI, 1.58–7.41); daily morphine usage OR, 0.83 (95% CI, 0.71–0.98); reoperation OR, 0.42 (95% CI, 0.26–0.69); and complications OR, 0.25 (95% CI, 0.07–0.90), are significant predictors of RTW for lumbar fusion patients.

Conclusion. This Lumbar fusion for the diagnoses of disc degeneration, disc herniation, and/or radiculopathy in a WC setting is associated with significant increase in disability, opiate use, prolonged work loss, and poor RTW status.

Key words: lumbar arthrodesis, workers' compensation, return to work, disability, opioids. **Spine 2010;XX: 000–000**

Lumbar arthrodesis (fusion) is a surgical procedure performed to unite spinal vertebrae to eliminate mobility. There have been few published studies evaluating lumbar fusion outcomes in US workers' compensation subjects.[1–4] In these studies, reoperation rates are the only outcome that has been consistently reported (about 22%). Surgical complications of 12% were reported in only one study at 3 months after surgery.[1] Permanent or temporary disability results 2 years after fusion are variable among the studies, 18% to 68%.[1,2,4] Similarly, return to work status (RTW) also varied from 41% to 78%.[2,4]

True outcomes are difficult to determine when results are variable. The number of lumbar fusions for degenerative conditions has increased 220% in the United States from 1990.[5] A recent systematic review of randomized clinical trials comparing lumbar fusion to conservative care indicates solid conclusions cannot be reached due to the methodologic limitations and limited data.[6] In 2006, a different systematic review questioned the cost effectiveness of lumbar fusion.[7]

In this study, OH Workers' Compensation data from January 1, 1999 to January 31, 2006 was used to assess the work status 2 years after lumbar fusion, permanent disability awards, surgical complications, reoperation status, and pain medication usage among cases and randomly selected controls with chronic low back pain (CLBP).

Materials and Methods

Data for this historical cohort study were collected from the Ohio Bureau of Workers' Compensation database. Extracted data included information on the injury (accident information and occupation), demographics, procedures, office visits, medications, RTW, permanent disability, and death. Personal identification information was not a part of the data.

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IRB Approval: This study proposal was approved by the Institutional Review Board at the University Of Cincinnati College Of Medicine prior to beginning the study.

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Table 1. ICD-9 CM Diagnoses for Low Back

Descriptions	Codes
Spondylolisthesis—acquired/degenerative	738.4
Radiculitis (leg or lumbar or lumbosacral)	724.4
Lumbago or sciatica due to displacement of intervertebral disc OR neuritis or radiculitis due to displacement or rupture of lumbar intervertebral disc	722.10
Lumbar stenosis	724.02
Spondylosis lumbar or lumbosacral without myelopathy	721.3
Degenerative intervertebral disc—lumbosacral	722.52
Sciatica	724.3
Displacement of lumbar intervertebral disc without myelopathy	722.1
Discogenic syndrome NOS or disc herniation or intervertebral disc NOS (extrusion, prolapse, protrusion, rupture)	722.2

ICD-9 CM indicates International Classification of Diseases, Ninth Revision, Clinical Modification.

Study Population

After approval by the Institutional Review Board at the University of Cincinnati College Of Medicine, 1450 study subjects were identified from the Ohio Bureau of Workers' Compensation database. Cases were subjects 18 to 70 years of age with CLBP classified by International Classification of Diseases, Ninth Revision, Clinical Modification diagnoses and Current Procedural Terminology codes for lumbar arthrodesis (Tables 1, 2).[8,9]

The database had 3138 workers with lumbar fusion and dates of injury between January 1, 1999 and December 31, 2001. "Date of injury" is the date on which a work-related injury occurred. Subjects with lumbar fusion after the cutoff date of July 31, 2003, and/or having injuries to other body parts in addition to the lumbar spine were excluded. A total of 725 lumbar fusion cases were eligible for the study. There were 10,518 nonoperated, CLBP subjects with similar injury dates and low back pain International Classification of Diseases, Ninth Revision, Clinical Modification diagnoses (Table 1). Subjects with spinal fracture, involvement of other body parts, cervical and/or thoracic areas, head trauma, or pregnancy were excluded. After exclusion due to involvement of other body parts and controlling for age, gender, and diagnoses, 3587 eligible controls remained. From this pool, 725 controls were selected randomly by computer (Figure 1).

This study design did not require direct contact with study subjects. The lost to follow-up rate was 1.4% due to lack of RTW status of 21 subjects (7 cases and 14 controls). Follow-up mean duration was 4.78 years for cases and 3.46 years for controls. The study ended on January 31, 2006.

Table 2. Instructions to Categorize the Types of Lumbar Fusion

Posterior uninstrumented fusion
- 1 level—22,612
- Multilevel—22,612 and 22,614

Posterior fusion with instrumentation
- 1 level—22,612 and 22,840
- Multilevel—22,612 and 22,614 and 22,842

Posterior lumbar interbody fusion (PLIF)
- 1 level—22,630 and 22,840 and 22,851
- Multilevel—22,630 and 22,632 and 22,842 and 22,851

Anterior lumbar interbody fusion (ALIF)
- 1 level—22,558 and 22,851
- Multilevel—22,558 and 22,585 and 22,851

Anterior and posterior fusion "360"
- 1 level—22,612 and 22,558 and 22,840 and 22,851
- Multilevel—22,612 and 22,614 and 22,842 and 22,558 and 22,585 and 22,851

Primary and Secondary Outcomes Measured

The primary outcome was RTW status. The secondary outcomes were permanent disability award, complications, reoperations, and opiate utilization.

RTW was considered successful if the injured worker returned to employment 2 years after the date of surgery for cases or 2 years after injury for controls as part-time, full-time workers with the same or a different employer. Unsuccessful RTW was defined as failure to RTW in any capacity. Disability status was defined as workers who were awarded permanent total disability status after surgery or after injury. Permanent total disability is permanent lifetime compensation.

Complications were classified as early major systemic (<6 weeks postoperative), neurologic, implant, late spinal, or wound complications.[10]

Reoperation was defined as repeat lumbar surgical procedure(s) performed during the follow-up period. These repeat surgical procedures included the following: fusions, removal and/or insertion of fixation device(s), laminectomy, bone grafts, exploration, and decompression of the lumbar spine.[11,12]

Opioid utilization was limited to the oral route. For each oral narcotic analgesic, the date, name, dose, and quantity dispensed were converted to morphine equivalent units (MEQ). Cumulative dose per day was calculated. Average amount of opioids before surgery, after surgery, and during the entire length of the study were determined.[13]

Mortality status was categorized as perioperative mortality (*i.e.*, within 6 weeks postoperative) and long-term mortality from any cause.[14,15]

Statistical Analysis

RTW rates among lumbar fusion subjects have been reported as 41% to 78%.[2,4] A sample size of 250 cases and 250 controls provided an alpha (2-sided) of 0.05 (Type I error) and beta value of 0.14 (Type II error). This sample size provided 86% power to detect a 10% difference between the surgical fusion cases and nonsurgical controls. This was a conservative estimate of the case–control difference.[16]

Baseline characteristics of the cohorts were compared using χ^2 tests, frequencies, and percentages for categorical variables. *T* tests, means, and standard deviations were reported for continuous variables. Independent variables included age, gender, diagnoses, smoking history, weekly wages, legal representation, marital status, education, total days off, number of days from the date of injury to date of surgery, number of reoperations, complications, lumbar magnetic resonance imaging (MRI) findings, number of vocational and rehabilitation ses-

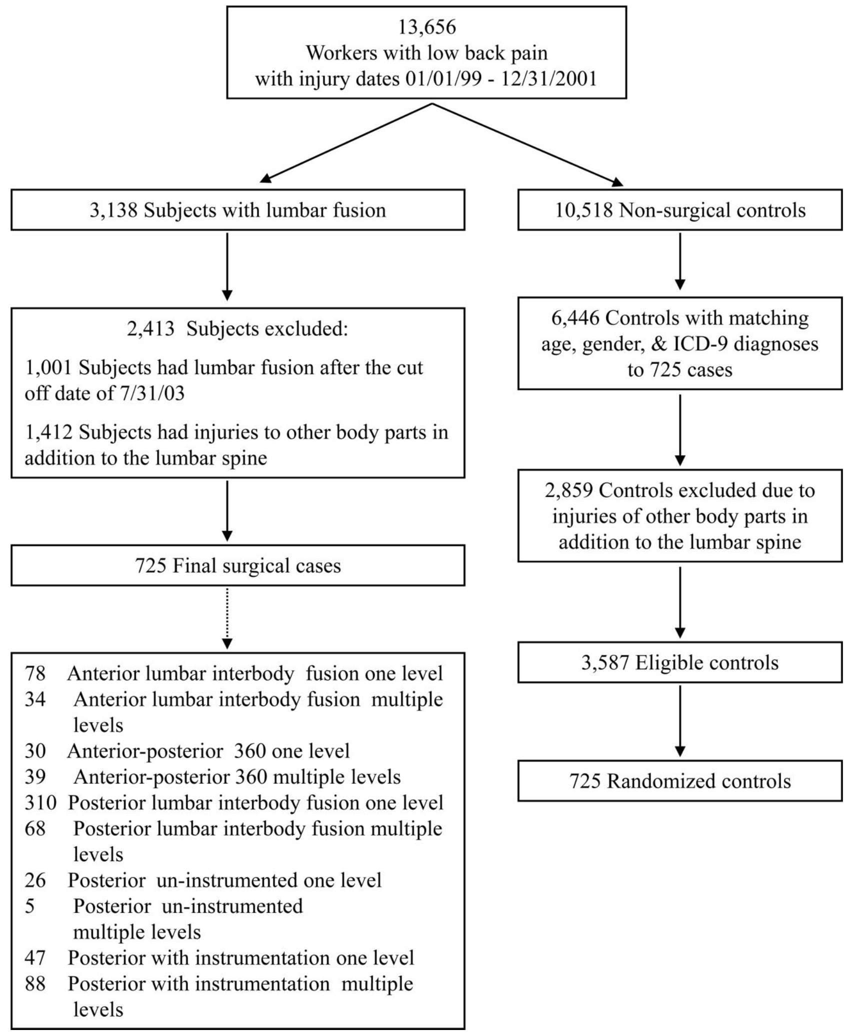

Figure 1. Subjects selection for lumbar arthrodesis—Historical Cohort Study.

sions, body mass index (BMI), daily opioid dose, fusion approaches, and discogram performance. The above covariates were included in the regression models because they have been reported in the literature to affect the outcomes of interest.[17–27] Stepwise logistic regression (LR) was performed to determine the magnitude of association of the independent variables in predicting RTW. Unadjusted and adjusted odds ratios (OR) are presented with 95% confidence intervals (CIs).

No statically important interactions were found. The final multivariate models were determined based on clinically meaningful and statistically significant predictors, high concordance indexes, and the Hosmer and Lemeshow Goodness of Fit test.

All analyses were performed using SAS software, version 9.1. Two-sided *P* values and 95% CIs are reported; $P < 0.05$ is considered to be statistically significant.

Results

Demographics of all subjects are presented in Table 3. Legal representation, current smokers, and female gender were more common in the surgical cases than in the controls. Sex was not a statistically significant predictor of RTW status in unadjusted or adjusted LR analyses. Smoking status was better documented for cases than controls secondary to cases having longer care and thus more office visits. Cases had more legal representation. Cases also had higher average preinjury weekly wages compared to controls. Age, BMI, education, and marital status were not statistically significant between the 2 groups. Approximately 72% of the diagnoses for all subjects were disc degeneration and disc herniation. About 80% of cases and 70% of controls had 1 or 2 levels of degenerative disc changes on MRI (Table 3). Lumbar MRI findings and diagnoses were not statistically significant predictors of the adjusted RTW status.

After considering subjects who were dead (17 cases, 11 controls), permanently disabled (82 cases, 11 controls) or in rehabilitation at 2 years (64 cases, 43 controls), the actual RTW status at 2 years was 26% (n = 188) of cases and 67% (n = 483) of controls. Surgical cases remained off work longer than controls 1140 days *versus* 316 days, respectively ($P < 0.001$). The average duration from the date of injury to the date of surgery was 597 days. This duration was not significant in the RTW adjusted analysis (Table 4).

There were 264 cases (36%) with surgical complications. Frequencies and definitions of complications are provided in Table 5. Complication frequency was high because of the inclusion of late spinal complications. This group

Table 3. Baseline Characteristics of Lumbar Fusion Cases and Nonsurgical Controls Among Ohio Workers' Compensation Subjects

Characteristic	Cases	Nonsurgical Controls	*P*
No. subjects	725	725	
Age* (yr) (mean ± SD)	39.43 ± 8.72	39.98 ± 8.50	0.23
Sex—no. (%)			0.005
Male	524 (72.28%)	570 (78.62%)	
Female	201 (27.72%)	155 (21.38%)	
BMI† (mean ± SD)	29.27 ± 6.0	29.55 ± 6.43	0.47
Education—no. (%)			0.35
Did not complete high school	162 (28.37%)	51 (29.31%)	
Complete high school	299 (52.36%)	88 (50.57%)	
Did not complete college	88 (15.41%)	23 (13.22%)	
Completion of college or higher	22 (3.85%)	12 (6.90%)	
Legal representation—no. (%)			<0.001
Yes	665 (91.72%)	544 (75.03%)	
No	60 (8.28%)	181 (24.97%)	
Marital status—no. (%)			0.51
Divorced	108 (14.90%)	103 (14.49%)	
Married	446 (61.52%)	429 (60.34%)	
Single	164 (22.62%)	176 (24.75%)	
Widowed	7 (0.97%)	3 (0.42%)	
Smoking history—no. (%)			0.02
Current smoker	404 (58.98%)	174 (53.54%)	
Ex-smoker	68 (9.93%)	23 (7.08%)	
Never smoker	213 (31.09%)	128 (39.38%)	
Weekly wages (mean ± SD)	553.11 ± 252.38	496.69 ± 296.76	<0.001
Diagnoses‡—no. (%)			<0.001
Disc degeneration	292 (24.25%)	221 (22.10%)	
Disc herniation	580 (48.17%)	515 (51.50%)	
Radiculopathy	142 (11.79%)	179 (17.90%)	
Spondylolisthesis	113 (9.39%)	29 (2.90%)	
Spinal stenosis	77 (6.40%)	56 (5.60%)	
Discography—no. (%)			<0.001
No	490 (67.59%)	675 (93.10%)	
Yes	235 (32.41%)	50 (6.90%)	
Lumbar MRI			
No. levels with decreased or loss of signal intensity—no. (%)			<0.001
Zero level	8 (1.10%)	30 (4.78%)	
One level	357 (49.31%)	204 (32.54%)	
Two levels	230 (31.77%)	239 (38.12%)	
Three or more levels	129 (17.82%)	154 (24.56%)	

*Age at the time of injury.
†BMI, (weight (lb)/[height (in)]^2 × 703).
‡Diagnoses are diagnoses before surgery for cases.
SD indicates standard deviation; MRI, magnetic resonance imaging.

made up 25% of all complications. Most late spinal complications consisted of post laminectomy syndrome and adjacent segment degeneration. The ranges of wound, implant, neurologic, and early complications were 2% to 6%. Of the surgical subjects, 64% had no complications.

Lumbar reoperations occurred in 27% of the cases (n = 194). About 66% (n = 160) of the reoperations occurred within 2 years of the index surgery. A large number of reoperations consisted of removal of instrumentation, re-exploration, and additional arthrodesis (Table 5). Complications and reoperations will be further investigated in subsequent article.

Throughout the entire study, 85% (n = 614) of the lumbar fusion cases were using opioids compared to 49% (n = 354) of controls. The average daily MEQ increased from 44.23 ± 33.57 U before surgery to 62.31 ± 70.80 U after surgery. There is a 41% increase in the mean daily opioid dosage postoperatively. The average daily, postsurgery MEQ reported is the amount of opioid taken more than 90 days postoperatively (Table 5). In both the univariate ($P <$ 0.001) and the multivariate ($P = 0.03$) LR analysis, the daily MEQ was a significant negative predictor of fusion cases having successful RTW (Tables 6, 7).

Unadjusted LR indicated a number of factors were significant negative predictors of RTW status at 2 years postfusion (Table 6). Complications as a group affected RTW status significantly ($P < 0.001$). More specifically, RTW chances were early major systemic complications OR, 0.22 (95% CI, 0.08–0.64; $P = 0.005$); implant complications OR, 0.07 (95% CI, 0.009–0.53; $P = 0.01$); late spinal complications OR, 0.49 (95% CI, 0.31–0.77; $P = 0.002$); and neurologic complications OR, 0.42 (95% CI, 0.09–2.06; $P = 0.29$). Neurologic and wound complications were not statistically significant (Table 6). This finding persisted in the adjusted LR analysis (Table 7).

Subjects who had reoperations once after the index fusion had a RTW OR, 0.28 (95% CI, 0.17–0.48; $P < 0.001$) compared to subjects with no reoperation (Table 6).

Table 4. Return to Work, Rehabilitation, Disabled, and Death Status

	Cases	Controls	*P*
Death*—no. (%)	17 (2.34%)	11 (1.52%)	0.26
Permanently disabled	82 (11.31%)	11 (1.52%)	$<$0.001
In rehabilitation†	64 (8.83%)	43 (5.93%)	0.04
Returned to work			
No	367 (50.62%)	163 (22.48%)	$<$0.001
Yes	188 (25.93%)	483 (66.62%)	$<$0.001
No information	7 (0.97%)	14 (1.93%)	0.12
Total	725	725	
Duration of Time Off	**Cases**	**Controls**	***P*‡**
Total No. days off§ (mean ± SD)	1140 ± 735	316 ± 463	$<$0.001
No. days from DOI to DOS¶	597 ± 330		
No. days off work from DOI to DOS‖	337 ± 277		

*All subjects are followed up to the end of the study for permanently disabled and death status.
†Return to work and rehabilitation status are determined at 2 year.
‡By *t* test.
§Total number of days off work from the date of injury to the end of the study.
¶Duration from the date of injury to the date of surgery in days.
‖The number of days remained off work from the date of injury to the date of surgery.
SD indicates standard deviation; DOI, date of injury; DOS, date of surgery.

The total number of days off work was a highly significant negative predictor of RTW in fusion cases and in nonoperated controls, in both adjusted and unadjusted models (Figure 2). At 30 days of work absence, the unadjusted OR for RTW in fusion cases was 0.93 (95% CI, 0.92–0.94; $P \leq 0.001$) and for nonoperated controls was 0.85 (95% CI, 0.82–0.88; $P \leq 0.001$) (Table 6).

Weekly wages was a strong predictor of RTW status for all subjects. The higher the preinjury weekly wages, the more likely the individual was to RTW (Figure 3). A subject earning $100.00 more per week had an increased odds of RTW (OR, 1.09; 95% CI, 1.01–1.18; $P < 0.02$) (Table 7).

Both current smoking and legal representation were significant negative predictors of RTW in univariate and multivariate analyses. Cases without legal representation were 3 times more likely to RTW OR 3.43 (95% CI, 1.58–7.41; $P < 0.002$) (Table 7).

The more rehabilitation sessions (therapy) provided, the less likely cases and controls were to RTW. At 10 therapy sessions, the RTW OR was 0.92 (95% CI, 0.87–0.97; $P \leq 0.001$) for fusion cases and 0.95 (95% CI, 0.93–0.98, $P < 0.001$) for controls. With 20 therapy sessions, the RTW OR was 0.85 (95% CI, 0.76–0.94; $P = 0.002$) for cases and 0.91 (95% CI, 0.86–0.96; $P < 0.001$) for controls (Table 6). Rehabilitation and vocational sessions were not statistically significant predictors of RTW in the final adjusted analysis.

Age, BMI, diagnoses, education, surgical fusion approach, sex, marital status, the number of lumbar levels with degenerative changes, and the number of vocational sessions were not significant predictors of RTW in either adjusted or unadjusted analysis.

Table 5. Reoperations After Index Surgery

	No. (%)
Reoperations*	
One	158 (81.44%)
Two	28 (14.43%)
Three	5 (2.58%)
Four	3 (1.55%)
Total	194 (100.00%)
Reoperations	
At ≤1 yr†	83 (34.44%)
At ≤2 yr	77 (31.95%)
At ≤3 yr	45 (18.67%)
At ≤4 yr	15 (6.22%)
At ≤5 yr	15 (6.22%)
At ≤6 yr	6 (2.49%)
Complications category	
Early major systemic‡	45 (6.21%)
Implant complications§	34 (4.69%)
Late spinal complications¶	183 (25.24%)
Neurologic complications‖	18 (2.48%)
No complications	461 (63.59%)
Wound complications**	27 (3.72%)

Daily Amount of Morphine	Cases	Nonsurgical Controls	*P*
Average daily MEQ†† (mean ± SD)	48.06 ± 43.88	65.57 ± 70.66	$<$0.001‡‡
No. subjects taking opioids§§ No. (%)	614 (84.69%)	354 (48.83%)	$<$0.001¶¶
Average daily MEQ before surgery	44.23 ± 33.57		
Average daily MEQ after surgery	62.31 ± 70.80		
Maximum daily MEQ		585.00	
Before surgery	276.00		
After surgery	878.00		

*One hundred ninety-four cases had reoperations. One hundred fifty-eight cases had reoperation once. Twenty-eight cases had reoperation twice. Five cases had reoperation three times. Three cases had reoperation four times.
†Reoperation time from the index lumbar fusion surgery.
‡Early major systemic post surgical complications: death, meningitis, myocardial infarction, cardiac arrhythmia, pneumonia, pulmonary embolism, acute renal failure, pancreatitis, acute prostatitis, urinary tract infection, gastrointestinal bleed, and avascular necrosis of the femoral head.
§Implant complications: failed and/or implant malposition.
¶Late spinal complications: disc space infection, pseudarthrosis, postlaminectomy syndrome, adjacent disc degeneration, stenosis, spondylolisthesis, and adjacent vertebral fracture.
‖Neurologic complications: impotence, incontinence and reflex sympathetic dystrophy.
**Wound complications: minor wound infection and incisional hernia.
††Dosages are calculated in daily total morphine equivalents for the duration of the study. Only oral preparations are included.
‡‡By *t* test.
§§Number of subjects taking opioids during the entire duration of the study.
¶¶By [chi]^2 testing.
SD indicates standard deviation; MEQ, morphine equivalents.

The final adjusted LR model indicated current smoking, the number of total days off work, and weekly wages were significant predictors of RTW status with OR, 0.65 (95% CI, 0.42–1.01; $P = 0.05$); OR, 0.93 (95% CI, 0.92–0.94; $P \leq 0.001$); and OR, 1.09 (95% CI, 1.01–1.18; $P = 0.02$) for the entire cohort, respectively (Table 7).

Multivariate analysis of only fusion cases showed the complications OR, 0.25 (95% CI, 0.07–0.90; $P = 0.03$); reoperation status OR, 0.42 (95% CI, 0.26–0.69; $P \leq 0.001$); total days off before surgery OR, 0.94 (95% CI, 0.92–0.97; $P \leq 0.001$); legal representation OR, 3.43 (95% CI, 1.58–7.41; $P = 0.002$); and total daily MEQ OR,

Table 6. Univariate Logistic Regression of Return to Work Status

Independent Variables	Surgical Unadjusted OR (95% CI)	*P*	Nonsurgical Unadjusted OR (95% CI)	*P*
Age* (yr)	1.00 (0.98–1.02)	0.81	0.99 (0.97–1.02)	0.60
BMI†	0.99 (0.96–1.02)	0.42	1.00 (0.97–1.04)	0.83
Complications‡		<0.001		
No complications (reference)				
Early major systemic	0.22 (0.08–0.64)	0.005		
Implant	0.07 (0.009–0.53)	0.01		
Late spinal	0.49 (0.31–0.77)	0.002		
Neurologic	0.42 (0.09–2.06)	0.29		
Wound complications	1.27 (0.42–3.84)	0.68		
Total days off§	0.93 (0.92–0.94)	<0.001	0.85 (0.82–0.88)	<0.001
Days off prior to surgery¶	0.93 (0.91–0.95)	<0.001		
Days from injury to surgery‖	0.98 (0.97–1.00)	0.03		
Diagnosis**		0.41		0.25
Degenerative disc disease (reference)				
Herniated disc	0.81 (0.56–1.18)	0.27	1.34 (0.91–1.97)	0.14
Radiculopathy	2.00 (0.70–5.75)	0.20	2.27 (1.08–4.76)	0.03
Spondylolisthesis	0.80 (0.37–1.34)	0.58	1.07 (0.20–5.67)	0.94
Spinal stenosis	1.75 (0.11–28.45)	0.70	1.07 (0.20–5.67)	0.94
Discogram (yes)††	0.65 (0.45–0.96)	0.03	0.35 (0.19–0.64)	<0.001
Education		0.06		0.12
Did not complete high school (reference)				
Completed high school	1.99 (1.12–3.51)	0.02	1.39 (0.65–2.99)	0.40
Did not complete college	1.44 (0.69–3.00)	0.34	3.47 (1.13–10.69)	0.03
Completed college or graduate education	3.13 (1.06–9.28)	0.04	2.78 (0.72–10.66)	0.14
Fusion type		0.72		
Posterior uninstrumented single level fusion (reference)				
ALIF multilevel‡‡	1.41 (0.39–5.13)	0.60		
ALIF single level	0.78 (0.25–2.40)	0.67		
Anterior-posterior 360 multilevel	0.35 (0.08–1.50)	0.16		
Anterior-posterior 360 single level	0.92 (0.25–3.39)	0.90		
PLIF multilevel§§	1.24 (0.40–3.88)	0.71		
PLIF single level	0.92 (0.33–2.58)	0.88		
Posterior uninstrumented multilevel	0.92 (0.07–12.32)	0.95		
Posterior with instrumentation multilevel	1.12 (0.37–3.40)	0.84		
Posterior with instrumentation single level	0.92 (0.27–3.14)	0.89		
Gender	0.90 (0.60–1.32)	0.57	0.77 (0.51–1.16)	0.21
Male (reference)				
Legal representation	3.98 (2.17–7.30)	<0.001	5.83 (3.14–10.83)	<0.001
Having legal representation (reference)				
Marital status		0.49		0.06
Single (reference)				
Divorced	1.26 (0.70–2.26)	0.44	0.95 (0.54–1.66)	0.85
Married	1.37 (0.89–2.11)	0.16	1.51 (0.99–2.30)	0.05
Widowed	0.61 (0.07–5.62)	0.66	0.22 (0.02–2.43)	0.21
Morphine (daily)¶¶	0.71 (0.61–0.83)	<.001	0.98 (.91–1.06)	0.65
Smoking		0.008		<0.001
Never smoker (reference)				
Current smoker	0.53 (0.36–0.79)	0.002	0.34 (0.19–.60)	<0.001
Ex-smoker	0.70 (0.36–1.34)	0.30	0.41 (0.14–1.15)	0.09
Reoperations		<0.001		
No reoperation (reference)				
Once	0.28 (0.17–0.48)	<0.001		
Twice	0.32 (0.12–0.86)	0.02		
Lumbar MRI				
Zero level (reference)				
Total MRI level‖‖		0.17		0.75
One level	0.93 (0.17–5.15)	0.93	0.98 (0.40–2.36)	0.95
Two levels	0.93 (0.17–5.25)	0.94	1.26 (0.52–3.05)	0.60
Three levels	1.89 (0.32–10.99)	0.48	1.28 (0.50–3.32)	0.61
Four levels	0.67 (0.08–5.68)	0.71	0.76 (0.24–2.35)	0.63
Five levels	0.86 (0.10–7.51)	0.89	1.05 (0.25–4.37)	0.94

(*Continued*)

Table 6. Continued

Independent Variables	Surgical Unadjusted OR (95% CI)	*P*	Nonsurgical Unadjusted OR (95% CI)	*P*
Total rehabilitation sessions***	0.92 (0.87–0.97)	<0.002	0.95 (0.93–0.98)	<0.001
Total vocational sessions†††	1.10 (0.60–1.90)	0.82	0.63 (0.35–1.12)	0.12
Weekly wages‡‡‡	1.13 (1.05–1.20)	<0.001	1.14 (1.06–1.22)	<0.001

*Age at the time of injury.
†BMI, (weight (lb)/[height (in)]^2 × 703).
‡Post surgical complications for cases only.
§Total number of days off from the date of injury to the end of the study. Odds ratio for return to work status at 30 days off work.
¶Number of days off work from date of injury to date of surgery. Odds ratio for return to work status at 30 days off work prior to surgery.
‖Duration in days from the date of injury to the date of surgery. Odds ratio for return to work status at 30 days duration from the date of injury.
**Diagnoses prior to surgery for cases.
††Odds ratio for return to work status if cases or controls has had discogram performed.
‡‡Anterior lumbar interbody fusion, multiple levels.
§§Posterior lumbar interbody fusion, multiple levels.
¶¶Daily opioid dose expressed as oral total morphine equivalents (MEQ). Odds ratio for return to work status at a dose of 25 total morphine equivalents per day.
‖‖MRI findings are reported as the total number of levels with decreased or loss of signal intensity.
***Odds ratio for return to work status at 10 sessions of rehabilitation.
†††Odds ratio for return to work status at 10 sessions of vocational training.
‡‡‡Odds ratio for return to work status at an increase of 100.00 dollars per week.
CI indicates confidence interval; OR, odds ratio; MRI, magnetic resonance imaging; BMI, body mass index.

0.83 (95% CI, 0.71–0.98; $P = 0.03$) as significant negative predictors of RTW, while higher average weekly wages remained a predictor of increase chances of RTW OR, 1.12 (95% CI, 1.03–1.21; $P = 0.008$) (Table 7).

Similar to surgical patients, age, BMI, diagnosis, education, sex, marital status, MRI findings, and vocational training were not significant predictors of RTW status in both unadjusted and adjusted LR analysis for nonsurgical controls. Legal representation, current smoking, and total rehab sessions were significant predictor of RTW status in only unadjusted analysis. These effects did not persist in the adjusted analysis for controls (Table 6).

Nonsurgical controls adjusted LR model showed only the total number of days off, and weekly wages were significant predictors of RTW. The longer the duration off work the less likely a subject was to RTW with an OR, 0.85 (95% CI, 0.82–0.88; $P \leq 0.001$). Weekly wages continued to show the same trend as cases. Higher wages increased the odds of RTW OR 1.16 (95% CI, 1.02–1.32; $P = 0.02$).

Discussion

Lumbar fusion is a controversial operation for degenerative disc disease and herniated disc.[5,6] It is most commonly performed in the United States for the diagnosis of degenerative disc disease.[5,28] A large population study of workers' compensation lumbar fusion subjects with multiple objective outcomes and randomly selected controls has not been published.

In this study, we evaluated RTW, disability, complications, reoperations, and opioid usage among cases and randomized controls. RTW is an important objective personal health outcome, as multiple studies have shown that being out of work is associated with poor health. Employment

Table 7. Final Multivariate Logistic Regression Models of Return to Work Status

Patient Characteristic	All Subjects Adjusted OR (95% CI)	*P*	Cases Adjusted OR (95% CI)	*P*	Controls Adjusted OR (95% CI)	*P*
Current smoker	0.65 (0.42–1.01)	0.05				
Total days off*	0.93 (0.92–0.94)	<0.001			0.85 (0.82–0.88)	<0.001
Weekly Wages†	1.09 (1.01–1.18)	0.02	1.12 (1.03–1.21)	0.008	1.16 (1.02–1.32)	0.02
Complications‡				0.007		
No complications (reference)						
Early major systemic			0.25 (0.07–0.90)	0.03		
Implant			0.13 (0.02–1.08)	0.06		
Late spinal			0.50 (0.29–0.87)	0.01		
Neurologic			0.65 (0.12–3.45)	0.61		
Wound complications			2.72 (0.69–10.66)	0.15		
Days off work prior to surgery§			0.94 (0.92–0.97)	<0.001		
Legal representation			3.43 (1.58–7.41)	0.002		
Morphine (daily)¶			0.83 (0.71–0.98)	0.03		
Reoperation			0.42 (0.26–0.69)	<0.001		

*Total number of days off work from the date of injury to the end of the study. Odds ratio for return to work status at 30 days off.
†Weekly wages are reported as an increase of 100.00 dollars. Odds ratio for return to work status with an increase of at $100.00 per week.
‡Post surgical complications for cases only.
§Number of days off work from date of injury to date of surgery. Odds ratio for return to work status at 30 days off work prior to surgery.
¶Daily morphine dose expressed as total morphine equivalent units (MEQ). Odds ratio for return to work status at a dose of 25 total morphine equivalent units per day.
CI indicates confidence interval; OR, odds ratio.

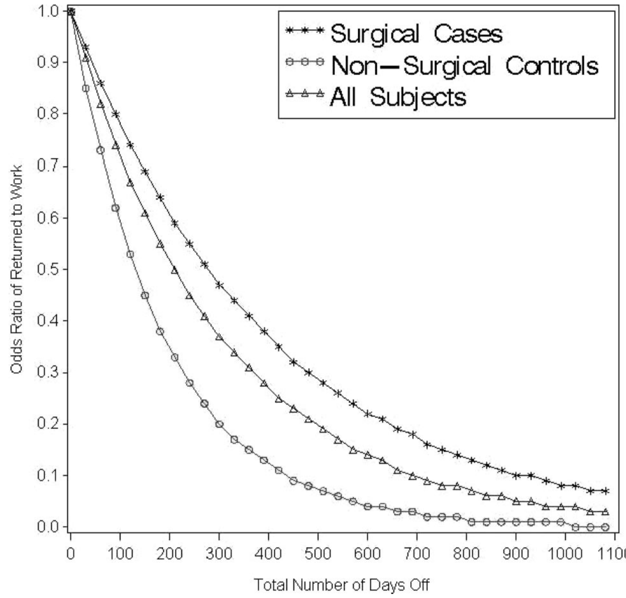

Figure 2. Total days off work as predictor of return to work status.

not only provides needed income, it is a part of the individual's self image and socioeconomic status. Being out of work or being disabled from work also has an important societal impact. Unemployment has been associated with cardiovascular disease, cancer, suicide, poverty, increase of spousal and child abuse, domestic violence, divorce, and higher utilization of healthcare services.[29–35] RTW is, and should be, an objective end point for treatment provided in a workers' compensation setting.

This study showed surgical fusion cases were more likely to be permanently disabled (n = 82 *vs.* n = 11, $P =$ 0.001) and more likely to not RTW than the nonsurgical controls (n = 367 *vs.* n = 163, $P \leq 0.001$). Combining the permanently disabled with surgical cases who failed to RTW, yielded a 62% disability status (n = 449). This result is consistent with the disability status reported from the Washington state workers' compensation database as 68% in 1994[4] and 64% in 2006.[1]

The average age for all subjects in the study was 39 years old, and these were healthy working individuals at the time of injury. The complications was high compared to Maghout-Juratli *et al* study[1] secondary to including long-term "late" spinal and neurologic complications. Adjacent segment degeneration and post laminectomy syndrome made up to 72% of the late spinal complications. Most lumbar surgical studies include only short-term complications (*i.e.*, within 6 weeks after fusion). As a result, late spinal complications are seldom reported. Without the late spinal and neurologic complications, our complications rate of 15% (early major systemic, implant and wound complications) is comparable to Maghout-Juratli's short-term complication rate of 12% (Table 5).

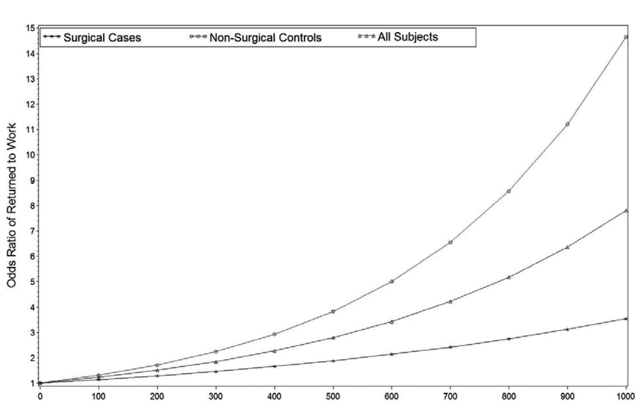

Figure 3. Weekly wages as predictor of return to work status.

Reoperation rates have been reported consistently by Utah and Washington states in the past, 20% and 22%, respectively.[2,1,4] Utah's reoperation rate was self reported. Both Washington studies reported reoperation rates within 2 years of the index surgery.[1,4] The reoperation rate was slightly higher (27%) in this study because reoperation was tracked until the end of the study. However, the reoperation rate was 22% if the reoperation was only considered within 2 years of the index surgery.

Lumbar spine fusion does not seem to be an effective operation for the workers' compensation subjects with the diagnoses of disc degeneration, disc herniation, and/or radiculopathy. Our data indicate 84% of the diagnoses for the surgical patients were disc degeneration, disc herniation, and radiculopathy (Table 3). These diagnoses remain controversial indications for lumbar fusion, while subjects with spondylolisthesis with instability, traumatic fractures, or tumor have had good results. Lumbar arthrodesis should be cautiously considered and recommended only in workers' compensation subjects with clear cut indications.

The best lumbar arthrodesis approach (posterior, anterior, or combined), technique (noninstrumented, instrumented, *etc.*), and single or multi-levels remain debatable in the spine literature. Our analyses indicated the type of surgery performed was not a statistically significant predictor of RTW status (Table 6).

It is important to note that 5 of the 8 factors that remained statistically significant in the final multivariate analysis are psychosocial variables including current smoking status, total days off, the number of days off before surgery, weekly wages, and legal representation (Table 7).[36–40]

The only clinical findings that remained significant in predicting RTW status were complications, reoperations, and daily MEQ. Similar to other studies, clinical factors of preoperative diagnoses, lumbar MRI findings, fusion types, the number of rehabilitation, or vocational sessions were not statistically significant and did not appear to be associated with RTW status.[1,2]

Total number of days off was the most important predictor of RTW status irrespective of surgical or nonsurgical treatment. This variable is distinct from another variable that measured the duration from the date of injury to the date of surgery; the latter was not statistically significant.

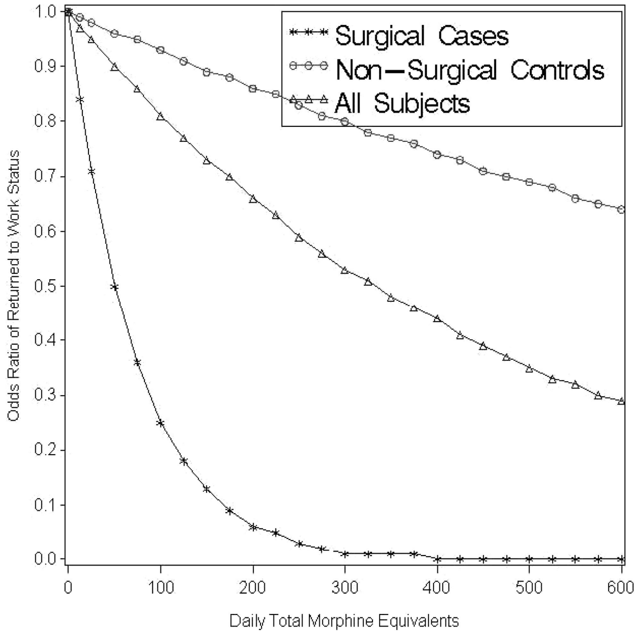

Figure 4. Total morphine equivalents as predictor of return to work status.

Thus, time off work (or time off work before surgery) and not time from injury to surgery was the predictive variable. The number of days off work remained highly significant in unadjusted and adjusted analyses of cases only, controls only, and the entire cohort. At 2 years off work, the odds that fusion cases would RTW were 0.16 (95% CI, 0.12–0.22; $P \leq 0.001$). This effect appears to be even more important in controls. Controls' odds of RTW were 0.02 (95% CI, 0.009–0.05; $P \leq 0.001$) (Figure 2). Controls with prolonged days off work had much smaller chances of RTW compared to cases. It should be noted that none of the medical factors were statistically significant predictors of RTW status in the final adjusted model for controls (Table 7).

Similarly, the number of days remaining off work before surgery was a significant predictor of RTW status. The longer the duration the subject remain off work before surgery, the less likely the chances of RTW successfully. At 90 days off work before surgery, the odds of RTW were 0.83 (Table 7).

At least 76% (n = 550) of the fusion cases were still taking opioids more than 90 days after surgery with average daily MEQ increased by 41%. The daily MEQ reported reflect an underestimate of the opioid dose because only oral opioids with reliable conversion to morphine were used to calculate daily total MEQ. Nasal sprays, transdermal, and parenteral routes of opioid administration were not included in this study. This outcome questions lumbar fusion effectiveness in relieving low back pain and the validity of the self-reported pain scores and functional questionnaires that have been used for years as a part of the measurement of the effectiveness of low back pain interventions. Figure 4 shows the ORs between opioid dose and RTW. This graph demonstrates the profound association of opioid use on RTW status with far greater impact on cases, as opposed to controls. The greater the daily total amount of opioids, the less likely it was for a worker to RTW. The odds of RTW dropped sharply with small increases in the dose of opioids. At 100 MEQ units, the OR of RTW for cases was 0.25 (95% CI, 0.14–0.46; $P < 0.001$) compared to the controls' OR of 0.93 (95% CI, 0.68–1.28, $P < 0.65$). Many other studies published previously have also suggested long-term opioid therapy for noncancer pain may not be in a patient's best interest.[41–46] Continued usage of opioids in the workers' compensation system without long-term randomized trials and/or large population studies is not recommended in light of these findings.

The association of wages and RTW status is seldom addressed in the medical literature. In this study, weekly wages was a significant predictor of RTW status in both univariate and multivariate LR analysis for all subjects (Tables 6, 7).

The higher the weekly wages, the more likely an injured worker was to RTW. Patients with higher incomes may have more incentive to RTW, or may have more employment options, as higher wages often suggests more marketable job skills.

Finally, similar to previous studies, this study showed that legal representation was a strong negative predictor of RTW in both cases (OR, 3.98; 95% CI, 2.17–7.30; $P < 0.001$) and nonsurgical controls (OR, 5.83; 95% CI, 3.14–10.83; $P < 0.001$).[1,2,47]

This study has several limitations. Not all risk factors that may affect the surgical outcomes are documented consistently in the database (*i.e.*, smoking history). Although numerous independent factors have been collected, it is possible that there are other significant but unconsidered factors. An historical cohort study design is not the best method to evaluate the effectiveness of surgical intervention. However, this study has many advantages. The study design permits a prolonged follow-up in a very large cohort with multiple objective outcomes measured. Using objective outcomes eliminates difficulties associated with self-reported questionnaires of pain and function. Data are collected from medical providers throughout the state of Ohio, and unlikely to be affected by referral pattern bias.

Our results are very similar to Washington state studies.[1,4] Randomized controlled trials specifically for workers' compensation subjects with lumbar fusion should be performed.

In summary, this large historical cohort study suggests that lumbar fusion may not be an effective operation in workers' compensation patients with the diagnoses of disc degeneration, disc herniation, and/or radiculopathy. This procedure is offered to improve pain and function, yet objective outcomes showed increased permanent disability, poor RTW status, and higher doses of opioids. The combination of lumbar fusion surgery for disc degeneration, disc herniation and/or radiculopathy, opiates, prolonged work absence, and legal representation appear to create a diminished quality of life for the injured workers under these circumstances. Additional studies are currently underway to further investigate these factors.

■ Key Points

- Workers' compensation subjects with lumbar arthrodesis had a poor RTW status 2 years after surgery, higher disability status, and a larger number of subjects continued on daily opioids compared to nonsurgical controls. Significant predictors of RTW status for surgical cases were the number of days off, legal representation, weekly wages, complications, reoperations, and total morphine usage. Number of days off and weekly wages were the only significant predictors of RTW status for nonsurgical controls.
- Legal representation decreased the odds of the injured worker returning to work.
- The use of opiates decreased the odds of RTW significantly for surgical subjects.
- Control subjects with prolonged work absence have poorer odds of RTW compared to surgical cases.

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