Original Study

Return to work and recovery time analysis after outpatient endoscopic lumbar transforaminal decompression surgery

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Contributions: (I) Conception and design: All authors; (II) Administrative support: KU Lewandrowski, A Yeung; (III) Provision of study materials or patients: KU Lewandrowski, NA Ransom; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: KU Lewandrowski, A Yeung; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: This study aimed to analyze the return to work (RTW) and recovery time (RT) to narcotic independence following outpatient endoscopic decompression for contained lumbar herniated disc causing sciatica-type low back and leg pain.

Methods: A retrospective study of 442 patients with symptomatic contained lumbar herniated disc was treated with the transforaminal endoscopic decompression surgery. The mean follow-up was 33.5 months, ranging from 24 to 85 months. The patients' age ranged from 30 to 85 years, with a mean age of 40.9 years. Statistical analysis of pre- and postoperative VAS, Macnab outcomes, improvement of postoperative walking endurance was performed. RTW rates were correlated with the type of work as classified according to energy consumption per minute (Kcal/min) as *Light*, *Medium*, and *Heavy* using guidelines adopted from the U.S. Department of Labor. Kaplan-Meier (KM) survival tables were calculated, and curves were plotted using IBM SPSS 25.0 to graphically illustrate the diverse RTW and RT dynamic when analyzed by the clinical outcome and the type of work performed by the patient preoperatively.

Results: *Excellent* (237/442) and *Good* (133/442) results were obtained in 83.7% (370/442) of patients. *Fair* results were reported by 43 patients (9.7%), and *Poor* results by 29 (6.6%), respectively. The mean preoperative VAS was 8.08. The mean postoperative VAS was significantly reduced to 2.55 (P<0.0001). The overall RTW rate was 92.5% (409/442). Patients performing *Heavy* (RTW rate =87.5%) and *Medium* (RTW rate =86.0%) work had a lower RTW rate than patients who were performing *Light* jobs (370/442; RTW rate =95.8%). Preoperatively, only 31.7% (140/442) had unlimited walking endurance. Postoperative walking endurance was unlimited in 77.4% (342/442; P<0.0001). Another 20.4% (90/442) of patients had pain-free walking endurance up to one mile. K-M analysis showed an estimated median RTW of 6 days for *Excellent*, 9 days for *Good*, 17 days for *Fair*, and 18 days for *Poor* Macnab outcomes. RTW analysis by the type of work showed estimated median RTW of 20 days for patients in the *Heavy*, 13 days in the *Medium*, and 6 days in the *Light* workgroup. The mean RT was 33.52 days in the *Heavy*, 19.17 days in the *Medium*, and 9.86 days in the *Light* workgroup (P<0.0001). The mean RTW was 22.27 days (P=0.008) in the *Heavy*, 13.97 days (P=0.004) in the *Medium*, and 7.58 days (P=0.004) in the *Light* workgroup. Postoperative irritation of the dorsal root ganglion (DRG) occurred in 68 of the 442 study patients (15.38%). DRG irritation delayed RTW to a mean of 18.94 days (P<0.0001) and RT to 15.31 days (P<0.001).

Conclusions: Patient RTW and RT data are "real-world" economic indicators of successful clinical outcomes with the lumbar endoscopic transforaminal decompression procedure and compare favorably to previously reported benchmarks for other types of translaminar surgeries. These median postoperative RTW and RT times with narcotic independence were on the order of 10 days or less in the vast majority of patients *Excellent* and *Good* outcomes (83.7%). The most relevant surgical predictor of delayed RTW and RT is a postoperative DRG irritation which predominantly affected patients adversely in the *Medium* and *Heavy* workgroups. These RTW and RT data may assist in the management of return-to-work expectations with the spinal endoscopy procedure.

Keywords: Lumbar endoscopy; transforaminal decompression; return to function

Submitted Sep 11, 2019. Accepted for publication Sep 27, 2019.
doi: 10.21037/jss.2019.10.01
View this article at: http://dx.doi.org/10.21037/jss.2019.10.01

Introduction

The rising cost of health care has become a major concern for large self-insured employers. Annual productivity losses due to sick leave are simply staggering to the point where many large corporations have begun to internally study the feasibility of direct contracting with centers of excellence with reliably proven best clinical practices, excellent outcomes and a high return to work (RTW) rates and short recovery times (RT) of their employees. This trend is not only motivated by out-of-control increases in health insurance premiums, but also by the need for improved management of their human resources. Low back pain related missed workdays are at the top of the list costing an estimated $28 billion per year in the United States alone (1-3). Other causes of chronic disability include cardiovascular disease, mental health, and cancer (4-6). Work disability stemming from these chronic problems is expected to escalate with high labor participation rates among people anticipated to live longer (7). Therefore, the ability for employers to predict RTW at a highly functional level with medical interventions of these chronic diseases has become a significant focus of internal research in an attempt to more effectively allocate corporate resources to improved value-based health care delivery to their employees. The objective is simple—reducing the personal hardship to their employees, as well as the financial, and public health burden (8). In this context, surgical treatment of low back pain syndromes has seen some significant scrutiny as not only a costly, but a potentially career changing- or ending event putting the employers' investment into valuable, highly trained and experienced employees at risk (9-12).

Minimally invasive and endoscopic lumbar spine decompression techniques have become popular in spinal surgery (13-16). There has been a substantial increase of endoscopic procedures being carried out in an ambulatory surgery center (ASC) at a reduced burden to patients (17,18). The advantages of endoscopic decompressions are obvious: Fewer postoperative complications, a shorter interval to social reintegration (19) and postoperative narcotic independence, and an overall reduced utilization of painkillers (20). While many of these advantages have been conclusively proven in the medical literature using standardized primary outcome measures, RTW is a "real-world" economic indicator highly relevant to employers trying to predict future work success (21).

Returning employees to work after spine surgery is a multifactorial problem of high complexity with many determinants beyond the disease going into the equation. Therefore, self-reported RTW analysis may be a less biased and perhaps more accurate assessment of the burden to the patient due to a surgical intervention. The purpose of this study was to correlate patient self-reported RTW and RT data with clinical outcomes of the lumbar endoscopic transforaminal decompression procedure in patients with a broad spectrum of health conditions, types of lifestyles and employment to establish useful benchmarks for patients, employers, payers, and surgeons. The authors did this by performing Kaplan-Meier survival analysis of the duration of the postoperative time interval before returning to work and to recovery from surgery to assist in the management of return-to-work expectations with the spinal endoscopy procedure.

Methods

Patient population

This retrospective study included 442 consecutive patients seen in our clinic who underwent outpatient lumbar endoscopic transforaminal foraminoplasty and discectomy between 2011 and 2016. The mean follow-up was 33.5 months ranging from 24 to 85 months with a standard deviation of 12.83 months at the time this study was concluded. The patients' age ranged from 30 to 85 years with a mean age of 40.92 years (*Figure 1*). The inclusion

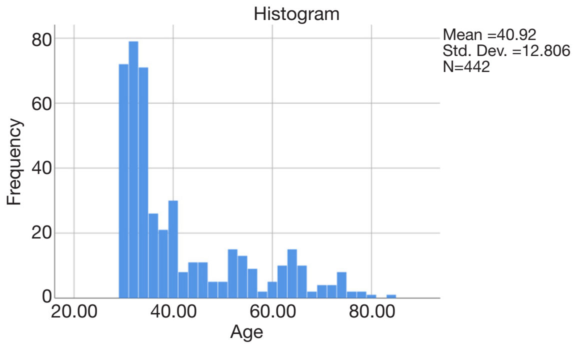

Figure 1 Age distribution of the 442 study patients. Patient's age ranged from 24 to 85 months of age and averaged 40.92 years.

and exclusion criteria for this study have been published elsewhere (22-25). All patients were treated for contained disc herniation with associated lateral recess and foraminal stenosis. This study by chance did not include any workman's compensation (WC) patients.

Preoperative work up and surgical decision making

Patients were worked up with a thorough history, physical examination, and imaging studies. Patients were subjected to an interventional diagnostic workup with lidocaine containing transforaminal epidural steroid injection (TESI) under biplanar fluoroscopic image intensifier guidance using established protocols (26-28). A TESI was considered diagnostic if the patient reported an immediate (within 15 min) VAS scale reduction >50% (29,30). Patients with conclusive diagnostic workup with matching clinical symptoms, MRI findings, diagnostic TESI response, and supporting history and physical examination were ultimately deemed appropriate surgical candidates for the endoscopic transforaminal decompression procedure. A number of radiographic classifications of foraminal and lateral recess stenosis described elsewhere were employed by the authors (31-33) to grade the preoperative MRI scan (25) by defining the location of the offending pathology within the neuroforamen. The heights of the posterior intervertebral disc and lumbar foramina were evaluated according to Hasegawa (34), who described a lumbar neuroforaminal height of 15 mm or more as normal and reduced posterior intervertebral disc height of 3 to 4 mm as suggestive of spinal stenosis. Only patients with a neuroforaminal width of 3 mm or less on the sagittal MRI cuts or lateral recess height of 3 mm or less on the axial MRI cuts were considered "stenotic" and treated surgically.

Clinical follow-up

Primary clinical outcome measures were reductions in the VAS for leg pain ranging from no pain [0] to worst pain [10] (29) and the Macnab criteria (31). Briefly, follow-up results were classified as *Excellent* if the patient had little pain and returned to desired activities with few limitations. Outcomes were classified as *Good* if the patient reported occasional pain or dysesthesias with daily activities with minor restrictions, and did not need any pain medication. Patients were assigned to one of the two remaining categories if their pain improved somewhat but they continued to need pain medication (*Fair*), or if their function worsened or they needed additional surgery to address their symptoms (*Poor*). Patients were asked whether they went to an emergency room, or were admitted to a hospital for any postoperative complications or sequelae (unavoidable problems following an expertly executed surgery). Any kind of additional treatment or surgery within 90 days was recorded as "re-incisions" related to the index endoscopic decompression surgery.

Surgical techniques & postoperative rehabilitation

All surgical procedures employed the endoscopic transforaminal approach using the "outside-in" technique (35,36) and employs a foraminoplasty in patients with or without lateral stenosis for the treatment of herniated disc. The author has published the details of the surgical decompression of this study group of patients elsewhere (22-24). Most patients did not require postoperative rehabilitation and supportive care requirements. Some patients were treated for postoperative irritation of the dorsal root ganglion with nonsteroidal anti-inflammatories, gabapentin, and TESI to treat any dysesthetic leg pain syndromes.

Return-to-work & RT analysis

Only gainfully employed patients who were working leading up to the endoscopic decompression surgery were included in this study. The type of physical work was classified according to energy consumption per minute (Kcal/min) as *Light*, *Medium*, *Heavy*, and *Very Heavy* using guidelines adopted from U.S. Department of Labor published in the online Dictionary of Occupational Titles (Washington, D.C.: U.S. Government Printing Office; *Table 1*) (37,38). Patients were grouped into these

Table 1 Physical work classification

Work classification	Calorie cost (kcal/min)	Oxygen cost (L/min)	Examples	Lifting LB	Carrying LB
Very light	–	–	–	Up to 10	Small objects
Light	<2.5	<0.5	Small objects	Up to 20	Up to 10
Moderate	<2.5–5	Up to 10	Up to 10	–	–
Medium	–	–	–	Up to 50	Up to 25
Heavy	<5–7.5	Up to 25	Up to 25	Up to 100	Up to 500
Very heavy	<7.5–10	Up to 500	Up to 500	Over 100	Over 50
Extremely heavy	<10	Over 50	Over 50	–	–

Sources: adopted from (37-39).

WORK TASK (Adjust energy cost for body size; add 10% for each 5 lb over 150 lb body weight)			
LIGHT WORK	Calorie Cost [kcal/min]	MEDIUM WORK	Calorie Cost [kcal/min]
Desk work	2.5	Paving roads	5.0
Standing, light activity	2.6	Gardening, weeding	5.6
Driving	2.8	Walk 3.5 mph (road/field)	5.6/7.0
Washing clothes	3.1	Stacking lumbar	5.8
Walking indoors	3.1	Chainsawing	6.2
Making bed	3.4	Laying stone	6.3
Drive motorcycle	3.4	Using pick & shovel	6.7
Metalworking	3.5	Shoveling (miners)	6.8
House painting	3.5	Walking downstairs	7.1
Cleaning windows	3.7	HEAVY WORK	Calorie Cost [kcal/min]
Carpentry	3.8	Shoveling snow	7.5
Farm chores	3.9	Chopping wood	7.5
Sweeping floors	3.9	Hike with 45 lb pack	7.5
Plastering walls	4.1	Crosscut sawing	7.5
Auto repair	4.2	Tree felling (ax)	8.5
Ironing	4.2	Gardening, digging	8.6
Raking, hoeing	4.7	VERY HEAVY WORK	Calorie Cost [kcal/min]
Mix cement	4.7	Walking upstairs	10+
Mopping floors	4.9	Jogging	10

Figure 2 Energy requirements of common work tasks. Sources: (39,40).

categories by published energy requirements of common work tasks (*Figure 2*) (39,40). The postoperative RTW rate was calculated. The RT was recorded as a patient self-reported postoperative outcome measure (PROM) when patient considered themselves recovered from surgery and narcotic independence was achieved. Patients were also asked whether they had convalesced from the surgery defined as no incisional pain, and no residual anesthesia side effects, such as nausea or vomiting. The number of postoperative RTW and RT days was calculated as the difference between the date of the surgery and the postoperative visit date. Patients were asked during their postoperative visits—typically within three months after the endoscopic decompression procedure—whether they had returned to work at a functional level similar to their preoperative function. The authors intentionally did not further elaborate on the definition of RTW or RT to patients since a recent research on PROMs suggested that outcomes are reported differently by patients depending on how the question concerning the functional context—whose relevancy may differ from patient to patient—is asked (41). In an attempt to minimize the introduction of additional biases in the responses collected from patients, the RTW and RT inquiry was intentionally left as is to ask the question as directly as possible. In other words, RT (defined in this study as postoperative narcotic independence) was obtained as an additional gross estimate of the time elapsed to recuperation from the endoscopic transforaminal surgery independent from the plethora of other contributing factors that may influence RTW or RT decision on the patients', employers', or treating surgeons' part. Additional objective patient data obtained included pre- and postoperative walking distance to the pain limit. The authors intentionally relied on these patient-reported outcome data (PROMs), which recently have been reported to be more reliable estimators of patient satisfaction, and return to function (41).

Correlative RTF analysis and surgical outcomes

For the clinical outcome, and RTW and RT analysis, descriptive statistics (mean and standard deviation), cross tabulation statistics and measures of association were computed for two-way tables using IBM SPSS Statistics software, Version 25.0. The Pearson χ^2 and the likelihood-ratio χ^2 tests were used as statistical measures of association. At final follow-up, primary clinical outcomes measures for patients who underwent the endoscopic transforaminal decompression procedure were assessed using modified Macnab criteria (31). The authors stratified patients towards *Excellent* and *Good* clinical outcomes by lessons learned with the intent of refining indications and patient selection criteria for endoscopic decompression under local anesthesia. In the case of *Fair* and *Poor* Macnab outcomes, patients' postoperative imaging studies were scrutinized for instability, recurrent stenosis at the index level. Patients were also asked to select a score on the visual analog scale (VAS) preoperatively (Preop VAS), and at final follow-up (Postop F/U VAS) (29) For the detailed outcome analysis, two-tailed *t*-test, ANOVA testing, and cross-tabulation statistics and measures of association were computed for two-way tables using IBM SPSS Statistics software, Version 25.0. Descriptive statistic measures were used to calculate the mean, range, and standard deviation as well as percentages. Crosstabulation methods were used to assess for any statistically significant association between RTW/RT data and clinical outcome data. Pearson Chi-Square and Fisher's Exact Test were employed as statistical measures of association. Expected cell counts, continuity corrections, and likelihood ratios were calculated for some analyses.

Kaplan-Meier (K-M) survival time (time to RTW and RT) probabilities and curves were constructed from tables containing: (I) patients' serial time; (II) their status at serial time {Macnab outcome – Excellent [1], Good [2], Fair [3], and Poor [4]; 0=censored if the total survival time for a patient could not be accurately assessed}, and (III) study groups (type of work: *Light*. *Medium*, and *Heavy*). These tables were sorted in an ascending manner beginning with the shortest serial times for each group. Patients who would have been censored included patients who dropped out of the study, were lost to follow-up, or in whom required data was not available. In this study, this data was not missing. The cumulative probability of having returned to work and having recovered excluding censored events is seen on the Y-axis of the K-M plot allowing to analyze patient treatment intervals of varying duration. The difference between the type of work RTW & RT (K-M survival) curves was quantified for statistical significance using the log rank test which was used to calculated the chi-square (χ^2) for each event time in the two treatment arms. The summed results for each group were added to derive the ultimate chi-square to compare the full K-M curves obtained for the RTW and RT analysis. The confidence intervals (95%) for the likelihood ratios were calculated using the "log rank method" according to Altman *et al.* (42).

Results

Excellent (237/442) and *Good* (133/442) results according to the Macnab criteria, were obtained in 83.7% (370/442) of patients following the endoscopic transforaminal decompression procedure. *Fair* results were reported by 43 patients (9.7%), and *Poor* results by 29 (6.6%), respectively. The mean preoperative VAS was 8.08 (Min 6, Max 10; STD 1.45). The mean postoperative VAS was reduced to 2.55 (Min 0, Max 6; STD 1.52) at a statistically significant level on two-tailed paired *t*-test (P<0.0001). The preoperative work was characterized as *Heavy* in 10.9% (48/442) of patients, as *Medium* in 24.1% (107/442) of patients, as *Light* in another 64.9% (287/442) of patients, respectively. The overall RTW rate was 92.5% (409/442). As expected, patients performing *Heavy* (RTW rate =87.5%) and *Medium* (RTW rate =86.0%) work had a lower RTW rate than patients who were performing *Light* (95.8%) jobs (*Table 2*). ANOVA testing showed no statistically significant difference in the mean preoperative VAS between the type of work (*Heavy*, *Medium*, and *Light*) groups. There was a statistically significant difference in postoperative VAS between the *Light*-work type group (2.4) on the one hand, and the *Medium* (2.81)- and *Heavy* (2.89) type workgroup on the other hand on posthoc analysis with Turkey's B calculation (P=0.015). Crosstabulation of outcomes versus radiographic indicators of advanced disc degeneration including posterior disc height of less than 3 mm, or the size of the disc herniation did not have any statistically significant association with the type of work, RTW, or RT data on chi-square testing. As an additional objective measure of

Table 2 Return to work versus type of work

Type of work	Return to work		
	No	Yes	Total
Heavy			
Count	6	42	48
% within type of work	12.5%	87.5%	100.0%
Medium			
Count	15	92	107
% within type of work	14.0%	86.0%	100.0%
Light			
Count	12	275	287
% within type of work	4.2%	95.8%	100.0%
Total			
Count	33	409	442
% within type of work	7.5%	92.5%	100.0%

patient outcomes, the preoperative walking endurance was compared to the postoperative walking endurance (*Figure 3*). Preoperatively, only 31.7% (140/442) had unlimited walking endurance. Another 17.4% (77/442) could walk up to 1 mile preoperatively until they had to stop. The remaining 50.9% (225/442) had significant restrictions of their ability to walk to the pain limit with their walking endurance limited to less than 0.5 miles. Crosstabulation of pre- and postoperative walking endurance and chi-square testing showed statistically significant improvement ($P<0.0001$) of walking endurance with 77.4% (342/442) of patients having unlimited walking endurance and another 20.4% (90/442) of patients having pain-free walking endurance up to one mile (*Figure 3*).

There were no major approach or anesthesia-related problems but a few clinical complications (*Figure 4*). There were no re-incisions within three months from the endoscopic index surgery. Neither was RTW or RT data affected at a statistically significant level by complications (3/442), postoperative visits to the emergency room (4/442) for management of postoperative dysesthesias due to irritation of the dorsal root ganglion (DRG). The complication rate was 0.7% due to 2 patients with *Light* duty jobs (0.5%) that were admitted to the hospital for management of their acute COPD exacerbation postoperatively. One additional patient with a *Light*-duty job suffered from a postoperative foot drop with transitory 3/5 weakness in the extensor hallucis longus following an L4/5 transforaminal endoscopic decompression for severe foraminal stenosis. The latter patient's RTW was unaffected by the transitory foot drop, which fully recovered with supportive care measures (*Figure 4*). There were no reherniations in the study population. Postoperative sequelae defined as unavoidable side effects of an otherwise expertly executed surgery occurred in an additional 20.14% (89/442) patients (*Figure 4*). The sequelae in these 89 patients included extravasation of irrigation fluid into the subcutaneous tissues in 13 patients (2.94% of n=442), poorly controlled postoperative incisional pain in 4 patients (0.9% of n=442), spinal headaches in 3 patients (0.68%; n=442). There was no statistically significant difference in the distribution of these sequelae between the *Heavy*, *Medium*, and *Light* workgroup patients (*Figure 4*) and RTW and RT were not affected by the occurrence of these sequelae at a statistically significant level. In comparison, postoperative DRG irritation, which occurred in another 68 patients (15.38%; n=442), delayed RTW to a mean of 18.94 days ($P<0.0001$) and RT ($P<0.001$) to 15.31 days on ANOVA testing at a statistically significant level.

Kaplan Meier (K-M) analysis showed estimated median (50% percentile) RT of 11 days for *Excellent*, 12 days for *Good*, 25 days for *Fair*, and 21 days for *Poor* Macnab outcomes. The respective estimated RT means are listed in *Figure 5*. The corresponding K-M survival curves are shown in *Figure 6* with the event being patient reporting recovery with narcotic independence and the serial time being the number of days until the event. K-M analysis showed estimated median (50% percentile) RTW of 6 days for *Excellent*, 9 days for *Good*, 17 days for *Fair*, and 18 days for *Poor* Macnab outcomes. The respective estimated means are listed in *Figure 7*. The corresponding K-M survival curves are shown in *Figure 8* with the event being patient reporting RTW and the serial time being the number of days until the event. K-M analysis of RTW by the type of work (*Heavy*, *Medium*, or *Light*), showed estimated median (50% percentile) RTW of 20 days for in the *Heavy*, 13 days in the *Medium*, and 6 days in the *Light* workgroup. The respective means are listed in *Figure 9*. The corresponding K-M survival curves are shown in *Figure 10* with the event being patient reporting RTW and the serial time being the number of days until the event broken down by the *Heavy*, *Medium*, or *Light* workgroup.

		Frequency	Percent	Valid Percent	Cumulative Percent
Preoperative Walking Endurance					
Valid	100 feet	10	2.3	2.3	2.3
	250 feet	35	7.9	7.9	10.2
	500 feet	33	7.5	7.5	17.6
	1000 feet	1	.2	.2	17.9
	0.25 mile	63	14.3	14.3	32.1
	0.5 mile	83	18.8	18.8	50.9
	1 mile	77	17.4	17.4	68.3
	unlimited	140	31.7	31.7	100.0
	Total	442	100.0	100.0	
Postoperative Walking Endurance					
Valid	0.5 mile	10	2.3	2.3	2.3
	1 mile	90	20.4	20.4	22.6
	unlimited	342	77.4	77.4	100.0
	Total	442	100.0	100.0	
Crosstabulation Pre- and Postoperative Walking Endurance					
		Postoperative Walking Endurance			
		0.5 mile	1 mile	unlimited	
Preoperative Walking Endurance	100 feet	3	3	4	10
	250 feet	4	15	16	35
	500 feet	3	8	22	33
	1000 feet	0	0	1	1
	0.25 mile	0	30	33	63
	0.5 mile	0	23	60	83
	1 mile	0	8	69	77
	unlimited	0	3	137	140
Total		10	90	342	442
Chi-Square Tests Crosstabulation Pre- and Postoperative Walking Endurance					
		Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square		144.753[a]	14	<0.0001	
Likelihood Ratio		127.663	14	<0.0001	
N of Valid Cases		442			
[a] 11 cells (45.8%) have expected count less than 5. The minimum expected count is 0.02.					

Figure 3 Pre- and postoperative walking endurance after endoscopic transforaminal decompression.

The overall estimated median (50% percentile) RTW across all workgroups was 9 days with an overall mean of 10.72 days. One-way ANOVA testing of the RTW and RT times listed in *Figure 11* showed statistically significant differences in the mean RT between the *Heavy* (33.52 days), the *Medium* (19.17 days), and the *Light* (9.86 days) workgroups (P<0.0001; *Figure 11*). A similar analysis of RTW showed statistically significant differences in the mean RTW between the *Heavy* (22.27 days; P=0.008), the *Medium* (13.97 days; P=0.004), and the *Light* (7.58 days; P=0.004) workgroups.

Discussion

Managing preoperative expectations for RT and RTW following spine surgery may be difficult for surgeons who often know little about the actual functional demands required of their patients in the modern workplace. For patients, being able to predict the postoperative course of recuperation is highly relevant to plan for time-off and resources required for rehabilitation, healing, and social reintegration. For employers, accurate estimates of days off work for their employees are essential in reallocating their human resources, to plan for workarounds, and to forecast

			Type of Work			
			Heavy	Medium	Light	Total
Complication		Count	48	107	284	439
		% within Complication	10.9%	24.4%	64.7%	100.0%
	COPD exacerbation	Count	0	0	2	2
		% within Complication	0.0%	0.0%	100.0%	100.0%
	Foot drop	Count	0	0	1	1
		% within Complication	0.0%	0.0%	100.0%	100.0%
Total		Count	48	107	287	442
		% within Complication	10.9%	24.2%	64.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.631[a]	4	0.803
Likelihood Ratio	2.602	4	0.626
N of Valid Cases	442		

[a] 6 cells (66.7%) have expected count less than 5. The minimum expected count is 0.11.

			Type of Work			
			Heavy	Medium	Light	Total
Sequelae		Count	32	84	237	353
		% within Sequelae	9.1%	23.8%	67.1%	100.0%
	Dorsal root ganglion irritation	Count	14	17	37	68
		% within Sequelae	20.6%	25.0%	54.4%	100.0%
	Ecchymosis	Count	0	1	2	3
		% within Sequelae	0.0%	33.3%	66.7%	100.0%
	Extravasation of irrigation fluid	Count	2	4	7	13
		% within Sequelae	15.4%	30.8%	53.8%	100.0%
	Poor pain control	Count	0	0	2	2
		% within Sequelae	0.0%	0.0%	100.0%	100.0%
	Spinal headaches	Count	0	1	2	3
		% within Sequelae	0.0%	33.3%	66.7%	100.0%
Total		Count	48	107	287	442
		% within Sequelae	10.9%	24.2%	64.9%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.103[a]	10	0.350
Likelihood Ratio	11.229	10	0.340
N of Valid Cases	442		

[a] 11 cells (61.1%) have expected count less than 5. The minimum expected count is 0.22.

Figure 4 Crosstabulation of complications & sequelae by type of work.

	Mean[a]				Median			
Macnab Outcome	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Excellent	11.764	0.442	10.898	12.629	11.000	0.464	10.091	11.909
Good	14.218	0.743	12.763	15.673	12.000	0.822	10.389	13.611
Fair	26.372	1.821	22.804	29.940	25.000	2.336	20.421	29.579
Poor	23.379	2.237	18.995	27.764	21.000	2.018	17.044	24.956
Overall	14.686	0.457	13.789	15.582	12.000	0.519	10.984	13.016

[a] Estimation is limited to the largest survival time if it is censored.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	84.236	3	<0.0001

Test of equality of survival distributions for the different levels of Outcome.

Figure 5 Means and medians for survival time for postoperative recovery time by Macnab outcomes.

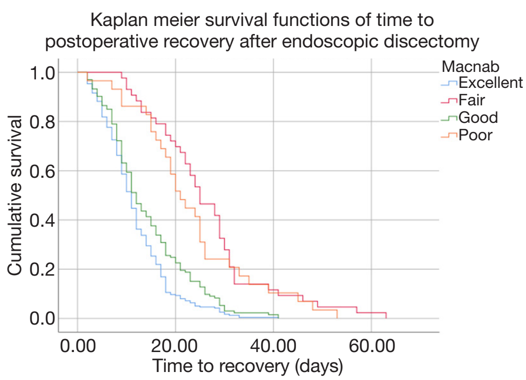

Figure 6 Kaplan-Meier (K-M) survival curves of recovery time (RT) reported by patients as narcotic independence. The estimated median (50% percentile) RT was 11 days for *Excellent*, 12 days for *Good*, 25 days for *Fair*, and 21 days for Poor Macnab outcomes. The respective estimated RT (event) means and 95% confidence interval upper and lower boundaries are listed in *Figure 5*.

any potential productivity losses. Traditionally, spine surgery has been associated with long RTs, and cumulative long-term disability with frequent need for additional surgery. The health information provided to patients by the US National Library of Medicine (MedlinePlus) indicates to expect an improvement of symptoms after discectomy or foraminotomy within a few weeks versus 3 to 4 months of recovery after laminectomy and fusion surgery with some symptoms persisting even longer for up to a year (43). This US government website tells patients to expect to be off work after spinal fusion for 4 to 6 weeks if young and healthy and if their job is not very strenuous. Older patients with more extensive spinal fusion surgery are advised that they may have to take 4 to 6 months off before they can get back to work (43). Minimally invasive spinal surgery techniques (MISST) have substantially decreased the burden to patients with faster recovery, less incisional pain, and fewer days to narcotic independence (44).

The authors used RTW and RT as the primary PROM and correlated it with standard clinical outcome measures including the VAS, the Macnab criteria, and postoperative improvement of walking endurance with the expectations that patients would reflect primarily on how they improved from the transforaminal endoscopic decompression surgery in the context of their overall functional demands rather than limiting it to whether or not they returned to work. While the RTW is the most tangible prognosticator of successful clinical outcome (45), it is also the most complex multifactorial problem which is difficult to investigate, particularly if a WC claim is involved. Many of the associated psychosocial factors including inactivity and social isolation from the workplace (46), and financial strain may lead to increased anxiety (47), depression and amplify the negative experience with a physical ailment and thereby produce a lower self-reported health and quality of life assessment unrelated to surgery (48,49).

In the authors' opinion, reporting RT in addition to RTW time was important to add another accurate measure of disease- and surgery-related recovery since the RTW was reported to be heavily impacted by the preoperative sick leave time (50). The presence of one additional medical co-morbidity was also found to make

	Mean[a]				Median			
Macnab Outcome	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Excellent	8.046	0.384	7.293	8.800	6.000	0.357	5.301	6.699
Good	11.917	0.767	10.414	13.420	9.000	1.152	6.741	11.259
Fair	17.907	1.128	15.695	20.119	17.000	1.090	14.863	19.137
Poor	16.483	1.557	13.430	19.535	18.000	1.785	14.501	21.499
Overall	10.724	0.378	9.982	11.466	9.000	0.686	7.656	10.344

[a] Estimation is limited to the largest survival time if it is censored.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	65.838	3	<0.0001

Test of equality of survival distributions for the different levels of Macnab Outcome.

Figure 7 Means and medians for survival time-time postoperatively return to work time by Macnab outcomes.

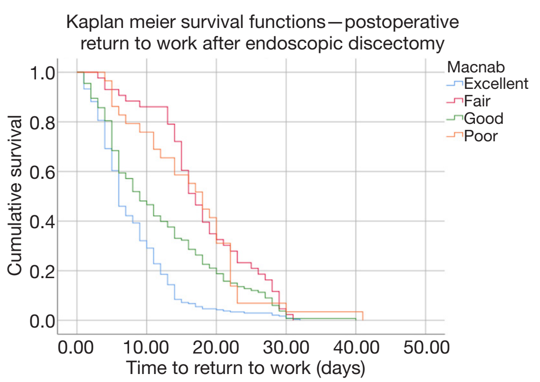

Figure 8 Kaplan-Meier (K-M) Survival curves of recovery time (RTW) reported by patients as the number of days postoperatively before going back to work. The estimated median (50% percentile) RTW return to work (RTW) of 6 days for *Excellent*, 9 days for *Good*, 17 days for *Fair*, and 18 days for *Poor* Macnab outcomes. The respective estimated means are listed in *Figure 6*.

patients less likely to RTW after surgery. However, co-morbidities were less relevant in our study and did not impact RTW data since the average age was 40.92 years, and the majority of patients were under 40 years of age (*Figure 1*). Socioeconomic, demographic, and surgical complications were not found to impact RTW data at a statistical significance level (51). One of the strongest positive predictors of RTW after surgery was preoperative work status (51), which was corroborated in our study with the RTW rate for all working patients being 92.5% (409/442). This high RTW rate compared favorably to reported numbers for return to duty in active service members after open decompression (66%) and fusion of 63% (52). Another study including 4694 patients analyzed RTW after traditional open lumbar spine surgery for herniated disc (n=2,437; 52%), lumbar stenosis (n=1,062; 23%), lumbar spondylolisthesis (n=720; 15%), recurrent

	Mean[a]				Median			
Type of work	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Heavy	22.271	0.962	20.385	24.156	20.000	0.990	18.060	21.940
Medium	13.972	0.703	12.594	15.350	13.000	0.646	11.734	14.266
Light	7.582	0.347	6.903	8.261	6.000	0.188	5.631	6.369
Overall	10.724	0.378	9.982	11.466	9.000	0.686	7.656	10.344

[a] Estimation is limited to the largest survival time if it is censored.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	133.565	2	<0.0001

Test of equality of survival distributions for the different levels of Type of work (Heavy, Medium, Light).

Figure 9 Means and medians for survival time-time postoperatively return to work by type of work (heavy, medium light).

disc herniation (n=339; 7%), adjacent-segment disease (n=96; 2%), and symptomatic mechanical disc collapse (n=30; 0.6%) (51). The overall RTW three months postoperatively among the 3855 patients who provided RTW information was 82%. An additional work-related factor predictive of lower three-month patient RTW rates is the type of occupation (51). Our results corroborated findings of a previous study (53) reporting statistically significantly lower RTW rates in patients in the *Heavy* (87.5%) and the *Medium* (86.0%) workgroups compared to patients in *Light* (95.8%) workgroups (*Table 2*).

On the employer's side, a strong commitment to health and safety, work accommodation, support for the returning worker without disadvantaging other co-workers and supervisors, inclusion of supervisors trained in prevention of work disability during the reintegration of the employee into the workforce (49), contacting the convalescing patient and coordinating RTW (54), and communication of workplace demands by employers with healthcare providers is associated with earlier RTW (45,55). Of the patient- and diagnosis-related factors, preoperative symptom duration of fewer than three months for herniated disc (56) and less than 12 months for spinal stenosis (53) were predictors of better outcomes and earlier RTW (49), compared to the preoperative history of diabetes and higher ASA scores negatively impacting RTW (57). Racial disparities partly related to educational barriers were also reported as relevant

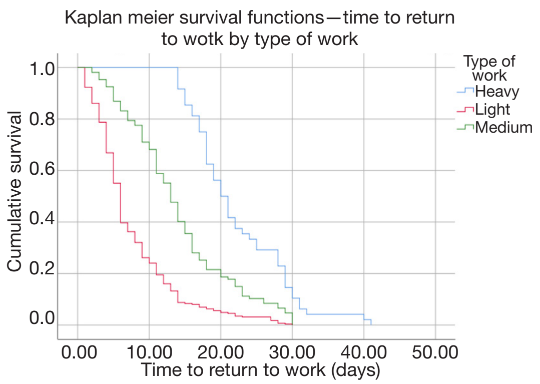

Figure 10 Kaplan-Meier (K-M) Survival curves of recovery time (RTW) by type of work (*Heavy*, *Medium*, or *Light*) reported by patients in the different work groups as the number of days postoperatively before going back to work. The estimated median (50% percentile) RTW return to work (RTW) of 22 days for in the *Heavy*, 13 days in the *Medium*, and 6 days in the *Light* work group. The respective means are listed in *Figure 9*.

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Recovery Time	Heavy	48	33.5208	9.49129	1.36995	30.7648	36.2768	17.00	63.00
	Medium	107	19.1682	5.22961	0.50557	18.1659	20.1706	5.00	31.00
	Light	287	9.8641	5.21151	0.30763	9.2586	10.4696	2.00	32.00
	Total	442	14.6855	9.61283	0.45724	13.7869	15.5842	2.00	63.00
Return To Work	Heavy	48	22.2708	6.66442	0.96193	20.3357	24.2060	14.00	41.00
	Medium	107	13.9720	7.27422	0.70323	12.5777	15.3662	2.00	30.00
	Light	287	7.5819	5.87153	0.34659	6.8997	8.2641	1.00	30.00
	Total	442	10.7240	7.95656	0.37846	9.9802	11.4678	1.00	41.00
Test of Homogeneity of Variances									
				Levene Statistic		df1	df2		Sig.
Recovery Time	Based on Mean			16.582		2	439		<0.0001
	Based on Median			9.655		2	439		<0.0001
	Based on Median and with adjusted df			9.655		2	285.112		<0.0001
	Based on trimmed mean			13.997		2	439		<0.0001
Return To Work	Based on Mean			4.887		2	439		0.008
	Based on Median			5.649		2	439		0.004
	Based on Median and with adjusted df			5.649		2	438.695		0.004
	Based on trimmed mean			5.526		2	439		0.004

Figure 11 Oneway ANOVA testing of recovery time and return to work time by type of work.

(57,58). Of the surgery-related factors, the addition of fusion to the decompression was reported as the most influential predictor of lower RTW rates at three months postoperatively (51). While investigating the impact of this patient-, work-, or diagnosis-related factors was beyond the scope of this study; it is clear that RTW and RT data with the outpatient lumbar endoscopic transforaminal decompression procedures compare favorably to three-months data reported for open or other types of minimally invasive translaminar surgeries (45). The overall RTW rate among the working patients of this study of 92.5% is a testament to the simpler recovery for patients with the outpatient small-incision endoscopic spine surgery. In part, this may be due to fewer postoperative complications (24) and less need for treatment during poorly managed transitions of care episodes due to decompensation of underlying medical co-morbidities which are more likely to lead to readmission (22) and unintended aftercare than surgical site complications (24).

The combined complication rate of 0.7% with the endoscopic transforaminal decompression procedure in this study population was low and approximately one magnitude lower than with microdiscectomy surgeries (24). There were no reherniations causing radiculopathy and was, hence, lower than reported in the literature (16,18,20). Only four patients (0.9%) presented for unintended aftercare due to an emergency room. The readmission rate of 0.45% (22) was low compared to microdiscectomy studies (18), and there were no re-incisions for any follow-up surgeries within 90 days. *Failure* to cure with *Poor* Macnab outcomes and without improvement of postoperative walking endurance occurred in 6.6% (29/442) of patients with bony stenosis in the central canal, lateral recess, and entry zone of the foramen. In these failed patients, the endoscopic decompression technology may have been inadequate to deal with the extent of the stenosis or the underlying disease process was most likely too advanced. The most common postoperative sequela (15.38%) by far was irritation of the DRG which delayed RTW to a mean of 18.94 days ($P<0.0001$) and RT ($P<0.001$) to 15.31 days with statistical significance in patients with *Heavy* jobs. Most postoperative problems, whether complication or sequelae, were handled on an outpatient basis in an office setting (24).

The Kaplan-Meier analysis of the time to RTW and RT was in the authors' opinion more appropriate for graphically illustrating the RTW and RT dynamic in patients who underwent the endoscopic transforaminal decompression procedure than merely reporting the mean RTW and RT times. The non-continuous nature of the K-M survival plots provide step-wise survival estimates until the event which in the case of the authors' study was the number of days when the patient reported either RTW or complete recovery as defined by narcotic independence. K-M curves are not a smooth function. Calculating exact survival points for the RTW and RT is actually quite tricky and depends on the number of positive and negative factors leading to the censoring of study patients with an event throughout the study or at its end without event. Since the author had no way to include additional workplace-related data into crosstabulation statistics, the K-M curves graphically represent the real postoperative RTW and RT dynamic reported by patients. For the vast majority of patients who were in the Light workgroup the K-M curve demonstrate that many patients returned much sooner to work left to the 50% percentile (median six days) than to the right of it (*Figure 10*). The vast majority of patients had *Excellent* and *Good* Macnab outcomes (83.7%; 370/442). K-M curves indicate very favorable RTW and RT times with 50% of patients (left to the 50% percentile median point) having achieved narcotic independence and returned to work within six days (*Excellent* Macnab outcome), or nine days (*Good* Macnab outcomes). However, K-M curves have to be cautiously evaluated since they become an estimate after the first patient has been censored. Therefore, the K-M curves showed an accurate graphic representation of the RTW and RT times until the first patient was censored. At that point, it is an estimation and extrapolations on future RTW, RT, and patient outcomes should be avoided. Based on the K-M analysis, this team of authors concluded that surgical treatment of sciatica symptoms due to contained lumbar herniated disc with the transforaminal endoscopic decompression allows the vast majority (83.7%) to RTW and achieve narcotic dependence in less than ten days postoperatively.

This study had several limitations. Many variables previously reported to impact RTW (51) (i.e., marital status, family support, preoperative disposition of wanting to work, working conditions, employer-employee relationship, work-related stress) were not recorded and, hence, are missing in this RTW and RT discussion after endoscopic spine surgery for symptomatic lumbar contained herniated disc with or without associated spinal stenosis. In comparison to predictive RTW model reports (59,60), the authors of this study did not intend to perform an in-depth RTW analysis but to illustrate shorter RTW and RT times in the immediate three-months postoperative recovery period following the outpatient lumbar endoscopic transforaminal decompression procedure with simple PROMs such as VAS, Macnab, and walking endurance to the pain limit. Additional limitations may have existed since the authors did not attempt to ascertain whether RTW reported by patients postoperatively were at the same work- or functional capacity level. However, the latter problem may be of lesser relevance to employers who are predominately interested in knowing when their employees are returning to the same job duties they held before their spine surgery.

Conclusions

RTW and RT with narcotic independence following an endoscopic transforaminal decompression surgery for sciatica-type low back, and leg pain due to contained lumbar herniated disc is on the order of 10 days or less in the vast majority of patients. The most relevant surgical predictor of delayed RTW and RT is a postoperative DRG irritation which predominantly affects patients in the Medium and Heavy workgroups. Low complication-, readmission-, and re-incision rates indicated that this outpatient surgery is associated with more straightforward recovery for the patient and with fewer postoperative unintended aftercare than with traditional translaminar open spine surgery. RTW rates (92.5%) are higher than those reported with traditional open and other types of minimally invasive translaminar decompression surgeries. Surgical translational outcome research should focus on analyzing the effectiveness of state-of-the-art endoscopic surgery interventions for herniated disc and stenosis in the lumbar spine to further determine how they impact the prognosis of RTW and RT in the surgical treatment of neurogenic claudication and lumbar radiculopathy.

Acknowledgments

None.

Footnote

Conflicts of Interest: The authors have no direct (employment, stock ownership, grants, patents), or indirect conflicts of interest (honoraria, consultancies to sponsoring organizations, mutual fund ownership, paid expert testimony). The authors are not currently affiliated with or under any consulting agreement with any vendor that the clinical research data conclusion could directly enrich. This manuscript is not meant for or intended to endorse any products or push any other agenda other than to report the return to work data and the associated clinical outcomes. The motive for compiling this clinically relevant information is by no means created and/or correlated to directly enrich anyone due to its publication. This publication was intended to substantiate contemporary endoscopic spinal surgery concepts to facilitate technology advancements.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. IRB approval was obtained for this study (CEIFUS 106-19). Written informed consent was obtained from the patient for publication of this Original Study and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Cite this article as: Lewandrowski KU, Ransom NA, Yeung A. Return to work and recovery time analysis after outpatient endoscopic lumbar transforaminal decompression surgery. J Spine Surg 2020;6(Suppl 1):S100-S115. doi: 10.21037/jss.2019.10.01

