



PREDICTORS OF FUNCTIONAL RECOVERY FOLLOWING SURGICAL DECOMPRESSION IN LUMBAR CANAL STENOSIS: A PROSPECTIVE COHORT STUDY

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Abstract

Background: Decompressive surgery reliably relieves symptoms of lumbar canal stenosis (LCS), but functional recovery varies between patients. Identifying preoperative predictors of recovery would improve patient selection and counselling.

Objectives: To quantify functional improvement after surgical decompression for LCS and to identify preoperative predictors of six-month improvement in the Oswestry Disability Index (ODI).

Methods: A prospective cohort of 120 patients undergoing decompressive surgery for symptomatic LCS was assessed preoperatively and at 3 and 6 months. Outcomes were the ODI (0–100), back and leg visual analogue scale (VAS) pain and walking distance. The primary endpoint was 6-month ODI improvement; a secondary binary endpoint was meaningful recovery (≥ 12.8 -point ODI improvement). Predictors were examined with multivariable linear regression.

Results: The cohort (mean age 64.3 ± 9.3 years; 61.7% male) improved substantially. Mean ODI fell from 54.0 ± 11.3 to 28.4 ± 10.9 (mean improvement 25.6 ± 5.9 points; $p < 0.001$); leg VAS fell from 7.1 ± 1.3 to 3.8 ± 1.5 and back VAS from 6.0 ± 1.4 to 3.4 ± 1.6 (both $p < 0.001$); mean walking distance rose from 280 ± 163 m to 886 ± 234 m. Meaningful recovery was achieved by 117 patients (97.5%). In multivariable regression ($R^2 = 0.44$), greater ODI improvement was independently predicted by higher baseline ODI ($\beta = +0.22$, $p < 0.001$) and was reduced by older age ($\beta = -0.20/\text{year}$, $p < 0.001$), diabetes ($\beta = -3.89$, $p < 0.001$), depression or anxiety ($\beta = -2.88$, $p = 0.015$), longer symptom duration ($\beta = -0.10/\text{month}$, $p = 0.003$) and higher BMI ($\beta = -0.24$, $p = 0.035$); sex, smoking and stenosis severity were not significant.

Conclusion: Surgical decompression produced large functional gains in LCS. Older age, diabetes, depression or anxiety, longer symptom duration and higher BMI predicted smaller functional recovery, whereas higher baseline disability predicted greater absolute gain — findings that support earlier surgery and attention to modifiable comorbidity.

Keywords: lumbar canal stenosis; decompression; Oswestry Disability Index; predictors; depression; diabetes

Introduction

Lumbar canal stenosis (LCS) is the most common indication for spinal surgery in adults older than 65 years and a leading cause of pain, neurogenic claudication and mobility loss in the ageing population [1]. It results from a degenerative cascade of disc height loss, facet hypertrophy, ligamentum flavum thickening and, in some patients, spondylolisthesis, which together narrow the central canal and neural foramina [2]. When conservative measures



fail, decompressive surgery aims to relieve neural compression, reduce leg-dominant pain and restore walking capacity.

The effectiveness of surgery relative to non-operative care has been established in both randomised and observational studies. Long-term prospective work reported more favourable outcomes with surgery than conservative treatment, while noting that many patients also improve without operation [3]. The Spine Patient Outcomes Research Trial (SPORT) demonstrated that patients treated surgically achieved significantly greater improvement in pain and function than those treated non-operatively, with advantages maintained at two and four years despite substantial cross-over [1,2]. These data support decompression as an effective intervention for appropriately selected patients.

Effectiveness at the group level, however, conceals meaningful variation between individuals. A proportion of patients gain little functional benefit, and the ability to predict who will recover would sharpen patient selection, inform shared decision-making and set realistic expectations. A systematic review of preoperative predictors found that depression, cardiovascular comorbidity, disorders influencing walking ability and scoliosis predicted poorer subjective outcomes, whereas better baseline walking ability, self-rated health and more pronounced central stenosis predicted better outcomes [5]. Prospective cohorts have specifically implicated depressive symptoms — both preoperatively and during early recovery — as robust predictors of poorer functional outcome at one and two years [8,9]. Age, comorbidity and low-back-dominant pain have likewise been associated with less favourable recovery in elderly surgical cohorts [6,7].

Despite this literature, predictors are outcome-specific and cohort-dependent, and continued prospective documentation using validated functional endpoints remains valuable. The present study evaluated functional recovery after decompressive surgery for LCS and sought to identify preoperative predictors of six-month ODI improvement. The objectives were to quantify change in the ODI, back and leg pain and walking distance, and to determine which baseline demographic, comorbidity and clinical factors independently predicted the magnitude of functional recovery.

2. Methods

Participants

One hundred and twenty patients undergoing decompressive surgery for symptomatic LCS were included. Eligible patients had clinical features of neurogenic claudication or radiculopathy with imaging-confirmed central and/or lateral recess stenosis, and had failed an adequate trial of conservative care.

Surgical procedure and perioperative variables

Patients underwent decompressive surgery — laminectomy or targeted decompression — at the affected levels, with the number of levels decompressed recorded. Operative time, estimated blood loss, length of stay and perioperative complications were documented.

Outcome measures

Patients were assessed preoperatively and at 3 and 6 months. The primary outcome was the ODI (0–100). Secondary outcomes were back and leg VAS pain (0–10) and self-reported walking distance (metres). The primary analytic endpoint was 6-month ODI improvement (preoperative ODI minus 6-month ODI). A binary endpoint of meaningful recovery was defined a priori as an ODI improvement of at least 12.8 points, an example minimal-clinically-important-difference threshold.

Statistical analysis

Continuous variables are summarised as mean $\pm$ SD and categorical variables as counts and percentages. Preoperative-to-6-month changes were tested with the paired *t* test. Predictors of 6-month ODI improvement were examined using multivariable linear regression including age, sex, BMI, diabetes, smoking, depression or anxiety, symptom duration, stenosis severity and baseline ODI; standardised diagnostics were reviewed and model fit summarised by R^2 . Because meaningful recovery was near-universal, the continuous ODI-improvement outcome was used for predictor modelling to avoid the instability of logistic regression under near-



complete separation. Two-sided $p < 0.05$ was considered significant. Analyses used Python (pandas, SciPy, statsmodels).

Results

Baseline characteristics

The cohort comprised 120 patients with a mean age of 64.3 ± 9.3 years; 74 (61.7%) were male and mean BMI was 26.8 ± 3.8 kg/m². Diabetes was present in 33 (27.5%), hypertension in 48 (40.0%), current smoking in 27 (22.5%) and depression or anxiety in 20 (16.7%); ASA class was II in 79 patients. Mean symptom duration was 23.7 ± 13.9 months. The main stenotic level was L4–L5 in 78 patients, and stenosis was graded severe in 60 and moderate in 60 (Table 1).

Perioperative variables

One or more levels were decompressed (one level 43, two levels 54, three levels 23). Mean operative time was 113.1 ± 24.2 minutes, mean estimated blood loss 181.2 ± 77.1 mL and mean length of stay 3.1 ± 1.0 days. Perioperative complications occurred in 9 patients (7.5%) (Table 2).

Functional recovery

All functional measures improved substantially from baseline to 6 months (Figure 1; Table 3). Mean ODI fell from 54.0 ± 11.3 preoperatively to 35.4 ± 10.6 at 3 months and 28.4 ± 10.9 at 6 months, a mean 6-month improvement of 25.6 ± 5.9 points (paired t test, $p < 0.001$). Leg VAS decreased from 7.1 ± 1.3 to 3.8 ± 1.5 and back VAS from 6.0 ± 1.4 to 3.4 ± 1.6 (both $p < 0.001$). Mean self-reported walking distance increased from 280 ± 163 m to 886 ± 234 m. Meaningful recovery (≥ 12.8 -point ODI improvement) was achieved by 117 patients (97.5%).

Predictors of ODI improvement

In multivariable linear regression ($R^2 = 0.44$), six baseline variables were independently associated with the magnitude of 6-month ODI improvement (Figure 2; Table 4). Greater improvement was predicted by higher baseline ODI ($\beta = +0.22$ points per baseline point, $p < 0.001$). Smaller improvement was predicted by older age ($\beta = -0.20$ per year, $p < 0.001$), diabetes ($\beta = -3.89$, $p < 0.001$), depression or anxiety ($\beta = -2.88$, $p = 0.015$), longer symptom duration ($\beta = -0.10$ per month, $p = 0.003$) and higher BMI ($\beta = -0.24$ per unit, $p = 0.035$). Female sex, smoking and severe (versus moderate) stenosis were not significant predictors. The direction and pattern of these associations are consistent with prior predictor studies emphasising age, comorbidity, depressive symptoms and symptom chronicity [5,6,8,9].

Table 1. Baseline demographic and clinical characteristics (N=120).

Characteristic	Value
Age, years (mean $\pm$ SD)	64.3 ± 9.3
Male sex, n (%)	74 (61.7)
BMI, kg/m ²	26.8 ± 3.8
Diabetes, n (%)	33 (27.5)
Hypertension, n (%)	48 (40.0)
Current smoking, n (%)	27 (22.5)
Depression or anxiety, n (%)	20 (16.7)
ASA class I / II / III	20 / 79 / 21



Symptom duration, months	23.7 ± 13.9
Main stenosis level: L3–L4 / L4–L5 / L5–S1	24 / 78 / 18
Stenosis severity: moderate / severe	60 / 60

Table 2. Perioperative variables (N=120).

Variable	Value
Levels decompressed: 1 / 2 / 3	43 / 54 / 23
Operative time, minutes	113.1 ± 24.2
Estimated blood loss, mL	181.2 ± 77.1
Length of stay, days	3.1 ± 1.0
Perioperative complication, n (%)	9 (7.5)

Table 3. Functional outcomes over time (mean ± SD).

Outcome	Pre-op	3 months	6 months	p (pre vs 6 mo)
ODI (0–100)	54.0 ± 11.3	35.4 ± 10.6	28.4 ± 10.9	<0.001
VAS back (0–10)	6.0 ± 1.4	—	3.4 ± 1.6	<0.001
VAS leg (0–10)	7.1 ± 1.3	—	3.8 ± 1.5	<0.001
Walking distance (m)	280 ± 163	—	886 ± 234	<0.001
ODI improvement (points)	—	—	25.6 ± 5.9	—
Meaningful recovery (≥12.8 pts), n (%)	—	—	117 (97.5)	—

Table 4. Multivariable linear-regression predictors of 6-month ODI improvement (R² = 0.44).

Predictor	β (points)	p value
Baseline ODI (per point)	+0.22	<0.001
Age (per year)	−0.20	<0.001
Diabetes	−3.89	<0.001
Depression or anxiety	−2.88	0.015
Symptom duration (per month)	−0.10	0.003
BMI (per unit)	−0.24	0.035
Female sex	−0.27	0.76 (NS)
Smoking	−0.91	0.39 (NS)
Severe stenosis	−0.68	0.48 (NS)

NS, not significant.

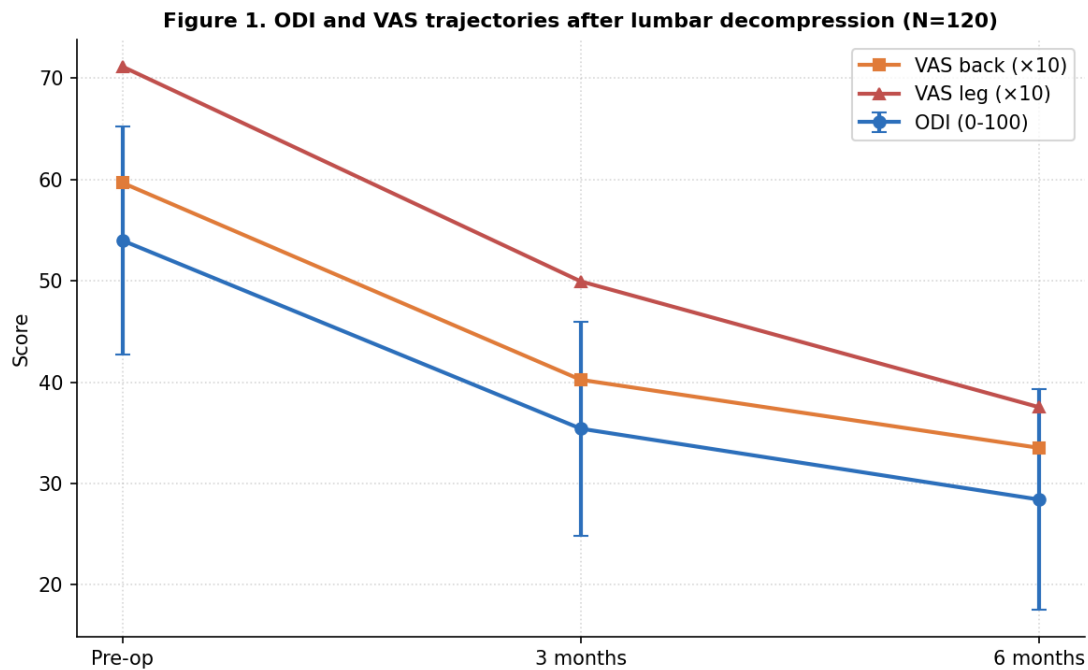


Figure 1. ODI and VAS (back and leg) trajectories from pre-op to 6 months (N=120); VAS values scaled ×10 for display on a common axis.

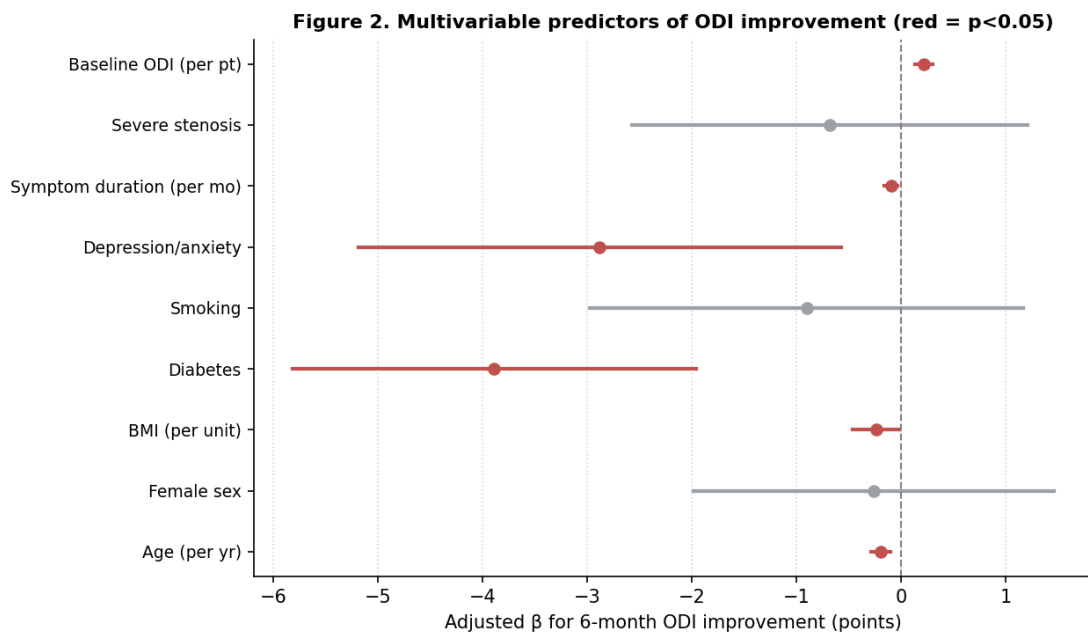


Figure 2. Adjusted regression coefficients (β with 95% confidence intervals) for predictors of 6-month ODI improvement; red indicates $p < 0.05$.

Discussion

In this prospective cohort of 120 patients undergoing decompressive surgery for LCS, functional recovery was large and consistent: mean ODI improved by more than 25 points, leg and back pain roughly halved, and self-reported walking distance more than tripled by six months, with meaningful recovery in almost all patients.



These findings reproduce, at the group level, the well-established benefit of decompression demonstrated in randomised and observational cohorts, including the sustained advantages of surgery over non-operative care reported by SPORT at two and four years and by long-term prospective series [1,2,3].

The principal contribution of this study lies in the predictors of the *magnitude* of recovery. Older age, diabetes, depression or anxiety, longer symptom duration and higher BMI each independently predicted smaller ODI improvement, whereas higher baseline disability predicted larger absolute gains. The association of depressive symptoms with poorer functional outcome is among the most consistently reported in the LCS literature: prospective cohorts have shown that depressive burden in the preoperative and early recovery phase predicts poorer disability, pain and walking outcomes at one and two years, and a systematic review identified depression as a predictor of poorer subjective outcome [5,8,9]. The negative influence of age and comorbidity likewise accords with elderly surgical series in which low-back-dominant pain, comorbidity and, in some analyses, female sex predicted less favourable recovery [6,7]. The independent effect of longer symptom duration supports the intuition — and prior evidence — that prolonged neural compression and deconditioning limit the ceiling of recovery, an argument for not deferring surgery unduly once an adequate conservative trial has failed.

The finding that higher baseline ODI predicted greater absolute improvement is expected and partly reflects greater room for change in more disabled patients; it should not be read as a reason to delay surgery until disability is severe, particularly given the opposing, adverse effect of longer symptom duration. Modifiable factors — diabetes control, weight and mood — emerge as plausible targets for perioperative optimisation. Screening for and treating depression or anxiety around the time of surgery is a specific, evidence-aligned recommendation, given the repeated demonstration that early-recovery depressive symptoms predict worse functional trajectories [8,9].

Several caveats temper interpretation. The near-universal rate of meaningful recovery (97.5%) meant that a binary recovery endpoint offered little discrimination and that logistic modelling was unstable; the continuous ODI-improvement outcome was therefore the appropriate basis for predictor analysis, and it yielded a coherent, clinically interpretable model. Stenosis severity did not predict recovery in this cohort, which is consistent with the mixed and sometimes counter-intuitive relationship between radiological severity and outcome reported previously, where more pronounced central stenosis has occasionally predicted *better* subjective outcome [5].

Conclusion

In cohort, surgical decompression for LCS produced large improvements in disability, pain and walking capacity by six months, with meaningful recovery in almost all patients. Older age, diabetes, depression or anxiety, longer symptom duration and higher BMI independently predicted smaller functional recovery, whereas higher baseline disability predicted greater absolute gain. These predictors support earlier surgical decision-making once conservative care has failed and attention to modifiable comorbidity — particularly mood disorder, diabetes and weight — as part of preoperative optimisation.

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