Brain and Spine 4 (2024) 103902

Contents lists available at ScienceDirect

Brain and Spine

journal homepage: www.journals.elsevier.com/brain-and-spine

Mental state as a predictor of outcome in spinal stenosis surgery: Four quadrants model integrating patient satisfaction and functional outcome

Judith van Grafhorst [a,*], Wouter van Furth [a,b], Carmen Vleggeert-Lankamp [a,b]

[a] University Neurosurgical Center Holland, LUMC | HMC | HAGA, the Netherlands
[b] Department of Neurosurgery, Spaarne Gasthuis, Haarlem, Hoofddorp, the Netherlands

ARTICLE INFO

Handling editor: F Kandziora

The preliminary outcomes of this paper have been presented at the online ISLSS 2022 and the EANS 2022, Belgrade, Serbia.

Keywords:
Lumbar spinal stenosis
Spondylolisthesis
Decompressive surgery
Mental status
Patient satisfaction
Functional outcome

ABSTRACT

Introduction: Mental status, characterised by anxiety and depression, significantly influences physical well-being, particularly in patients with spinal stenosis symptoms.
Research question: The prevalence of depression and anxiety in our cohort. The correlation between psychological distress and physical outcome after surgery, including postoperative recovery and satisfaction.
Materials and methods: Questionnaires evaluating anxiety and depression (HADS), functionality (ODI), quality of life (EQ-5D), and perceived recovery (Likert-scale) were sent to a randomly selected cohort of 450 lumbar spinal stenosis patients, with or without spondylolisthesis, who underwent surgery between 2007 and 2013. Results are presented, dichotomised by HADS score (score $\geq$8 indicating psychologically impaired) and in a Four Quadrants Model integrating functional outcomes and perceived recovery separately for psychologically impaired and non-impaired cases.
Results: Among the 147 included patients, 32 (22%) exhibited anxiety and/or depression (impaired cases). Satisfactory outcome (perceived recovery) was reported in 29.0% of the impaired cases and 78.3% of the non-impaired cases ($p < 0.001$). The mean postoperative functionality score of the impaired cases was 42.46 ± 16.24, in contrast to 18.48 ± 18.25 for the non-impaired cases ($p < 0.001$). In the impaired group, only 12.5% achieved both a good functional outcome (ODI $\leq$24) and satisfactory perceived recovery, compared with 58.4% in the non-impaired group.
Discussion and conclusion: Patients reporting anxiety and/or depression demonstrate an inferior long-term outcome after spinal stenosis surgery compared to non-impaired patients. This clinically relevant difference underscores the importance of addressing depression and anxiety in preoperative counselling to optimize patient satisfaction and functional outcomes.

1. Introduction

Lumbar spinal stenosis (LSS) is a condition in which the spinal canal is narrowed (Andaloro, 2019), usually based on degenerative spine alterations. LSS may provoke back pain and neurogenic claudication, hamper patients' walking ability and physical functioning, and lead to a decreased quality of life (Rampersaud et al., 2014; Forsth et al., 2016). Since lumbar spinal stenosis is a condition whose prevalence increases with age (Haig and Tomkins, 2010), the treatment is increasingly relevant in an ageing population (Deyo et al., 2010). Surgical treatment is generally preferred over non-surgical interventions such as physical therapy and/or pain relief using epidural steroid injections (Weinstein et al., 2008; Amundsen et al., 2000; Malmivaara et al., 2007). After surgical treatment, approximately 1/3 of patients are dissatisfied with the outcome (Strömqvist et al., 2013; Choi et al., 2014), and 7–23% of patients are even reoperated (Rampersaud et al., 2014; Forsth et al., 2016; Ghogawala et al., 2016; Ulrich et al., 2017; Lad et al., 2014; Sigmundsson et al., 2017; Javalkar et al., 2011; Deyo et al., 2011; Jansson et al., 2003). This is in line with our data: based on a retrospective cohort study, we concluded that two months postoperatively, 78% of patients were satisfied with their surgery and that 13% of patients were reoperated (van et al., 2023). In literature, this raises the question of what causes dissatisfaction in patients and whether satisfaction with outcomes can be predicted at baseline to optimize patient counselling.

It is essential to manage patients' expectations. A smaller gap

* Corresponding author. Department of Neurosurgery, Leiden University Medical Centre, Albinusdreef 2, 2300, RC, Leiden, the Netherlands.
E-mail address: J.M.P.van_Grafhorst@lumc.nl (J. van Grafhorst).

https://doi.org/10.1016/j.bas.2024.103902
Received 23 April 2024; Received in revised form 5 August 2024; Accepted 6 September 2024
Available online 7 September 2024

between patients' expectations and genuine outcomes after surgery (lower expectations-actuality discrepancy) is associated with higher satisfaction (Witiw et al., 2018). Managing patients' expectations can be effectuated by demonstrating their peers' results after lumbar spinal surgery. It is hypothesised that depression and/or anxiety are essential in both preoperative expectations and postoperative well-being and functionality.

A Four Quadrants Model integrating patient satisfaction from the Likert scale and the physical functionality from the Oswestry Disability Index (ODI) results in 4 integrated quadrants. This tool can be used in counselling patients and give depressed and/or anxious patients an insight into their global perceived outcome by reflecting on their peers' results.

This study aims to demonstrate the prevalence of depression and anxiety in the follow-up of lumbar stenosis patients who received decompressive surgery. Additionally, the correlation between psychological distress ('impairment') and the combination of physical outcome and satisfaction with surgery will be evaluated using a tool that can be integrated into patient counselling before surgery.

2. Methods

2.1. Patient data collection

Previously, we described the nine-years follow-up and clinical outcome of a cohort of 934 patients who underwent decompressive surgery (without fusion) for neurogenic claudication for lumbar spinal (van et al., 2023). Inclusion criteria were: adult patients with symptomatic lumbar spinal stenosis with or without degenerative spondylolisthesis who were operated on for this indication. Symptomatic lumbar stenosis had to be characterised by neurogenic claudication. Stenosis could be due to spondylotic degeneration, ligamentous hypertrophy, discogenic protrusion, or a combination. Exclusion criteria were: previous operations on the lumbar spine, spondylolisthesis due to lysis or trauma, and scoliosis defined by a Cobbs angle of 10° or more.

For this current study, questionnaires were sent to a random selection of 450 patients to get less biased and more detailed outcome information. Patient Reported Outcome Questionnaires involved the Oswestry Disability Index (ODI)(Fairbank and Pynsent, 2000; Austevoll et al., 2019; Werner et al., 2017; Tonosu et al., 2012; Parai et al., 2018), Euro-Qol-5D a health-related quality of life utility measure (EQ5-D) (Austevoll et al., 2019; Werner et al., 2017; Parai et al., 2018; EuroQol–a new facility for the, 1990; M et al., 2016), Hospital Anxiety and Depression Scale (HADS), and patient-perceived recovery. Baseline characteristics (gender, age, stenosis with or without spondylolisthesis, level of stenosis, grade of spondylolisthesis), initial satisfaction at two months ("yes" or "no"), reoperation yes or no and level of reoperation were obtained from medical files. A more extensive description of the PROMS and their used cutoff values can be found in Appendix 1.

2.2. Hospital Anxiety and Depression Scale (HADS)

The HADS consists of two 7-item questionnaires (Zigmond and Snaith, 1983; Bjelland et al., 2002) concerning anxiety and depression separately. Each of the 14 questions contains a four-point scale scoring from 0 to 3. The outcome scoring is individually assessed, resulting in an anxiety score and a depression score. Originally, the outcome was divided into three groups; non-impaired cases (score range 0–7), doubtful cases (score range 8–10), and impaired cases (score range 11–21)(Zigmond and Snaith, 1983; Bjelland et al., 2002). In order to dichotomise the data, clinical outcomes can be divided into 'impaired cases and 'non-impaired cases (Bjelland et al., 2002). An impaired case is defined as a case reporting a score of $\geq$8, either on the anxiety or depression scale.

2.3. Four Quadrant Model

To visualise the outcome of surgery, a Four Quadrant Model was presented(de et al., 2021), based on ODI (functionality) 'success' scores (cut-off value of $\leq$24) and dichotomised Likert-scale 'perceived recovery' scores (cut-off value of $\geq$6) for impaired and non-impaired cases separately (Fig. 1a and b). This resulted in four quadrants: good outcome/Q1 (functional success based on the ODI as well as perceived recovery), poor outcome/Q4 (no functional success and no perceived recovery), and two intermediate outcome categories/Q 2 and 4 (Q 2: perceived recovery but no functional success and Q3: functional success but no perceived recovery). This method is applied to and compared between the impaired and non-impaired groups.

2.4. Statistical analysis

Data were analysed using IBM SPSS 24.0. All stenosis patients, regardless of whether they had degenerative spondylolisthesis, are grouped based on their HADS scores. They are either impaired cases, doubtful impaired cases, or non-impaired cases based on the scores from the anxiety questions and/or depression questions. When dichotomised, patients are grouped into impaired and non-impaired cases. Mean scores were compared with an Analysis of variance (ANOVA), and categorical data were compared using the Chi-square test (χ^2 test). A significance level of 0.05 was maintained when comparing the groups.

To examine the contribution of mental status to the success of the surgery, the ODI and the Likert scale will be plotted against each. First, the cohort is split into impaired and non-impaired cases by either a HADS-anxiety score of 8 or higher and/or a HADS-depression score of 8 or higher, followed by dividing the patients by the ODI cut-off value of 24 and the Likert scale cut-off value of 6. By doing so, four groups are formed: those with a "good outcome" with a favourable outcome on both the ODI and Likert scale, those with "intermediate outcomes" with either a favourable outcome on the ODI or Likert scale, and those with a "poor outcome" without a favourable outcome on either scale.

3. Results

3.1. Group characteristics

From the 450 questionnaires sent out, 33 were returned as undeliverable. A total number of 147 patients returned the questionnaires, resulting in a response score of 35%. Demographics are reported in Table 1; only the mean age of 74 years in the responders' group significantly differed from the mean age of 77 years in the whole group.

3.2. Hospital Anxiety and Depression Scale

Dividing the cohort into the three groups for anxiety and three groups for depression results in 13 anxiety cases, 11 borderline-anxiety cases, 123 non-anxiety cases, 11 depression cases, 13 borderline-depression cases, and 123 non-depression cases, with some overlap in (borderline) anxiety and depression cases (Table 2). If the cohort is divided into two groups, 32 impaired cases (HADS subscale score $\geq$8) (21.8%) and 115 non-impaired cases are present.

Considering the overlap between the six groups (three based on anxiety and three based on depression), we will continue with the two groups; impaired and non-impaired. The mean age in the impaired group was 74.5 $\pm$ 9.5 and in the non-impaired group 75.5 $\pm$ 9.4 ($p = 0.987$; Table 3).

3.3. Clinical outcome

The mean ODI score of the impaired and non-impaired cases is 42.46 $\pm$ 16.24 and 18.48 $\pm$ 18.25, respectively ($p < 0.001$; Table 4). The impaired cases demonstrate 'ODI-success' in 12.5% of patients, and the

Table 1
Baseline characteristics.

	Responder (n = 147)	Population (n = 796)	p-value
Mean age (SD)	74(±9.5)	77(±10.6)	**.001**
Male (%)	69 (46.9%)	383 (48.1%)	0.793
Level of stenosis			**.000**
L1-L2	0	5 (0.6%)	
L2-L3	6 (4.1%)	31 (3.9%)	
L3-L4	20 (13.6%)	112 (14.1%)	
L4-L5	79 (53.7%)	366 (46.0%)	
L5-S1	5 (3.4%)	45 (5.7%)	
Multi-Level	31 (21.1%)	237 (29.8%)	
Unknown	6 (4.1%)	0 (0.0%)	
Grade			0.415
Grade 1	72 (100%)	181 (97.8%)	
Grade 2	0	4 (2.2%)	
Satisfied (%)	111 (75.5%)	620 (77.9%)	0.839
Reoperation (%)	21 (14.3%)[a]	105 (13.2%)	0.720
Same level (%)	10 (47.6%)	52 (49.5)	0.080
Unstable	0	1 (1.0%)	
Persistent pain	5 (23.8%)	29 (27.9%)	
Recurrent pain	5 (23.8%)	23 (22.1%)	
Different level (%)	10 (47.6%)	53 (50.5%)	
Persistent pain	2 (1.4%)	33 (4.1%)	
Recurrent pain on different level	7 (33.3%)	14 (13.5%)	
Not specified	2 (9.5%)	0	

[a] 1 missing level of reoperation. Statistical significance ($p < 0.05$, two-tailed) presented in bold.

Table 2
Overlap in HADS-Anxiety and HADS-Depression cases.

	Non-cases	Borderline cases	Abnormal cases
Anxiety (n)	123	11	13
Depression: Non-case (n)	115	5	3
Borderline case (n)	6	3	4
Abnormal case (n)	2	3	6
Depression (*missing = 6)* (n)	N = 123	N = 13	N = 11
Depression: Non-case (n)	115	6	2
Borderline case (n)	5	3	3
Abnormal case (n)	3	4	6

The distribution of anxiety or depression scores, crosstabulated by each other. Cases are presented by their scores: non-cases (score 1–7), borderline cases (score of 8–10), and abnormal cases (score of >10).

Table 3
Patient characteristics among impaired and non-impaired cases.

	Impaired (n = 32)	Non-impaired (n = 115)	p-value
Age (yr)	74.5 ± 9.5	75.5 ± 9.4	0.987
Gender (F/M)	22/10	56/59	**.044**

Age and gender distribution among patients classified as impaired and non-impaired patients, based on their HADS. Score ≥8 on either the anxiety or depression scale. Statistical significance ($p < 0.05$, two-tailed) presented in bold.

non-impaired cases show 'ODI-success' in 66.4% ($p < 0.001$).

Comparing the ODI scores between the three HADS-anxiety and HADS-depression groups leads to the following outcomes; the anxiety cases had a higher ODI score (40.59 ± 14.26) as well as the borderline (45.90 ± 15.90) compared with the non-cases (19.95 ± 19.15; $p < 0.001$; Table 7a). Two anxiety cases and one borderline-anxiety case scored 'ODI-success', in contrast to 45 non-anxiety cases ($p < 0.001$). A comparable trend is demonstrated in the HADS-depression groups. The depression cases had a higher ODI score (51.09 ± 12.54) as well as the borderline cases (37.57 ± 16.68) compared with the non-cases (19.81 ± 18.76; $p < 0.001$; Table 7b). When the ODI is dichotomised by the cut-off value of 24 for success, none of the depression cases scores successfully compared with 2 of the borderline-depression cases and 77 of the non-cases ($p < 0.001$).

Table 4
The Patient Reported Outcome Measurements for impaired and non-impaired cases.

	Impaired cases N = 32	Non-impaired cases N = 115	P-value
ODI[a]	42.46 ± 16.24	18.48 ± 18.25	**<.001**
ODI ≤24 (%)	4 (12.5)	75 (66.4)	**<.001**
ODI >24 (%)	28 (87.5)	38 (33.6)	
EQ-5D[b]	0.546 ± 0.288	0.791 ± 0.222	**<.001**
EQ-5D ≤ 0.68 (%)	19 (59.4)	17 (14.9)	**<.001**
EQ-5D > 0.68 (%)	13 (40.6)	97 (85.1)	
ZCQ-score[c]	64.87 ± 13.88	44.41 ± 16.92	**<.001**
Likert-scale[d]	4.03 ± 1.87	5.85 ± 1.57	**<.001**
Perceived recovery (%)	9 (29.0)	90 (78.3)	**<.001**

Patient reported outcome measurements are presented as mean scores with standard deviation.
Statistical significance ($p < 0.05$, two-tailed) presented in bold.
[a] ODI missing data: 2 non-impaired cases.
[b] EQ-5D missing data: 1 non-impaired case.
[c] ZCQ-score missing data: 1 impaired case and 10 non-impaired cases.
[d] Likert-scale and not perceived recovery missing data: 1 impaired case.

The mean EQ-5D score for the impaired cases is 0.546 ±, 0.288 whilst the non-impaired cases have a mean EQ-5D score of 0.791 ± 0.222 ($p < 0.001$; Table 4). By dichotomising the EQ-5D by a score of 0.68, 40.6% of impaired cases scored successfully versus 85.1% of non-impaired cases ($p < 0.001$).

When the HADS-anxiety and -depression are divided into three groups, similar trends are seen. The HADS-anxiety cases score worse on the EQ-5D (mean 0.439 ± 0.331) than the borderline anxiety cases (0.607 ± 0.255) and the non-anxiety cases (0.78 ± 0.224; $p < 0.001$; Table 7a). Again, the same accounts for the HADS-depression groups; The depression cases score worse (0.446 ± 0.277) than the borderline cases (0.597 ± 0.323) and the non-cases (0.779 ± 0.227, $p < 0.001$; Table 7b).

Perceived recovery is reported in 29.0% of the impaired cases and 78.3% of the non-impaired cases ($p < 0.001$). Perceived recovery in the HADS-anxiety group is reported in 15.4% of the cases, 36.4% of the borderline cases, and 76.2% of the non-cases ($p < 0.001$; Table 7a). Perceived recovery in the HADS-depression groups is reported in none of the cases, 30.8% of the borderline cases, and 77.2% of the non-cases ($p < 0.001$; Table 7b).

3.4. Cross table

When integrating the functional questionnaire (ODI) and the perceived recovery (Likert scale), a good outcome was achieved in 12.5% of the impaired cases compared with 58.4% of the non-impaired cases. The intermediate outcome was observed in 15.6% of the impaired cases and 27.5% of the non-impaired cases. A significantly larger proportion of poor outcomes was seen in the impaired cases (68.8%) compared with the non-impaired cases (13.9%; Table 5a and b, Fig. 1a and b).

When integrating the quality-of-life questionnaire (EQ-5D) with perceived recovery (Likert scale), significant differences in the quadrants are found in the non-impaired group (Table 6b). However, there are no significant differences between the quadrants in the impaired group; a good outcome is found in 15.6% of patients, an intermediate outcome is found in 32.5% of patients, and a poor outcome in 43.8% of patients (Table 6a). The difference between the two Cross Tables is significant, with a p-value of < 0.001 (Fig. 2a and b).

3.5. Reoperation

21 of the 147 (14%) patients had a second surgery. No significant

Table 5a
Cross Table of functional outcomes (ODI) integrated with perceived recovery (Likert-scale); impaired cases.

Likert-scale ≥6 N = 9[a]	Q 2: Intermediate 5 (15.6%)	Q 1: Good 4 (12.5%)
Likert-scale <6 N = 22[a]	Q 4: Poor 22 (68.8%)	Q 3: Intermediate 0
Impaired cases N = 32 p-value = **< .001**	ODI >24 N = 28	ODI ≤24 N = 4

Q1: Both functional (ODI) and perceived recovery (Likert) show a favourable outcome. Q2: Perceived recovery, but no favourable functional outcome. Q3: Not perceived recovery, but a favourable functional outcome. Q4: Neither measurement show favourable outcome. Statistical significance ($p < 0.05$, two-tailed) presented in bold.
[a] 1 Likert-scale outcome is missing (=3.1%).

Table 5b
Cross Table of functional outcomes (ODI) integrated with perceived recovery (Likert-scale); non-impaired cases.

Likert-scale ≥6 N = 90	Q 2: Intermediate 22 (19.1%)	Q 1:Good 66 (57.4%)
Likert-scale <6 N = 25	Q 4: Poor 16 (13.9%)	Q 3: Intermediate 9 (7.8%)
Non-impaired cases N = 115 p-value = **< .001**	ODI >24 N = 38[a]	ODI ≤24 N = 75[a]

Q1: Both functional (ODI) and perceived recovery (Likert) show a favourable outcome. Q2: Perceived recovery, but no favourable functional outcome. Q3: Not perceived recovery, but a favourable functional outcome. Q4: Neither measurement show favourable outcome.
Statistical significance ($p < 0.05$, two-tailed) presented in bold.
[a] 2 ODI outcomes are missing (=1.7%).

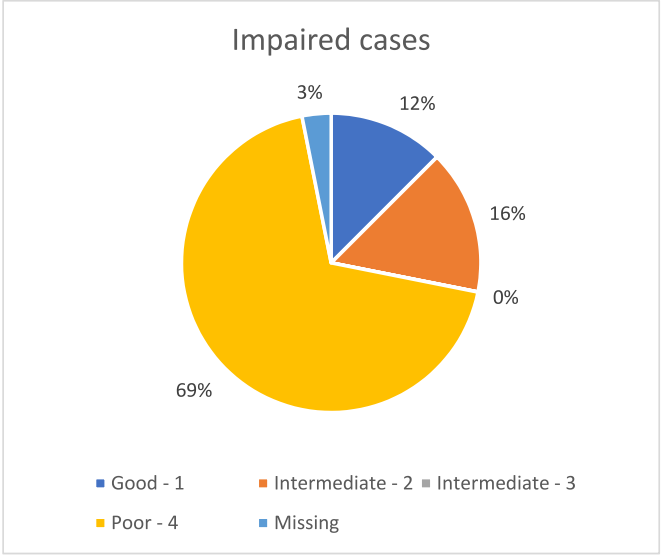

Fig. 1a. Four Quadrants Model of impaired cases. *Colour should be used in print.* Pie chart of impaired cases integrating functional outcome (ODI) with perceived recovery (Likert-scale). Good: Both functional (ODI) and perceived recovery (Likert) show a favourable outcome. Intermediate 2: Perceived recovery, but no favourable functional outcome. Intermediate 3: Not perceived recovery, but a favourable functional outcome. Poor: Neither measurement show favourable outcome. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

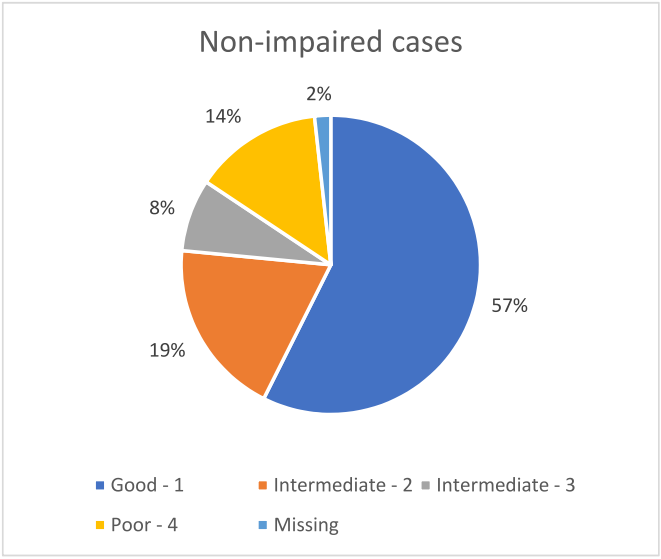

Fig. 1b. Four Quadrants Model of non-impaired cases. *Colour should be used in print.*
Pie chart of non-impaired cases integrating functional outcome (ODI) with perceived recovery (Likert-scale). Good: Both functional (ODI) and perceived recovery (Likert) show a favourable outcome. Intermediate 2: Perceived recovery, but no favourable functional outcome. Intermediate 3: Not perceived recovery, but a favourable functional outcome. Poor: Neither measurement show favourable outcome. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 6a
Cross Table of quality of life (EQ-5D) integrated with perceived recovery (Likert-scale); impaired cases.

Likert-scale ≥6 N = 9[a]	Q 2: Intermediate 4 (12.5%)	Q 1: Good 5 (15.6%)
Likert-scale <6 N = 22[a]	Q 4: Poor 14 (43.8%)	Q 3: Intermediate 8 (25%)
Impaired cases N = 32 p-value = 0.326	EQ-5D ≤ 0.68 N = 18	EQ-5D > 0.68 N = 13

Q1: Both quality of life (EQ-5D) and perceived recovery (Likert) show a favourable outcome. Q2: Perceived recovery, but no quality of life. Q3: Not perceived recovery, but a favourable quality of life. Q4: Neither measurement show favourable outcome.
Statistical significance ($p < 0.05$, two-tailed) presented in bold.
[a] 1 Likert-scale outcome is missing (=3.1%).

Table 6b
Cross Table of quality of life (EQ-5D) integrated with perceived recovery (Likert-scale); non-impaired cases.

Likert-scale ≥6 N = 89	Q 2: Intermediate 2 8 (7.0%)	Q 1: Good 81 (70.4%)
Likert-scale <6 N = 25	Q 4: Poor 9 (7.8%)	Q 3: Intermediate 16 (13.9%)
Non-impaired cases N = 115[a] p-value = **<.001**	EQ-5D ≤ 0.68 N = 17	EQ-5D > 0.68 N = 97

Q1: Both quality of life (EQ-5D) and perceived recovery (Likert) show a favourable outcome. Q2: Perceived recovery, but no quality of life. Q3: Not perceived recovery, but a favourable quality of life. Q4: Neither measurement show favourable outcome.
Statistical significance ($p < 0.05$, two-tailed) presented in bold.
[a]1 EQ-5D outcome is missing (=0.9%).

Table 7a
Patient Reported outcome measurements between HADS-Anxiety groups (ANOVA/chi-square).

	Non-cases	Borderline cases	Cases	P-value
	N = 123	N = 11	N = 13	
Mean ODI*	19.95 ± 19.15	45.90 ± 15.90	40.59 ± 14.26	**<.001**
ODI ≤24 (%)	76 (62.8)	1 (9.1)	2 (15.4)	**<.001**
ODI >24 (%)	45 (37.2)	10 (90.9)	11 (84.6)	
EQ-5D†	0.781 ± 0.224	0.607 ± 0.255	0.439 ± 0.331	**<.001**
EQ-5D ≤ 0.68 (%)	21 (17.2)	4 (36.4)	11 (84.6)	**<.001**
EQ-5D > 0.68 (%)	101 (82.8)	7 (63.6)	2 (15.4)	
ZCQ-score‡	45.94 ± 17.49	65.68 ± 12.47	63.68 ± 17.00	**<.001**
Likert-scale§	5.78 ± 1.60	4.27 ± 1.68	3.54 ± 2.07	**<.001**
Perceived recovery (%)	93 (76.2)	4 (36.4)	2 (15.4)	**<.001**

Statistical significance ($p < 0.05$, two-tailed) presented in bold.
*ODI missing; 2 non-cases.
†EQ-5D missing; 1 non-case.
‡ZCQ-score missing; 10 non-cases; 1 case.
§Likert-scale and perceived recovery missing; 1 non-case.

Table 7b
Patient Reported outcome measurements between HADS-Depression groups (ANOVA/Chi-square).

	Non-cases	Borderline cases	Cases	P-value
	N = 123	N = 13	N = 11	
Mean ODI *	19.81 ± 18.76	37.57 ± 16.86	51.09 ± 12.54	**<.001**
ODI ≤24 (%)	77 (63.6)	2 (15.4)	0	**<.001**
ODI >24 (%)	44 (36.4)	11 (84.6)	11 (100)	
EQ-5D †	0.779 ± 0.227	0.597 ± 0.323	0.446 ± 0.277	**<.001**
EQ-5D ≤ 0.68 (%)	21 (17.2)	6 (46.2)	9 (81.8)	**<.001**
EQ-5D > 0.68 (%)	101 (82.8)	7 (53.8)	2 (18.2)	
ZCQ-score‡	45.45 ± 17.04	63.39 ± 14.95	71.52 ± 11.53	**<.001**
Likert-scale§	5.84 ± 1.57	4.31 ± 1.89	2.70 ± 1.34	**<.001**
Perceived recovery (%)	95 (77.2)	4 (30.8)	0	**<.001**

Statistical significance ($p < 0.05$, two-tailed) presented in bold.
*ODI missing; 2 non-cases.
†EQ-5D missing; 1 non-case.
‡ZCQ-score missing; 10 non-cases; 1 case.
§Liker-scale and perceived recovery missing; 1 case.

differences in the distribution of the HADS groups were found between reoperated and non-reoperated patients (Table 8).

4. Discussion

The data presented in this study convincingly confirm the hypothesis that patients suffering from spinal stenosis symptoms and additionally being burdened by anxiety and/or depression are likely to demonstrate less favourable postoperative recovery. The outcome squares representation of results facilitates a clear insight into the differences between groups. This insight can be used as a basis for developing a prediction model in the future which can be used as a valuable tool in patients' counselling and surveillance.

This cohort study describes long-term outcomes after lumbar spinal stenosis surgery. The mean follow-up is nine years. In this Dutch population, 21.8% of patients reported feelings of depression and/or anxiety, which is higher than the 12.1% prevalence of anxiety and depression in the general Dutch population of 65 years or older (Breslau et al., 2021; van der et al., 2022). Do note that those percentages are obtained by different questionnaires than those used in our study, the Mental Health Index or Inventory, whilst we used the HADS. According to van der Velden et al. (van der et al., 2022), physical disease is a risk factor for anxiety and depression symptoms (aOR 1.51 (95% CI

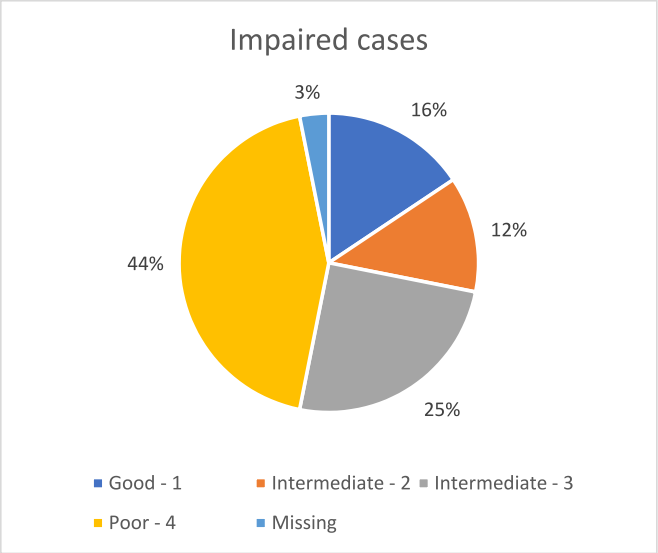

Fig. 2a. Four Quadrants Model of impaired cases. *Colour should be used in print.* Pie chart of impaired cases integrating quality of life (EQ-5D) with perceived recovery (Likert-scale). Good: Both quality of life (EQ-5D) and perceived recovery (Likert) show a favourable outcome. Intermediate 2: Perceived recovery, but no quality of life. Intermediate 3: Not perceived recovery, but a favourable quality of life. Poor: Neither measurement show favourable outcome. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

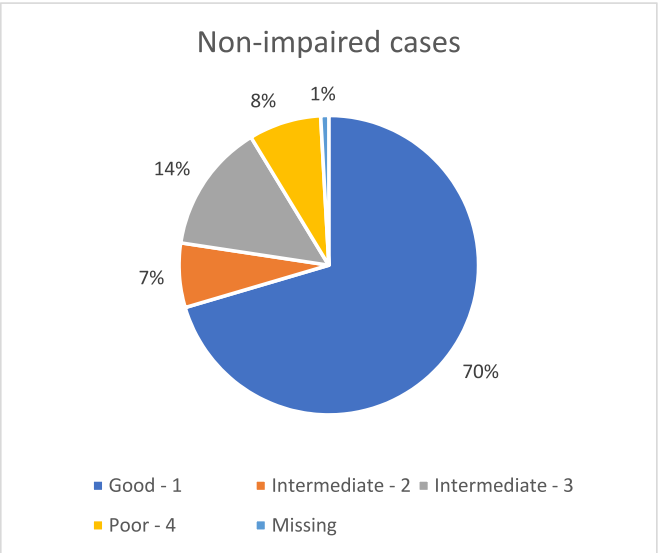

Fig. 2b. Four Quadrants Model of non-impaired cases. *Colour should be used in print.*
Pie chart of non-impaired cases integrating quality of life (EQ-5D) with perceived recovery (Likert-scale). Good: Both quality of life (EQ-5D) and perceived recovery (Likert) show a favourable outcome. Intermediate 2: Perceived recovery, but no quality of life. Intermediate 3: Not perceived recovery, but a favourable quality of life. Poor: Neither measurement show favourable outcome. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 8
Reoperation rates between HADS-Anxiety and HADS-depression groups (Chi-square).

	Reoperation (N = 21)	No reoperation (N = 126)	p-value
Anxiety			0.082
Non-cases	16 (13.0%)	107 (87.0%)	
Borderline cases	4 (36.4%)	7 (63.6%)	
Cases	1 (7.7%)	12 (92.3%)	
Depression			0.737
Non-cases	18 (14.6%)	105 (85.4%)	
Borderline cases	1 (7.7%)	12 (92.3%)	
Cases	2 (18.2%)	9 (81.8%)	

1.17–1.94; $p < 0.01$). This could explain the higher prevalence in our population and makes it even more important to acknowledge this silent problem amongst lumbar spinal stenosis and spondylolisthesis patients.

Kashlan et al. (2020) analysed the Quality Outcome Database for patients undergoing Meyerding 1-grade degenerative lumbar spondylolisthesis surgery in the United States. They have found a comparable prevalence of depressive and/or anxiety disorders (25.6%) in their population. Patients were divided into depressed and/or anxious based on the patient's medical record at the time of enrolment. Kashaln et al. described that preoperative depressed patients were significantly less likely to achieve an improvement of at least 20% in ODI at three months. This was not observed in the case of an anxiety disorder. However, at two years follow-up, there was no significant difference in the odds of achieving an improvement of at least 20% in ODI in the case of a depressive or anxiety disorder. Therefore, Kashlan et al. (2020) concluded that depressed patients take longer to achieve the goal of an improvement of at least 20% in ODI but do eventually get there. Even though depressed and/or anxious patients take longer to achieve an ODI of 20% less, according to Kashlan et al., a difference in functional outcomes remained. Our study demonstrates that this conclusion cannot be extended towards 'no difference' between depressed and/or anxious patients after nine years of follow-up.

Multiple studies and systematic reviews have been performed to define preoperative risk factors for unsatisfactory lumbar spinal stenosis surgery outcomes. McKillop et al.'s systematic review concluded that preoperative depression is likely a prognostic factor for dissatisfying postoperative lumbar spinal stenosis symptom severity and disability (McKillop et al., 2014). These findings align with the systematic review by Aalto et al. concluding that preoperative depression is associated with worse treatment satisfaction and more severe symptoms (Aalto et al., 2006). Yamamoto et al. demonstrated that not preoperative depression but anxiety was a significant prognostic factor for patient satisfaction in their multivariate analysis (Yamamoto et al., 2022). However, none of the aforementioned studies has addressed the long-term postoperative presence of anxiety or depressive status. In our study, we demonstrated that patients who report anxiety and/or depression in the follow-up after LSS surgery are significantly more dissatisfied with the surgical outcome in comparison to the non-anxious and/or depressed patients. This is in line with one-year postoperative results reported by Falavigna et al. (2015); postoperative patients who reported being depressed exhibited more dissatisfaction. Remarkably, Falavigna et al. also demonstrated that patients who did show depression before surgery but not after surgery had similar physical outcomes to patients without preoperative depression. These data arouse the assumption that lumbar stenosis patients' physical burden might be correlated to their psychological distress. In line, Wagner et al. (2020) reported that preoperative psychological distress improves after surgery, concluding that patients can significantly benefit physically and mentally from surgery. No analysis was performed on the correlation between the outcome of LSS surgery and psychological outcome—unfortunately, no factors to predict which depressed patients will recover and which will not were yielded.

Previous research has shown that the relationship between depression and functional outcome is most likely bidirectional; Falavigna et al. and Lebow et al. (2012) both concluded that some preoperative depressed patients returned to good mental health postoperatively, with a decline in the prevalence of depression (28.6%–17.6% (Falavigna et al., 2015)). However, with Falavigna's relatively short follow-up period of 1 year (compared with ours of 9 years), the question of "*what came first, the anxiety and/or depression or the physical problems*" remains. There is a possibility that patients report having fewer mental problems in the first year following their surgery because of the sudden relief of their pain and gain in functionality. Still, after that first year, their physical complaints return, as well as their psychological problems. Therefore, in developing a prediction model integrating anxiety and/or depression, long-term follow-up data seem to give more realistic outcome data.

The two-dimensional representation of the data gives a clear and straightforward insight into the outcome of surgery for depression/anxiety patients and those who are non-depressed/anxious. This is helpful in preoperative counselling of patients who want to be well-informed before undergoing LSS surgery. Eventually, we want to create a prediction model; a patient fills in a HADS questionnaire before surgery, and based on the score, it is obvious which of the four quadrants-figure applies to the patient's surgical outcome.

4.1. Limitations

Our study had some limitations. Firstly, there were no preoperative PROMs. Hence, we could not track PROM changes before and after surgery. However, the postoperative PROMs that we found correspond with the PROMs found in the literature(Forsth et al., 2016; Wagner et al., 2020). Secondly, this study has a response rate of 35%. This response rate is acceptable because a somewhat older study population is considered with a relatively long follow-up. It accurately represents the population of interest (Forsth et al., 2016).

5. Conclusion

Patients who underwent spinal stenosis surgery and report being depressed and/or anxious have significantly worse clinical outcomes nine years postoperatively. Therefore, the HADS is an important prognostic factor that can be used in patient counselling.

Sources of funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability

The data of this research is not available online.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. Dr. Vleggeert-Lankamp reports a relationship with Cervical Spine Research Society that includes: board membership and funding grants. Dr. Vleggeert-Lankamp reports a relationship with Netherlands Neurosurgical Society (NVvN) that includes: board membership. Dr. Vleggeert-Lankamp reports a relationship with EUROSPINE The Spine Society of Europe that includes: board membership. Dr. Vleggeert-Lankamp reports a relationshiigsp with Advisory Board Rijndam Rehabilitation that includes: consulting or advisory. Dr. Vleggeert-Lankamp reports a relationship with Covidien that includes: funding grants. Dr. Vleggeert-Lankamp reports a relationship with YM Fund that includes:

funding grants. Dr. Vleggeert-Lankamp reports a relationship with Achmea Health Insurance that includes: funding grants. Dr. Vleggeert-Lankamp reports a relationship with Nuvasive that includes: speaking and lecture fees. Dr. Vleggeert-Lankamp reports a relationship with Stryker Spine that includes: speaking and lecture fees. Dr. van Furth reports a relationship with Sella Therapies that includes: Co-Founder/CEO.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bas.2024.103902.

References

Aalto, T.J., Malmivaara, A., Kovacs, F., Herno, A., Alen, M., Salmi, L., et al., 2006. Preoperative predictors for postoperative clinical outcome in lumbar spinal stenosis: systematic review. Spine 31 (18), E648–E663.

Amundsen, T., Weber, H., Nordal, H.J., Magnaes, B., Abdelnoor, M., Lilleas, F., 2000. Lumbar spinal stenosis: conservative or surgical management?: a prospective 10-year study. Spine 25 (11), 1424–1435. ; discussion 35-6.

Andaloro, A., 2019. Lumbar spinal stenosis. Jaapa 32 (8), 49–50.

Austevoll, I.M., Gjestad, R., Grotle, M., Solberg, T., Brox, J.I., Hermansen, E., et al., 2019. Follow-up score, change score or percentage change score for determining clinical important outcome following surgery? An observational study from the Norwegian registry for Spine surgery evaluating patient reported outcome measures in lumbar spinal stenosis and lumbar degenerative spondylolisthesis. BMC Muscoskel. Disord. 20 (1), 31.

Bjelland, I., Dahl, A.A., Haug, T.T., Neckelmann, D., 2002. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. J. Psychosom. Res. 52 (2), 69–77.

Breslau, J., Finucane, M.L., Locker, A.R., Baird, M.D., Roth, E.A., Collins, R.L., 2021. A longitudinal study of psychological distress in the United States before and during the COVID-19 pandemic. Prev. Med. 143, 106362.

Choi, W.S., Oh, C.H., Ji, G.Y., Shin, S.C., Lee, J.B., Park, D.H., et al., 2014. Spinal canal morphology and clinical outcomes of microsurgical bilateral decompression via a unilateral approach for lumbar spinal canal stenosis. Eur. Spine J. 23 (5), 991–998 official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society.

de Vries, F., Lobatto, D.J., Verstegen, M.J.T., Schutte, P.J., Notting, I.C., Kruit, M.C., et al., 2021. Outcome squares integrating Efficacy and Safety, as applied to functioning Pituitary Adenoma surgery. The Journal of clinical endocrinology and metabolism 106 (9), e3300–e3311.

Deyo, R.A., Mirza, S.K., Martin, B.I., Kreuter, W., Goodman, D.C., Jarvik, J.G., 2010. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. JAMA 303 (13), 1259–1265.

Deyo, R.A., Martin, B.I., Kreuter, W., Jarvik, J.G., Angier, H., Mirza, S.K., 2011. Revision surgery following operations for lumbar stenosis. J. Bone Jt. Surg. Am. Vol. 93 (21), 1979–1986.

EuroQol–a new facility for the measurement of health-related quality of life. Health Pol. 16 (3), 1990, 199–208.

Fairbank, J.C., Pynsent, P.B., 2000. The Oswestry disability Index. Spine 25 (22), 2940–2952. ; discussion 52.

Falavigna, A., Righesso, O., Teles, A.R., Conzati, L.P., Bossardi, J.B., da Silva, P.G., et al., 2015. Responsiveness of depression and its influence on surgical outcomes of lumbar degenerative diseases. Eur. J. Orthop. Surg. Traumatol. 25 (Suppl. 1), S35–S41.

Forsth, P., Olafsson, G., Carlsson, T., Frost, A., Borgstrom, F., Fritzell, P., et al., 2016. A randomized, controlled trial of fusion surgery for lumbar spinal stenosis. N. Engl. J. Med. 374 (15), 1413–1423.

Ghogawala, Z., Dziura, J., Butler, W.E., Dai, F., Terrin, N., Magge, S.N., et al., 2016. Laminectomy plus fusion versus Laminectomy alone for lumbar spondylolisthesis. N. Engl. J. Med. 374 (15), 1424–1434.

Haig, A.J., Tomkins, C.C., 2010. Diagnosis and management of lumbar spinal stenosis. JAMA 303 (1), 71–72.

Jansson, K.A., Blomqvist, P., Granath, F., Nemeth, G., 2003. Spinal stenosis surgery in Sweden 1987-1999. Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 12 (5), 535–541.

Javalkar, V., Cardenas, R., Tawfik, T.A., Khan, I.R., Bollam, P., Banerjee, A.D., et al., 2011. Reoperations after surgery for lumbar spinal stenosis. World neurosurgery 75 (5–6), 737–742.

Kashlan, O., Swong, K., Alvi, M.A., Bisson, E.F., Mummaneni, P.V., Knightly, J., et al., 2020. Patients with a depressive and/or anxiety disorder can achieve optimum Long term outcomes after surgery for grade 1 spondylolisthesis: analysis from the quality outcomes database (QOD). Clin. Neurol. Neurosurg. 197, 106098.

Lad, S.P., Babu, R., Ugiliweneza, B., Patil, C.G., Boakye, M., 2014. Surgery for spinal stenosis: long-term reoperation rates, health care cost, and impact of instrumentation. Spine 39 (12), 978–987.

Lebow, R., Parker, S.L., Adogwa, O., Reig, A., Cheng, J., Bydon, A., et al., 2012. Microdiscectomy improves pain-associated depression, somatic anxiety, and mental well-being in patients with herniated lumbar disc. Neurosurgery 70 (2), 306–311. ; discussion 11.

M, M.V., K, M.V., Maae, S., de Wit, G.A., Prenger, R., E, A.S., 2016. Dutch tariff for the five-level version of EQ-5D. Value Health 19 (4), 343–352.

Malmivaara, A., Slatis, P., Heliovaara, M., Sainio, P., Kinnunen, H., Kankare, J., et al., 2007. Surgical or nonoperative treatment for lumbar spinal stenosis? A randomized controlled trial. Spine 32 (1), 1–8.

McKillop, A.B., Carroll, L.J., Battié, M.C., 2014. Depression as a prognostic factor of lumbar spinal stenosis: a systematic review. Spine J. : official journal of the North American Spine Society 14 (5), 837–846.

Parai, C., Hagg, O., Lind, B., Brisby, H., 2018. The value of patient global assessment in lumbar spine surgery: an evaluation based on more than 90,000 patients. Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 27 (3), 554–563.

Rampersaud, Y.R., Fisher, C., Yee, A., Dvorak, M.F., Finkelstein, J., Wai, E., et al., 2014. Health-related quality of life following decompression compared to decompression and fusion for degenerative lumbar spondylolisthesis: a Canadian multicentre study. Canadian journal of surgery Journal canadien de chirurgie 57 (4), E126–E133.

Sigmundsson, F.G., Jonsson, B., Stromqvist, B., 2017. Determinants of patient satisfaction after surgery for central spinal stenosis without concomitant spondylolisthesis: a register study of 5100 patients. Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 26 (2), 473–480.

Strömqvist, B., Fritzell, P., Hägg, O., Jönsson, B., Sandén, B., 2013. Swespine: the Swedish spine register : the 2012 report. Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 22 (4), 953–974.

Tonosu, J., Takeshita, K., Hara, N., Matsudaira, K., Kato, S., Masuda, K., et al., 2012. The normative score and the cut-off value of the Oswestry Disability Index (ODI). Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 21 (8), 1596–1602.

Ulrich, N.H., Burgstaller, J.M., Pichierri, G., Wertli, M.M., Farshad, M., Porchet, F., et al., 2017. Decompression surgery alone versus decompression plus fusion in symptomatic lumbar spinal stenosis: a Swiss prospective multicenter cohort study with 3 Years of follow-up. Spine 42 (18). E1077-e86.

van der Velden, P.G., Marchand, M., Das, M., Muffels, R., Bosmans, M., 2022. The prevalence, incidence, and risk factors of mental health problems and mental health service use before and 9 months after the COVID-19 outbreak among the general Dutch population. A 3-wave prospective study. PLoS One 17 (11), e0276834.

van Grafhorst, J.M.P., Dijkerman, M.L., Peul, W.C., Vleggeert-Lankamp, C.L.A., 2023. Symptomatic lumbar stenosis due to low-grade degenerative spondylolisthesis can effectively be treated with mere decompression. Acta Neurochirurgica 165 (8), 2145–2151.

Wagner, A., Shiban, Y., Wagner, C., Aftahy, K., Joerger, A.K., Meyer, B., et al., 2020. Psychological predictors of quality of life and functional outcome in patients undergoing elective surgery for degenerative lumbar spine disease. Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 29 (2), 349–359.

Weinstein, J.N., Tosteson, T.D., Lurie, J.D., Tosteson, A.N., Blood, E., Hanscom, B., et al., 2008. Surgical versus nonsurgical therapy for lumbar spinal stenosis. N. Engl. J. Med. 358 (8), 794–810.

Werner, D.A.T., Grotle, M., Gulati, S., Austevoll, I.M., Lonne, G., Nygaard, O.P., et al., 2017. Criteria for failure and worsening after surgery for lumbar disc herniation: a multicenter observational study based on data from the Norwegian Registry for Spine Surgery. Eur. Spine J. : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 26 (10), 2650–2659.

Witiw, C.D., Mansouri, A., Mathieu, F., Nassiri, F., Badhiwala, J.H., Fessler, R.G., 2018. Exploring the expectation-actuality discrepancy: a systematic review of the impact of preoperative expectations on satisfaction and patient reported outcomes in spinal surgery. Neurosurg. Rev. 41 (1), 19–30.

Yamamoto, Y., Kawakami, M., Minetama, M., Nakagawa, M., Teraguchi, M., Kagotani, R., et al., 2022. Psychological predictors of satisfaction after lumbar surgery for lumbar spinal stenosis. Asian spine journal 16 (2), 270–278.

Zigmond, A.S., Snaith, R.P., 1983. The hospital anxiety and depression scale. Acta Psychiatr. Scand. 67 (6), 361–370.