Depression is associated with poorer outcome of lumbar spinal stenosis surgery

Sanna Sinikallio · Timo Aalto · Olavi Airaksinen ·
Arto Herno · Heikki Kröger · Sakari Savolainen ·
Veli Turunen · Heimo Viinamäki

Received: 19 June 2006 / Revised: 9 February 2007 / Accepted: 20 February 2007 / Published online: 30 March 2007
© Springer-Verlag 2007

Abstract The objective of this observational prospective study was to investigate the effect of depression on short-term outcome after lumbar spinal stenosis (LSS) surgery. Surgery was performed on 99 patients with clinically and radiologically defined LSS, representing ordinary LSS patients treated at the secondary care level. They completed questionnaires before surgery and 3 months postoperatively. Depression was assessed with the 21-item Beck Depression Inventory (BDI). Physical functioning and pain were assessed with Oswestry disability index, Stucki Questionnaire, self-reported walking ability, visual analogue scale (VAS) and pain drawing. Preoperatively, 20% of the patients had depression. In logistic regression anal-

yses, significant associations were seen between preoperative depression and postoperative high Oswestry disability and Stucki severity scores and high intensity of pain (VAS score). In subsequent analyses, the patients with continuous depression, measured with BDI (60% of the patients who had preoperative depression), showed fewer improvements in symptom severity, disability score, pain intensity and walking capacity than the patients who did not experience depression at any phase. In those patients who recovered from depression, according to BDI-scores (35% of the patients with preoperative depression), the postoperative improvement was rather similar to the improvement seen in the normal mood group. In the surgical treatment of LSS, we recommend that the clinical practice should include an assessment of depression.

S. Sinikallio (✉)
Department of Rehabilitation (2981), Kuopio University
Hospital, Tarinan sairaala, 71800 Siilinjärvi, Finland
e-mail: sanna.sinikallio@kuh.fi

T. Aalto · O. Airaksinen · A. Herno
Department of Physical Medicine and Rehabilitation,
Kuopio University Hospital, Kuopio, Finland

H. Kröger · V. Turunen
Department of Surgery/Orthopaedics,
Kuopio University Hospital, Kuopio, Finland

H. Kröger
The Bone and Cartilage Research Unit,
Kuopio University, Kuopio, Finland

S. Savolainen
Department of Neurosurgery, Kuopio University Hospital,
Kuopio, Finland

H. Viinamäki
Department of Psychiatry,
Kuopio University and Kuopio University Hospital,
Kuopio, Finland

Keywords Lumbar spinal stenosis · Depression ·
Surgery · Short-term outcome

Introduction

Surgical treatment of lumbar spinal stenosis (LSS) is a treatment option for patients who remain severely symptomatic after a course of conservative treatment [18, 30]. The typical symptoms of LSS are low back pain, neurogenic claudication, radiating pain in the lower extremities, numbness and tingling in the legs during activity, leading to decreased walking capability and disability [18, 31].

Previous research has highlighted the importance of psychological factors in relation to outcome of surgical treatment of LSS. There are known to be several important psychological factors, e.g. presurgical psychological distress [4, 24], abnormal pain behaviour [13] and depression [14, 15, 19].

However, very few studies have collected prospective data to examine the relationship of depression and outcome of LSS surgery. In a 6 months' prospective follow-up study [15], baseline depression assessed with the Zung depression scale [33] was found to be associated with more postoperative pain. Also in a 6 months' [16] prospective follow-up study, preoperative depression measured with a 3-item scale was found to be associated with more severe symptoms, poorer walking capacity and less treatment satisfaction. In a 2 years' follow-up of the same sample [18], a high preoperative depression score was associated with poorer postoperative treatment satisfaction.

Nevertheless, none of these studies has assessed the course of depression during the postoperative phase. Furthermore, prior studies have not used any cut-off values for defining clinically significant depression among surgically treated LSS patients.

In short, the effects of depression on short-term postoperative surgery outcome are still relatively unknown. Therefore, the aim of this prospective study was to investigate the effect of depression, as measured by the Beck Depression Inventory (BDI) [2, 22], on short-term clinical outcome after LSS surgery.

Materials and methods

Patients

The study subjects were 102 patients with both clinically and radiologically defined lumbar spinal stenosis (LSS) selected for surgical treatment. At baseline, two of the study patients had missing BDI data. At the 3 months' follow-up, one of the 100 baseline patients had missing BDI data, thus the final sample size was 99 patients. The collection of sample has been described in detail elsewhere [25, 26].

Briefly, selection for surgery was made by the orthopaedist or neurosurgeon between October 2001 and October 2004 in Kuopio University Hospital, Finland. The inclusion criteria were: (1) presence of severe back, buttock, and/or lower extremity pain, with radiographic evidence (computed tomography, magnetic resonance imaging, myelography) of compression of the cauda equina or exiting nerve roots by degenerative changes (ligamentum flavum, facet joints, osteophytes and/or disc material). (2) The surgeon's clinical evaluation that the patient had degenerative lumbar spinal stenosis requiring operative treatment [17]. In addition, all patients had a history of ineffective responses to conservative treatment. According to preoperative interview and palpation of pulses of lower legs by the study physician (who did not

take part in the decisions for surgical treatment), 86% (88/102) of the patients of the total study population had neurogenic type claudication symptoms; 5% (5/102) had both neurogenic and vascular type claudication symptoms; one patient had claudication symptoms of vascular origin; the rest of the patients (8) had mixed leg and back symptoms.

A previous spine operation or co-existing disc herniation was not an exclusion criterion. Thirteen patients (out of 102 study patients) had previously undergone one or more lumbar spine operations. Of the 102 patients, 13 patients had preoperatively lumbar disc herniation, defined radiologically; 2 of these patients had had an earlier spine operation. The exclusion criteria were: emergency or urgent spinal operation precluding recruitment and protocol investigations; cognitive impairment prohibiting completion of the questionnaires or other failures in co-operation; presence of metallic particles in the body preventing the MRI-investigation. The surgeons sent the information of eligible patients to-be-operated to the Department of Physical and Rehabilitation Medicine, which organized the study.

The patients received an account of the study during their outpatient visit to the Department of Physical and Rehabilitation Medicine and provided informed consent. The study design was approved by the Ethics Committee of University of Kuopio and Kuopio University Hospital.

Questionnaires

Both at baseline and follow-up, questions about socio-demographic background (age, marital status, employment status), smoking habits and time since first back pain episode were included. Also questions concerning self-reported walking capacity and use of supportive belt were included. Somatic comorbidity was assessed with one modified item (item number 3) of the Work Ability Index (WAI) questionnaire [28]; the self-reported number of current or recurring somatic diseases diagnosed by a physician (range 0–49). The number of diseases was then recorded as a sum score. The musculoskeletal diseases (in addition to LSS) were: Pain and degeneration in the extremities (41%), cervical pain and degeneration (33%), disc herniation (13%), rheumatoid arthritis (3%). The concomitant circulatory diseases were: arterial hypertension (46%), coronary artery disease (17%), a history of myocardial infarction (7%) and cardiac insufficiency (4%). Also questions concerning self-reported walking capacity and use of a supportive belt were included. Data concerning previous lumbar spine operation was collected from anamnesis and medical charts.

Both baseline and 3 months follow-up questionnaire included the following items: a modified pain drawing [20]

to locate the pain and numbness (patients marked the sensations felt in various body parts on a schematic map of the body) with the map being divided into 100 cells (range 0–100). Overall back and leg pain intensity was assessed with a self-administered visual analogue scale (VAS) (range 0–100 mm). This has proved to be a valid index of experimental, clinical and chronic pain [21]. Subjective disability was measured by the validated Finnish version of Oswestry Disability Index (0–100%), where 0% represents no disability and 100% extreme debilitating disability [6, 7, 12]. The questionnaire devised by Stucki [27] assessed LSS related symptom severity, physical disability and postoperative satisfaction with higher scores indicating more LSS related problems. The questionnaire was translated into Finnish by one of the authors (TA) and a native English speaker checked the translation. There are currently no published validation studies using the Finnish version of the Stucki questionnaire. The questionnaire consists of three scales: (1) a seven question scale on symptom severity where all but one item had Likert response scales with five categories scored 1–5 (none; mild; moderate; severe; very severe). The score was calculated as an unweighted mean of all answered items. (2) A scale of physical disability where all but one item had Likert response scales with four categories (no, could not perform; yes, but always with pain; yes, but sometimes with pain; yes, comfortably). The score was calculated as an unweighted mean of all answered items. The possible range of scores was 1 to 4. (3) The scale for postoperative satisfaction was not analysed in this study. We have described the analyses of postoperative satisfaction in detail elsewhere (Sinikallio et al., *Disabil and Rehabil* 2007, in press).

Depression was assessed with the Finnish version of the 21-item BDI with scores ranging from 0 to 63 [2, 22]. The cut-off point for depression was set at 14/15, 0–14 indicating normal mood and 15 or more indicating depression, that is, elevated depressive symptoms. This cut-off point has been found to best indicate a major depression diagnosis in connection with the diagnostic SCID interview, among outpatients seeking treatment for depression, regardless of the phase of the major depressive disorder. Also the sensitivity (0.88), specificity (0.84) and the area under the ROC curve (0.93) have been found to be good with this cut-off point [32].

Statistical analyses

All statistical analyses were performed using SPSS/PC (version 12.0.1, SPSS, Chicago, IL, USA). Statistical methods included the *t* test for independent samples with continuous variables and the Mann–Whitney *U* test for continuous variables with a grossly nonnormal distribution.

Data distribution was tested against normality using the Kolmogorov–Smirnov Goodness-of-Fit test.

Multivariate logistic regression analyses (method enter) were used to assess the preoperative factors independently associated with poor surgery outcome at 3 months' follow-up. Specifically, we studied the risk factors for high Oswestry disability score ($\geq$ median (24): no/yes), high VAS score ($\geq$ median (14): no/yes), poor walking capacity ($<$ median (2,000): no/yes) and high Stucki severity score ($\geq$ median (2.4): no/yes). The relevant background variables and baseline depression were included as predictors in the logistic regression models. In all, the following baseline variables were included: age (years), sex (male: no/yes), marital status (single: no/yes), somatic comorbidity ($\geq$ median (5): no/yes), previous lumbar spine operation (no/yes), Oswestry disability score ($\geq$ median (44): no/yes), VAS ($\geq$ median (61): no/yes), Stucki severity score ($\geq$ median (3.3): no/yes) and BDI score (continuous score). Though improving walking capacity is one of the main targets of LSS surgery, we also performed second logistic regression analyses including preoperative walking capacity ($<$ median (900): no/yes), in addition to the predictors shown in Table 2.

In further analyses, comparisons were made between groups of patients according to depression status: (1) the normal mood patients ($n = 79$) had normal mood (BDI-score ≤ 14) both at baseline and follow-up. (2) The patients with continuous depression ($n = 12$) were depressed (BDI-score ≥ 15) both at baseline and follow-up. (3) The recovered patients ($n = 7$) had depression (BDI-score ≥ 15) at baseline but not at follow-up. One patient was not included in the group analysis: he was depressed at follow-up but not at baseline, according to his BDI-scores.

Results

The background and baseline clinical characteristics of all the surgically treated lumbar spinal stenosis patients are presented in Table 1. In the logistic regression analyses, a high preoperative BDI score was associated independently with important clinical postoperative outcome assessments (Oswestry disability scores, Stucki severity scores, VAS scores). In addition, older age was associated with a high Oswestry score and with poorer walking capacity (Table 2). When adding preoperative walking capacity in the predictor list shown in Table 2, the results changed only slightly (all data not shown): preoperative depression predicted postoperative disability and symptom severity, as in the first regression model. A minor decrease of statistical significance was seen in preoperative BDI-score predicting postoperative pain (VAS score over median;

Table 1 Background and baseline clinical characteristics of the lumbar spinal stenosis patients

Variable	<i>n</i> = 99	Variable	<i>n</i> = 99
Age (years; mean (SD))	61.7 (11.2)	Stucki score (mean (SD))	
Male	60.0 (11.8)	Severity	3.3 (0.6)
Female	62.9 (10.6)	Disability	2.5 (0.5)
Sex: male (%)	42	Oswestry % (mean (SD))	43.7 (15.2)
Marital status, in relationship (married or co-habiting) (%)	66	VAS, mm (mean (SD))	32.8 (23.9)
Employment status, at work (%)	14	Walking capacity, m (mean (SD))	1,427.1 (1,802.9)
Current smoker (%)	21	Pain drawing (markings) (mean (SD))	22.6 (19.5)
Number of somatic diseases		Time since first back pain episode, years (mean (SD))	15.8 (13.9)
0–5 (%)	56.5		
6–11 (%)	41.3		
12–17 (%)	2.2		
Use of supportive belt (%)	24	BDI score (mean(SD))	10.2(6.0)
		Depressed (%)	20

Table 2 Logistic regression models showing odds ratios (with 95% confidence intervals) of baseline factors predicting outcome variables at 3 months' follow-up

Baseline factor	Osw $\geq$ median (24):no/yes	VAS $\geq$ median (14):no/yes	Stucki severity $\geq$ median (2.4):no/yes	Walking capacity < median (2,000): no/yes
Age (years)	1.06 ^a (1.00–1.13 ^b)*	0.98 (0.94–1.03)	1.03 (0.98–1.09)	1.07 (1.01–1.13)*
Sex (male: no/yes)	1.38 (0.46–4.10)	1.66 (0.61–4.47)	1.51 (0.53–4.30)	1.66 (0.58–4.73)
Single (no/yes)	1.52 (0.45–5.14)	1.35 (0.45–4.00)	1.40 (0.42–4.65)	1.99 (0.64–6.18)
Somatic comorbidity ($\geq$ median (5): no/yes)	1.67 (0.55–5.02)	0.73 (0.25–2.16)	1.02 (0.34–3.11)	2.02 (0.69–5.88)
Previous lumbar spine operation: (no/yes)	1.31 (0.19–9.20)	3.67 (0.59–22.92)	6.93 (0.63–75.96)	4.45 (0.69–28.90)
Osw $\geq$ median (44):no/yes	1.29 (0.34–4.96)	2.33 (0.65–8.31)	0.54 (0.14–2.17)	1.27 (0.34–4.80)
VAS $\geq$ median (61):no/yes	2.10 (0.57–7.68)	1.95 (0.58–6.55)	2.53 (0.70–9.17)	1.12 (0.32–3.95)
Stucki severity $\geq$ median (3.3):no/yes	2.06 (0.61–7.00)	0.66 (0.20–2.17)	2.93 (0.87–9.86)	1.87 (0.56–6.22)
Depression (continuous BDI score)	1.19 (1.05–1.36)**	1.13 (1.00–1.27)*	1.16 (1.02–1.31)*	1.06 (0.95–1.19)

* $P < 0.05$, ** $P < 0.01$ ^a Odds ratio^b Confidence interval

OR 1.13; 95% CI 1.00–1.27; $P = 0.05$). Preoperative walking capacity (<median (900): no/yes) predicted only postoperative walking capacity in the second regression model (OR 12.56; 95% CI 2.30–52.62; $P < 0.05$). As for other significant associations, higher age predicted postoperative disability, as in the first regression model. Finally, as a new result, previous lumbar spine operation predicted poorer postoperative walking capacity (walking capacity less than median; OR 8.71; 95% CI 1.02–74.13; $P < 0.05$) in the second model. No other significant associations emerged.

In further analyses, we studied specifically the effect of depression status on postoperative improvement on all of the clinical variables (Table 3). The patients with

continuous depression, according to their BDI scores, showed postoperatively poorer improvement in symptom severity, and fewer improvements in disability score, pain intensity and walking capacity variables than the patients who did not have depression at any phase. Importantly, in those patients who recovered from depression, according to BDI scores, the postoperative improvement was rather similar to the improvement seen in the normal mood group.

It is noteworthy that only one (8%) of the 12 patients who had continuous depression had used antidepressant medication before surgery. Of the seven patients whose depression had recovered at follow-up, only one patient (14%) had used antidepressant medication at baseline.

Table 3 Clinical characteristics and changes of scores from baseline to follow-up among surgically treated lumbar spinal stenosis patients in relation to depression status

Variable	Normal mood ^a (<i>n</i> = 79)	Continuous depression ^b (<i>n</i> = 12)	Depression recovered ^c (<i>n</i> = 7)
<i>Stucki score</i>			
<i>Severity (median(IQR^d))</i>			
At baseline	3.30 (2.98–3.70)	3.50 (3.18–4.00)	3.3 (3.00–3.70)
At follow-up	2.30 (1.90–2.70)	3.10 (2.60–3.30)	2.60 (2.4–2.9)
Change	1.00 (0.50–1.40)	0.40 (0.00–1.00)* ^e	0.70 (0.20–1.43)
95% CI ^f for mean	0.85–1.13	0.16–0.82	0.26–1.26
<i>Stucki score</i>			
<i>Disability (mean(SD))</i>			
At baseline	2.46 (0.48)	2.80 (0.34)	2.43 (0.50)
At follow-up	1.77 (0.55)	2.30 (0.56)	1.77 (0.44)
Change	0.69 (0.59)	0.50 (0.52)	0.66 (0.64)
95% CI for mean	0.57–0.83	0.23–0.90	0.07–1.25
<i>Oswestry % (mean (SD))</i>			
At baseline	41.19 (15.03)	56.13 (11.24)	46.79 (9.90)
At follow-up	23.42 (16.89)	48.33 (17.60)	29.86 (18.57)
Change	17.77 (13.94)	7.79 (14.74)*	16.92 (21.64)
95% CI for Mean	14.83–21.27	–2.22 to 18.49	–3.08 to 36.94
<i>Pain drawing; markings (median (IQR))</i>			
At baseline	16.00 (11.00–28.50)	24.00 (20.25–42.25)	9.00 (4.00–23.00)
At follow-up	11.47 (4.00–14.00)	16.00 (9.00–34.75)	5.00 (4.00–16.00)
Change	4.53 (2.00–15.25)	8.00 (1.25–23.00)	4.00 (0.00–14.00)
95% CI for mean	6.35–12.46	–2.83 to 22.10	–1.15 to 12.00
<i>VAS; millimetres (mean(SD))</i>			
At baseline	31.14 (23.81)	40.17 (23.38)	36.86 (27.14)
At follow-up	17.25 (21.36)	32.25 (27.48)	18.29 (15.86)
Change	13.89 (24.43)	7.92 (28.93)*	18.57 (25.36)
95% CI for mean	8.41–19.36	–10.47 to 26.30	–4.88 to 42.02
<i>Walking capacity; meters (mean(SD))</i>			
At baseline	1,498.66 (1,942.95)	1,022.50 (904.37)	1,514.29 (1,335.95)
At follow-up	5,136.94 (22,332.02)	1,400.00 (1,373.12)	1,528.57 (1,142.68)
Change	3,838.28 (1,373.12)	377.50 (1,299.33)*	14.29 (1,165.37)*
95% CI for mean	–1,133.12 to 8,410.28	–1,281.47 to 548.74	–1,063.50 to 1,092.08
<i>Beck Depression Inventory (BDI) score (mean(SD))</i>			
At baseline	7.92 (3.73)	20.50 (5.81)	17.14 (2.19)
At follow-up	6.04 (4.13)	18.83 (3.33)	10.71 (2.56)
Change	–1.89 (3.74)	–1.66 (5.37)	–6.43 (4.04)**
95% CI for mean	1.25–2.91	–1.01 to 5.74	2.69–10.16

^a Normal mood (BDI-score ≤ 14) both at baseline and follow-up^b Depressed (BDI-score ≥ 15) both at baseline and follow-up^c Depression (BDI-score ≥ 15) at baseline but not at follow-up^d Interquartile range^e *t* test/Mann–Whitney *U* test for two independent groups of observations, comparing means of change of scores between the depression status group [continuous depression (*n* = 12)/recovered (*n* = 7)] with the normal mood group (*n* = 79)^f Confidence interval**P* < 0.05, ***P* < 0.01

Discussion

The first important result of this study is that preoperative depression was significantly associated with postoperative disability and pain among surgically treated LSS patients. In the logistic regression analyses, independent associations were seen between preoperative high depression scores and postoperative high Oswestry disability and Stucki severity scores and high intensity of overall back and leg pain (VAS-score).

Secondly, in further analyses concentrating on depression status and postoperative improvement, several interesting results emerged: the patients with continuous depression (60% of the patients who had preoperative depression) showed poorer postoperative improvement in many variables, i.e. symptom severity, disability score, pain intensity and walking capacity compared to the patients who did not have depression at any phase. It is clinically important that in the patient group who had recovered from depression (35% of the patients with preoperative depression), the relief from depression was associated with an improvement in the majority of the clinical variables. In fact, the postoperative improvement result resembled in all essential respects the same functional and pain related improvement seen in the normal mood group. One can conclude that the patients who did not exhibit depression at any phase reported clear functional and pain related improvement at 3 months' follow-up, whereas the depressed patients showed significantly poorer postoperative improvement. We are not aware of any prior prospective studies with a comparable design reporting similar results. However, whether the recovery of depression was accompanied by a clinical improvement or whether a clinical improvement was accompanied by a recovery of depression, remains a question for future intervention studies, since causal inferences are not possible on the basis of this observational study.

The patients in the continuous depression group had fairly high BDI scores both at baseline and follow-up. Thus, from a clinical point of view, these patients do report clearly elevated depressive symptoms. Looking at the recovered patients' BDI score decrease (−37.5%), one can conclude that an alleviation of depressive symptoms had occurred. The BDI-21 has been criticized for overestimating depression in patients with chronic pain, due to the overlap of somatic-vegetative symptoms of depression and patients' medical and physical conditions [5, 11, 29]. However, the BDI cut-off (14/15) that we used is higher than the cut-off (9/10) originally proposed by Beck and Beamesderfer [3] to be used with medical patients. In addition, the usefulness of the BDI-21 as a tool for assessing depression in patients suffering from chronic pain [11] and chronic low back pain has been established [23].

The mean decrease of the BDI score (−37.5%) in the recovered patients group is clinically noteworthy, particularly with respect to the typical reduction of 50%, considered a treatment goal in depression [8]. However, future intervention studies are needed to investigate whether the recovery of depression is attributable to the reduction of pain related and the functional disability or vice versa. As noted earlier, only one patient in the recovered depression group had used antidepressant medication prior to surgery. Thus, undertreatment of depression was found, at least with respect to the use of antidepressant drugs.

Furthermore, older age was predictive of high Oswestry disability score and of poorer walking capacity postoperatively, according to logistic regression analyses. However, we did not find any significant preoperative differences in age between the depressed patients and the patients with normal mood, as we reported earlier [25]. Rather, it seems that the accumulation of preoperative depression and older age predicts more short-term disability and poorer walking capacity. Previously, younger age has been found to be predictive of better postoperative walking ability in a 6 months' follow-up [15]. Generally, older age has not been found to predict poor clinical outcome in long-term studies [1, 10].

There are some limitations that must be recognized. As noted previously, the assessment of depression is based only on a self-rating instrument. Thus, some of those patients that we classified as depressed might not have received a psychiatric diagnosis, such as major depressive disorder or dysthymia. In addition, due to the small sample size, the risk of false negative findings (type II statistical error) cannot be ruled out. The subsamples of patients with continuous depression and of recovered patients are very small and thus the results need to be interpreted with caution. The follow-up period of 3 months may also be criticized. However, we believe that our results show clearly that the early detection of depression among postoperative LSS patients is important. We do not think that there would be any benefit gained by observing the LSS patients' clinical and functional recovery for longer periods of time, since clear disadvantages associated with depression were seen already in the short-term follow-up. Generally, the optimum functional gain is obtained within 3–6 months after LSS surgery [9]. A reasonable timeframe for postoperative improvement includes the patient returning to light work at 6 weeks and to heavy manual work at 3 months after surgery [9].

In terms of patient selection, we can conclude that due to our hospital districts referral practise, the study patients represent ordinary LSS patients treated operatively at the secondary care level, not merely the “worst off” LSS patients. Furthermore, the study patients had various somatic co-morbidities, as is often the case with clinical

samples. Therefore, caution must be exercised in the interpretation of the results. However, at this point, our results can be generalized, at least to surgically treated LSS patients receiving secondary care level treatment.

Conclusions

Our results suggest that in the search for optimal LSS surgery outcome, preoperative depression is a factor that needs to be recognized. Depression, measured with the BDI, predicted postoperative disability and pain among surgically treated LSS patients. In group comparisons, patients with continuous depression showed less postoperative improvement than the patients with normal mood. In those patients who recovered from depression, the postoperative improvement was rather similar to the clear improvement seen in the normal mood group. Among surgically treated LSS patients, the clinical practice recommendations should include an assessment of depression.

Acknowledgments We thank Ewen MacDonald, Ph.D. (University of Kuopio, Department of Pharmacology and Toxicology) for language checking. S. Sinikallio wishes to thank the Kuopio University Hospital for EVO research grant. The study design was reviewed and approved by the Ethics Committee of University of Kuopio and Kuopio University Hospital, Finland, and experiments were in compliance with Finnish law.

References

- Arinzon ZH, Fredman B, Zohar E, Shabat S, Feldman JS, Jedek R, Gepstein RJ (2003) Surgical management of spinal stenosis: a comparison of immediate and long term outcome in two geriatric patient populations. *Arch Gerontol Geriatr* 36:273–279
- Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J (1961) An inventory for measuring depression. *Arch Gen Psychiatry* 4:561–571
- Beck AT, Beamesderfer A (1974) Assessment of depression: the depression inventory. *Mod Probl Pharmacopsychiatry* 7:151–169
- DeGroot KI, Boeke S, van der Berge HJ, Duivenvoorden HJ, Bonke B, Passchier J (1997) The influence of psychological variables on postoperative anxiety and physical complaints in patients undergoing lumbar surgery. *Pain* 69:19–25
- Estlander AM, Takala EP, Verkasalo M (1995) Assessment of depression in chronic musculoskeletal pain patients. *Clin J Pain* 11:194–200
- Fairbank JC, Couper J, Davies JB, O'Brien JP (1980) The Oswestry low back pain disability questionnaire. *Physiotherapy* 66:271–273
- Fairbank JC, Pynsent PB (2000) The Oswestry disability index. *Spine* 25:2940–2953
- Frank E, Prien RF, Jarrett RB, Keller MB, Kupfer DJ, Lavori PW, Rush AJ, Weissman MM (1991) Conceptualization and rationale for consensus definitions of terms in major depressive disorder. Remission, recovery, relapse, and recurrence. *Arch Gen Psychiatry* 48:851–855
- Freeman BJC (2004) Laminectomy for spinal stenosis. In: Herkowitz HN, Dvorak J, Nordin M (eds) *The lumbar spine*. Lippincott Williams & Wilkins, Philadelphia, pp 501–508
- Galiano K, Obwegeser AA, Gabl MV, Bauer R, Twerdy K (2005) Long-term outcome of laminectomy for spinal stenosis in octogenarians. *Spine* 30:332–335
- Geisser ME, Roth RS, Robinson ME (1997) Assessing depression in persons with chronic pain using the Centre for Epidemiological Studies-Depression Scale and the Beck Depression Inventory. A comparative analysis. *Clin J Pain* 13:163–170
- Grönblad M, Hupli M, Wennerstrand P, Järvinen E, Lukinmaa A, Kouri JP, Karaharju EO (1993) Interrelations and re-test reliability of the pain disability index (PDI) and the Oswestry disability questionnaire (ODQ) and their correlation with pain intensity in low back pain patients. *Clin J Pain* 9:189–195
- Gunzburg R, Keller TS, Szpalski M, Vandeputte K, Spratt KF (2003) Clinical and psychofunctional measures of conservative decompression surgery for lumbar spinal stenosis: a prospective cohort study. *Eur Spine J* 12:197–204
- Herno A, Airaksinen O, Saari T (1993) The long-term prognosis after operation for lumbar spinal stenosis. *Scand J Rehabil Med* 25:167–171
- Iversen MD, Daltroy LH, Fossel AH, Katz JN (1998) The prognostic importance of patient pre-operative expectations of surgery for lumbar spinal stenosis. *Patient Educ Couns* 34:169–178
- Katz JN, Lipson SJ, Brick GW, Grobler LJ, Weinstein JN, Fossel AH, Lew RA, Liang MH (1995) Clinical correlates of patient satisfaction after laminectomy for degenerative lumbar spinal stenosis. *Spine* 15:1155–1160
- Katz JN, Lipson SJ, Lew RA, Grobler LJ, Weinstein JN, Brick GW, Fossel AH, Liang MH (1997) Lumbar laminectomy alone or with instrumented or noninstrumented arthrodesis in degenerative lumbar spinal stenosis. Patient selection, costs, and surgical outcomes. *Spine* 22:1123–1131
- Katz JN, Stucki G, Lipson SJ, Fossel AH, Grobler LJ, Weinstein JN (1999) Predictors of surgical outcome in degenerative lumbar spinal stenosis. *Spine* 24:2229–2233
- Levy HI, Hanscom B, Boden S (2002) Three-question depression screener used for lumbar disk herniations and spinal stenosis. *Spine* 27:1232–1236
- Margolis RB, Tait RC, Krause SJ (1986) Rating system for use with patient pain drawings. *Pain* 24:57–65
- Price DD, McGrath PA, Rafii A, Buckingham B (1983) The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. *Pain* 17:45–56
- Raitasalo R (1977) Depression and its association with the need for psychotherapy (book in Finnish). The Social Insurance Institute of Finland publications, Helsinki, A:13
- Rush AJ, Polatin P, Gatchel J (2000) Depression and chronic low back pain. *Spine* 25:2566–2571
- Schillberg M, Nystrom B (2000) Quality of life before and after microsurgical decompression in lumbar spinal stenosis. *J Spinal Disord* 13:237–241
- Sinikallio S, Aalto T, Airaksinen O, Herno A, Kröger H, Savolainen S, Turunen V, Viinamäki H (2006) Depression and associated factors in patients with lumbar spinal stenosis. *Disabil Rehabil* 28:415–422
- Sinikallio S, Aalto T, Airaksinen O, Herno A, Kröger H, Savolainen S, Turunen V, Viinamäki H (2006) Somatic comorbidity and younger age are associated with life dissatisfaction among patients with lumbar spinal stenosis before surgical treatment. *Eur Spine J* 15 [Epub ahead of print]
- Stucki G (1996) Measurement properties of a self-administered outcome measure in lumbar spinal stenosis. *Spine* 21:796–803
- Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A (1998) An approved version of the Work Ability Index. Occupational health series 19, Finnish Institute of Occupational Health, Helsinki

29. Turk D, Okifuji A (1994) Detecting depression in chronic pain patients: adequacy of self-reports. *Behav Res Ther* 32:9–16
30. Turner JA, Ersek M, Herron L, Deyo R (1992) Surgery for lumbar spinal stenosis. Attempted meta-analysis of the literature. *Spine* 17:1–8
31. Verbiest H (1954) A radicular syndrome from developmental narrowing of the lumbar vertebral canal. *J Bone Joint Surg Br* 36:230–237
32. Viinamäki H, Tanskanen A, Honkalampi K, Koivumaa-Honkanen HT, Haatainen K, Kaustio O, Hintikka J (2004) Is the Beck Depression Inventory suitable for screening major depression in different phases of the disease? *Nord J Psychiatry* 58:49–53
33. Zung WKK (1967) Depression in the normal aged. *Psychometrics* 8:287–292