Pain During Sex Before and After Surgery for Lumbar Disc Herniation

A Multicenter Observational Study

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Study Design. Observational multicenter study. 
Objective. The aim of this study was to evaluate changes in pain during sexual activity after surgery for lumbar disc herniation (LDH).
Summary of Background Data. There are limited data available on sexual function in patients undergoing surgery for LDH.
Methods. Data were retrieved from the Norwegian Registry for Spine Surgery. The primary outcome was change in pain during sexual activity at one year, assessed by item number eight of the Oswestry disability index (ODI) questionnaire. Secondary outcome measures included ODI, EuroQol-5D (EQ-5D), and numeric rating scale (NRS) scores for back and leg pain.

Results. Among the 18,529 patients included, 12,103 (64.8%) completed 1-year follow-up. At baseline, 16,729 patients (90.3%) provided information about pain during sexual activity, whereas 11,130 (92.0%) among those with complete follow-up completed this item. Preoperatively 2586 of 16,729 patients (15.5%) reported that pain did not affect sexual activity and at 1 year, 7251 of 11,130 patients (65.1%) reported a normal sex-life without pain. Preoperatively, 2483 (14.8%) patients reported that pain prevented any sex-life, compared to 190 patients (1.7%) at 1 year. At baseline, 14,143 of 16,729 patients (84.5%) reported that sexual activity caused pain, and among these 7232 of 10,509 responders (68.8%) reported an improvement at 1 year. A multivariable regression analysis showed that having a life partner, college education, working until time of surgery, undergoing emergency surgery, and increasing ODI score were predictors of improvement in pain during sexual activity. Increasing age, tobacco smoking, increasing body mass index, comorbidity, back pain >12 months, previous spine surgery, surgery in two or more lumbar levels, and complications occurring within 3 months were negative predictors.

Conclusion. This study clearly demonstrates that a large proportion of patients undergoing surgery for LDH experienced an improvement in pain during sexual activity at 1 year.

Key words: back pain, improvement, lumbar disc herniation, observational study, pain related disability, sexual activity.

Level of Evidence: 2

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Lumbar disc herniation (LDH) is a common cause of lower back and radiating leg pain, and it is occasionally also associated with sensory and motor deficits. In most patients the natural course is favorable, and surgery is typically offered to patients with persistent pain despite conservative treatment, intractable pain, or acute serious paresis including cauda equina syndrome. LDH is a major contributor to the global burden of disease and remains the most frequent indication for spinal surgery. Further, degenerative lumbar spine conditions such as LDH represent a major economic burden for patients, families, and
society. LDH may greatly impact patients’ quality of life and functional level, including sexual health which is important for physiological well-being and relationships. Despite its fundamental role in human life, there are limited data available on sexual function and health in patients undergoing surgery for LDH.

The aim of this study was to evaluate improvement in pain during sexual activity after surgery for LDH using prospectively collected data from the Norwegian Registry for Spine Surgery (NORspine).

METHODS
Reporting is consistent with the strengthening the reporting of observational studies in epidemiology (STROBE) statement. The Regional Committee for Medical Research and Health Research Ethics in Central Norway approved the study (2016/840), and all participants provided written informed consent.

Study Population
NORspine is a comprehensive registry for quality control and research and currently includes all forty centers performing spinal surgery in Norway. Approximately, 70% of all patients who undergo lumbar spine surgery in Norway are included in NORspine. Patients were eligible if they had a primary diagnosis of LDH and underwent either lumbar microdiscectomy or open lumbar discectomy between 2007 and 2017. Participation in the registration by patients was not mandated, nor was participation required for a patient to gain access to health care.

Surgical Procedures
Variations in the surgical management and surgical procedures can only be described in general terms and in accordance with the data available in NORspine. Microsurgical discectomy involves preoperative fluoroscopy for detection of the target level, paramedian or median skin incision of about 3 to 4 cm, opening of the paravertebral muscular fascia, and subperiosteal release of the paravertebral musculature from the spinous process and lamina above and below the target level, paramedian or median skin incision of about 3 to 4 cm, opening of the paravertebral muscular fascia, and subperiosteal release of the paravertebral musculature from the spinous process and lamina above and below the target disc-level. Self-retaining retractors are introduced and a microscope or loupes are utilized. In most cases a flavectomy and limited arctomy of the lamina above the disc level are done. Careful mobilization of the nerve-root medially is performed before evacuating the herniated disc. Evacuation might involve entering the disc space, or just removing a free sequestrated disc fragment. The traditional open discectomy was performed without visual enhancement and typically requires a larger incision and more soft tissue exposure.

Outcome Measures
The primary outcome was change in item no. 8 of the Oswestry disability index (ODI) version 2.0. Item no. 8 contains the following response alternatives:

0p My sex life is normal but causes no extra pain.
1p My sex life is normal but causes some extra pain.
2p My sex life is nearly normal but is very painful.
3p My sex life is severely restricted by pain.
4p My sex life is nearly absent because of pain.
5p Pain prevents any sex life at all.

Secondary outcome measures were change in disease-specific functional outcome between baseline and 1-year follow-up was measured with the ODI which has been translated into Norwegian and tested for psychometric properties. The ODI questionnaire is used to quantify disability for degenerative conditions of the lumbar spine and covers intensity of pain, ability to lift, ability to care for oneself, ability to walk, ability to sit, sexual function, ability to stand, social life, sleep quality, and ability to travel. For each topic, there are 6 statements describing potential scenarios. The index is scored from 0 to 100 (no disability to 100 bedridden). Both ODI raw score and ODI percentage change can be used to define a successful outcome 12 months after surgery with high accuracy.

Changes in generic health-related quality of life were measured with the Euro-Qol-5D 3L (EQ-5D) between baseline and 1-year follow-up. EQ-5D contains a short descriptive system questionnaire and a visual analogue scale (EQ VAS) which provides a simple descriptive profile of the respondent’s health state. The EQ VAS records the respondent’s overall current health on a vertical visual analogue scale, where the endpoints are labeled “The best health you can imagine” and “The worst health you can imagine.” The Norwegian version of EQ-5D has shown good psychometric properties. Changes in low back pain and leg pain were measured with numeric rating scales (NRS).

Surgeons provided the following data on perioperative complications: unintentional durotomy, cardiovascular complications, respiratory complications, anaphylactic reactions, wrong level of surgery, and intraoperative hemorrhage requiring blood replacement or postoperative hematoma. Patients reported the following complications if occurring within 3 months of surgery: wound infection, urinary tract infection, micturition problems, pneumonia, pulmonary embolism, and deep vein thrombosis.

Data Collection
On admission for surgery (baseline) the patients completed a self-administered questionnaire, which included questions about demographics and personal characteristics (marital status, education, body mass index, and smoking) in addition to the outcome measures. Using a standard registration form, surgeons recorded data on diagnosis, comorbidity (including rheumatic diseases, hip or knee osteoarthritis, depression or anxiety, musculoskeletal pain, neurological disorder, cerebrovascular disease, cardiovascular disease, vascular claudication, lung disease, cancer, osteoporosis, hypertension, endocrine disorders), American Society of Anesthesiologists (ASA) grade, image findings, surgical procedure, and complications. The NORspine registry distributed self-administered questionnaires to the patients by mail 3 and 12 months after surgery, without involving the treating hospitals. Nonresponders received one reminder with a new copy of the questionnaire.
Statistical Analysis
All statistical analyses were performed with SPSS version 26.0 (IBM Corporation). For statistical comparison tests, we defined the significance level as \( P \leq 0.05 \). Frequencies were used for demographic variables at baseline, and changes in ODI, EQ-5D, and NRS from baseline to 1-year scores were compared with paired sample \( t \) test. For correlation between EQ-5D VAS and changes in sexual function at 1 year, we used paired sample \( t \) test with Spearman correlation procedure. A multivariable logistic regression analysis was performed to identify patient and treatment characteristics that could be associated with improvement in pain during sexual activity at 1 year.

Missing Data
Mixed linear model analyses were used for handling missing data on outcome variables. This was in line with previous studies showing that imputations are not needed before performing a mixed model analysis on longitudinal data.\(^\text{17}\) In the mixed model, patients were not excluded from the analysis if a variable was missing at some, but not all, time points after baseline.

RESULTS
A total of 18,529 patients were included in our study, and 12,103 (64.8%) completed 1-year follow-up. At baseline, 16,729 patients (90.3%) completed item no. 8 about sexual activity in the ODI, whereas 11,130 (92.0%) among those with complete 1-year follow-up answered this question. Baseline characteristics and information on surgical treatment and events are presented in Table 1. The mean age at baseline was 46.8 (± 14.0) years and 41.3% were women.

Primary Outcome
Figure 1 demonstrates patient-reported pain during sexual activity at baseline and 1 year after surgery. At baseline, 2586 of 16,729 patients (15.5%) reported having a normal sex-life with no pain, and at 1 year, 7251 of 11,130 patients (65.1%) reported a normal sex-life without pain. Preoperatively, 2483 (14.8%) patients reported that pain prevented any sex-life, compared to 190 patients (1.7%) at 1 year. At baseline, 14,143 of 16,729 patients (84.5%) reported that sexual activity caused pain, and among these 7232 of 10,509 responders (68.8%) reported an improvement in pain during sexual activity at 1 year.

The multivariable analysis is presented in Table 2 and demonstrates that having a life partner (odds ratio [OR] 1.26, 95% confidence interval [CI] 1.05–1.51, \( P = 0.014 \)), college education (OR 1.26, 95% CI 1.08–1.45, \( P = 0.004 \)), currently working (OR 1.52, 95% CI 1.26–1.84, \( P < 0.001 \)), undergoing emergency surgery (OR 1.50, 95% CI 1.17–1.92, \( P < 0.001 \)), and increasing ODI score (OR 1.04, 95% CI 1.03–1.04, \( P < 0.001 \)) were independent predictors of improvement in pain during sexual activity.

Age (OR 0.99, 95% CI 0.99–1.00, \( P = 0.011 \)), tobacco smoking (OR 0.65, 95% CI 0.55–0.76, \( P < 0.001 \)), higher body mass index (OR 0.97, 95% CI 0.95–0.98, \( P < 0.001 \)), ASA Grade >2 (OR 0.76, 95% CI 0.56–1.04, \( P = 0.084 \)), back pain >12 months (OR 0.35, 95% CI 0.31–0.41, \( P < 0.001 \)), previous lumbar spine surgery (OR 0.72, 95% CI 0.34–0.96, \( P = 0.024 \)), previous surgery in the same level (OR

### Table 1. Characteristics for the Total Population (n = 18,529)

| Demographic Variables | N (%) or Mean (SD) |
|-----------------------|--------------------|
| Age, y                | 46.8 ± 14.0        |
| Female                | 7647 (41.3%)       |
| Married or partner    | 13,811/18,391 (75.1%) |
| Current tobacco smoker| 4962/18,374 (27.0%) |
| Education >12 years   | 6996/18,374 (38.1%) |
| Working               | 4111/18,007 (22.8%) |
| Body mass index       | 26.9 ± 4.4         |
| Comorbidity           | 5321/18,529 (28.7%) |
| ASA Grade >2          | 1051/18,292 (5.7%) |
| Back pain history     |                    |
| Absence of back pain  | 599/17,747 (3.4%)  |
| Back pain between 3 and 12 mo | 7820/17,747 (44.1%) |
| Back pain >12 mo      | 6398/17,747 (36.1%) |
| Radiculopathy history|                    |
| Absence of radiculopathy | 586/17,617 (3.3%) |
| Radiculopathy <3 mo   | 2843/17,617 (16.1%) |
| Radiculopathy between 3 and 12 mo | 7620/17,617 (43.3%) |
| Radiculopathy >12 mo  | 6275/17,617 (35.6%) |
| Previous lumbar spine surgery | 3509/18,363 (19.1%) |
| Previous surgery in the same level | 2396/18,529 (12.9%) |
| Indication of surgery |                    |
| Cauda equina syndrome | 216/18,529 (1.2%)  |
| Surgical treatments, complications, and events | |
| Perioperative complications | 419/18,529 (2.3%) |
| Unintentional duretomy | 309/18,529 (1.7%)  |
| Nerve injury          | 34/18,529 (0.2%)   |
| Blood replacement (transfusion), postoperative hematoma | 32/18,529 (0.2%) |
| Cardiovascular complica| tions | 8/18,529 (0.0%) |
| Respiratory complications | 5/18,529 (0.0%)  |
| Anaphylactic reaction | 10/18,529 (0.1%)   |
| Wrong-level surgery   | 32/18,529 (0.2%)   |
| Emergency surgery     | 3389/18,413 (18.4%) |
| Patient reported complications after hospital discharge (<3 months) | 982/12,758 (7.7%) |
| Wound infection       | 382/12,758 (3.0%)  |
| Urinary tract infection| 295/12,758 (2.3%) |
| Pneumonia             | 58/12,758 (0.5%)   |
| Pulmonary embolism    | 11/12,758 (0.1%)   |
| Deep venous thrombosis| 16/12,758 (0.1%)   |
| Urinary and/or fecal incontinence | 331/12,758 (2.6%) |
| Surgical procedure | |
| Microscope and/or surgical loupes | 17,095/18,529 (97.2%) |
| Levels of surgery ≥2  | 1075/18,529 (5.8%) |
| Level of surgery | |
| L2-L3                 | 421 (2.3%)         |
| L3-L4                 | 1748 (9.4%)        |
| L4-L5                 | 8960 (48.4%)       |
| L5-S1                 | 8375 (45.2%)       |
0.64, 95% CI 0.47–0.89, *P* = 0.008), surgery in two or more lumbar levels (OR 0.77, 95% CI 0.59–1.01, *P* = 0.060), and complications occurring within 3 months (OR 0.55, 95% CI, 0.43–0.70, *P* < 0.001) were predictors for less improvement of pain during sexual activity.

**Secondary Outcomes**

The overall outcomes for the total population are presented in Table 3. For the total study population, there were large and statistically significant improvements in all patient-reported outcome measures. The mean difference in EQ-5D at 1 year represents a clinically important change with an effect size of 1.39 (Cohen *d*). Mixed linear model analyses showed similar results for all patient-reported outcomes. As shown in Figure 2, there was a positive correlation (Spearman *rho* = 0.646, *P* < 0.001) between pain during sexual activity at 1 year and perceived overall health status measured with the EQ-5D VAS score.

**DISCUSSION**

This study clearly demonstrates that a large proportion of patients undergoing surgery for LDH experience an improvement in pain during sexual activity at 1 year. Among those who reported pain during sexual activity before surgery, approximately 69% experienced an improvement at 1 year. There was also a large reduction in the number of patients who reported that pain prevented any sexual activity at all at the end of follow-up. Furthermore, there were large clinically important improvements in all patient-reported outcomes for the total study population at 1 year and few serious complications.

The baseline factors of having a partner, working until the time of surgery, higher preoperative ODI score, and higher education were associated with improvement in pain during sexual activity. Increasing preoperative back pain-related disability has also been identified as a strong predictor for improvement in other studies.18–20 Duration of back pain

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**TABLE 2. Multivariable Regression Analysis With Predictors of Improvement in Sexual Function 1 Year After Surgery (n = 7232/10509)**

| Variable                           | OR    | 95% CI          | *P*  |
|------------------------------------|-------|-----------------|------|
| Age                                | 0.99  | 0.99–1.0        | 0.011|
| Female                             | 0.90  | 0.78–1.05       | 0.166|
| Partner                            | 1.26  | 1.05–1.51       | 0.014|
| Current tobacco smoker             | 0.65  | 0.55–0.76       | <0.001|
| Education >12 y                    | 1.26  | 1.08–1.45       | 0.004|
| Body mass index                    | 0.97  | 0.95–0.98       | <0.001|
| Working                            | 1.52  | 1.26–1.84       | <0.001|
| ASA >2                             | 0.76  | 0.56–1.04       | 0.084|
| ODI Score Preoperative             | 1.04  | 1.03–1.04       | <0.001|
| Pain >12 mo                        | 0.35  | 0.31–0.41       | <0.001|
| Previous lumbar spine surgery      | 0.72  | 0.54–0.96       | 0.024|
| Previous surgery in the same level | 0.64  | 0.47–0.89       | 0.008|
| Levels of surgery ≥2               | 0.77  | 0.59–1.01       | 0.060|
| Perioperative complications         | 1.16  | 0.70–1.90       | 0.569|
| Complications after hospital discharge (<3 mo) | 0.55 | 0.43–0.70 | <0.001|
| Surgical microscope or loupes      | 1.11  | 0.84–1.39       | 0.546|
| Emergency surgery                  | 1.50  | 1.17–1.92       | 0.001|
| Cauda equina syndrome              | 1.17  | 0.47–2.91       | 0.740|

ASA indicates American Society of Anesthesiologists; CI, confidence interval; ODI, Oswestry Disability Index; OR, odds ratio.
exceeding 1 year before surgery seems to be a negative predictor for improvement in pain during sexual activity, adding to the evidence that chronic pain is associated with unfavorable outcomes and that timing of surgery is important.21–24 Tobacco smoking was also identified as a negative predictor, supporting the existing evidence that smoking is associated with inferior outcomes following surgery.25 Previous studies have shown that tobacco smokers are less likely to achieve clinically important improvement following surgery for lumbar spinal stenosis and LDH,20,26,27 and that smokers have an increased risk of postsurgical recurrent disc herniation.28 Our study cannot establish a definite causal relationship between daily tobacco smoking and lower treatment effects following microdiscectomy for LDH, and smoking may be a marker for other characteristics responsible for the association that are unadjusted for in the regression model. It is known that patient-reported quality of life is lower among smokers in a general population and it is possible that this may affect disease-specific questionnaires such as the ODI.29

Increasing age, serious comorbidity, and complications within 3 months were also identified as negative predictors. There is a wide range of factors that may impact sexual health with age,30 including comorbidity that can limit physical activity and contribute to pain during sexual activity. Furthermore, many common general medical disorders have negative effects on sexual health.31 Still, there is solid evidence supporting that both lumbar microdiscectomy and decompressive surgery for lumbar spinal stenosis can improve functional status and quality of life in selected elderly patients including those with comorbidity.32–34 That increasing body mass index was identified as a negative predictor for improvement in pain during sexual activity, adding to the evidence that chronic pain is associated with unfavorable outcomes and that timing of surgery is important.

### Table 3. Outcome variables at baseline and one year after surgery

| Outcome Variable (Complete Case Analysis) | Baseline—Mean (SD) | One Year—Mean (SD) | Mean Difference (95% CI) | P      |
|-------------------------------------------|--------------------|--------------------|--------------------------|--------|
| ODI (n = 11958)                           | 45.9 (19.0)        | 16.9 (16.5)        | 29.0 (28.6–29.4)         | <0.001 |
| EQ-5D (n = 10659)                         | 0.28 (0.36)        | 0.73 (0.28)        | -0.45 (-0.46 to -0.44)   | <0.001 |
| VAS (n = 10285)                           | 44.9 (21.8)        | 74.4 (21.7)        | -29.5 (-30.0 to -29.0)   | <0.001 |
| NRS Back pain (n = 11659)                | 6.3 (2.5)          | 3.0 (2.6)          | 3.3 (3.2–3.4)            | <0.001 |
| NRS Leg pain (n = 11665)                 | 6.9 (2.2)          | 2.5 (2.7)          | 4.5 (4.4–4.5)            | <0.001 |

| Outcome Variable (Mixed Linear Model Analysis) | Baseline—Mean (SD) | One year—Mean (SD) | Mean Difference (95% CI) | P      |
|-----------------------------------------------|--------------------|--------------------|--------------------------|--------|
| ODI (n = 18505)                               | 45.8 (18.9)        | 17.2 (19.5)        | 28.5 (28.2–28.9)         | <0.001 |
| EQ-5D (n = 18284)                             | 0.27 (0.41)        | 0.72 (0.41)        | -0.45 (-0.45 to -0.44)   | <0.001 |
| VAS (n = 18173)                               | 44.8 (22.1)        | 73.8 (26.8)        | -29.0 (-29.5 to -28.5)   | <0.001 |
| NRS Back pain (n = 18394)                    | 6.3 (2.4)          | 3.0 (3.1)          | 3.3 (3.2–3.3)            | <0.001 |
| NRS Leg pain (n = 18405)                     | 6.9 (2.2)          | 2.5 (3.3)          | 4.4 (4.4–4.5)            | <0.001 |

NRS indicates Numeric Rating Scale; ODI, Oswestry Disability Index; VAS, Visual Analog Scale.

Figure 2. Correlation between pain during sexual activity at 1 year after surgery and perceived overall health status measured with the EQ-5D VAS score. EQ-5D indicates EuroQol-5D; VAS, Visual Analog Scale.
predictor of improvement in pain during sexual activity might not come as a surprise as obesity has been linked to impairments in sexual quality of life.35,36

Reanalysis of data from a randomized trial comparing four different types of fusion surgery with nonsurgical management of chronic low back pain showed that patients who underwent surgery experienced less pain during sexual activity at 2 years’ follow-up.37 However, the improvement following anterior fusion was counteracted by disturbances of ejaculation and genital sensation in male patients and a trend toward disturbed orgasm and genital sensation in female patients. In a reanalysis of a trial comparing total disc replacement via an anterior retroperitoneal approach versus instrumented posterior lumbar fusion, similar improvement in pain during sexual activity was reported.38 However, impaired ability to achieve orgasm was more common in the posterior lumbar fusion group. With the role of fusion surgery under increasing scrutiny because of increased costs, risk of complications, and questionable added value compared to decompressive surgery alone,39–41 it is important to assess changes in sexual function following more common and less invasive spine procedures such as lumbar microdiscectomy.

We found a strong correlation between pain during sexual activity at one year and patients’ perceived overall health status (Figure 2). A recent study involving US adults showed that sexual health is in fact a highly important aspect in quality of life.6 Sexual health and function are multifaceted and not only limited to pain during sexual activity as we measured in our study.

Strengths and Limitations
The strengths of this study were the use of prospective registry data with high external validity and the large sample size. The main limitations of our study were the inability to capture other aspects of sexual health and function such as enjoyment, desire, genital sensation, ability to achieve orgasm and ejaculation. It is therefore especially difficult to assess changes in sexual function in the subgroup of patients with cauda equina syndrome. Furthermore, we do not know whether those patients who reported that pain did not limit sexual function, actually resumed an active sexual life or were limited by other factors. Loss to follow-up at 1 year is a concern, but a previous study on a similar population from NORspine showed no difference in outcomes between responders and nonresponders.42

CONCLUSION
This study clearly demonstrates that a large proportion of patients undergoing surgery for LDH experienced important improvement of pain during sexual activity at 1 year.

Key Points
☐ A large proportion of patients undergoing surgery for LDH experienced an improvement in pain during sexual activity at 1 year.

☐ Among those who reported pain during sexual activity before surgery, approximately 69% experienced an improvement at 1 year.

☐ The baseline factors of having a partner, working until the time of surgery, increasing back pain-related disability, and higher education were associated with improvement in pain during sexual activity.

☐ Increasing age, tobacco smoking, increasing body mass index, longer preoperative pain duration, previous spine surgery, multilevel surgery, and complications were negative predictors in terms of improvement in pain during sexual activity.

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References
1. Ropper AH, Zafonte RD. Sciatica. N Engl J Med 2015;372:1240–8.
2. Deyo RA, Mirza SK. CLINICAL PRACTICE. Herniated Lumbar Intervertebral Disk. N Engl J Med 2016;374:1763–72.
3. Hoy D, March L, Brooks P, et al. The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis 2014;73:968–74.
4. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet (London, England) 2017;390:1260–344.
5. van Tulder MW, Koes BW, Bouter LM. A cost-of-illness study of back pain in The Netherlands. Pain 1995;62:233–40.
6. Akbas NB, Dalbayrak S, Kulu D, et al. Assessment of sexual dysfunction before and after surgery for lumbar disc herniation. J Neurosurg Spine 2010;13:581–6.
7. Flynn KE, Lin L, Bruner DW, et al. Sexual satisfaction and the importance of sexual health to quality of life throughout the life course of U.S. Adults J Sex Med 2016;13:1642–50.
8. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet (London, England) 2007;370:1453–7.
9. Nerland US, Jakola AS, Solheim O, et al. Minimally invasive decompression versus open laminectomy for central stenosis of the lumbar spine: pragmatic comparative effectiveness study. BMJ 2015;350:h1603.
10. Arts MP, Brand R, van den Akker ME, et al. Tubular discectomy vs conventional microdiscectomy for sciatica: a randomized controlled trial. JAMA 2009;302:149–58.
11. Sorlie A, Gulati S, Giannadakis C, et al. Open discectomy vs microdiscectomy for lumbar disc herniation—a protocol for a pragmatic comparative effectiveness study. F1000Res 2016;5:2170.
12. Pochet F, Bartanusz V, Klenstueck FS, et al. Microdiscectomy compared with standard discectomy: an old problem revisited with new outcome measures within the framework of a spine surgical registry. Eur Spine J 2009;18 (suppl 3):360–6.
13. Fairbank JC, Couper J, Davies JB, et al. The Oswestry low back pain disability questionnaire. Physiotherapy 1980;66:271–3.
14. Groen M, Brox JI, Vollenstad NK. Cross-cultural adaptation of the Norwegian versions of the Roland-Morris Disability
Questionnaire and the Oswestry Disability Index. J Rehabil Med 2003;35:241–7.
15. Werner DAT, Grotle M, Gulati S, et al. Can a successful outcome after surgery for lumbar disc herniation be defined by the Oswestry Disability Index Raw Score?. Global Spine J 2020;10:47–54.
16. Solberg TK, Olsen JA, Ingebrigtsen T, et al. Health-related quality of life assessment by the EuroQol-5D can provide cost-utility data in the field of low-back surgery. Eur Spine J 2005;14:1000–7.
17. Twisk J, de Boer M, de Vente W, et al. Multiple imputation of missing values was not necessary before performing a longitudinal mixed-model analysis. J Clin Epidemiol 2013;66:1022–8.
18. Giannakakis C, Nerland US, Solheim O, et al. Does obesity affect outcomes after decompressive surgery for lumbar spinal stenosis? A multicenter, observational, registry-based study. World Neurosurg 2015;84:1227–34.
19. Gulati S, Jakola AS, Nerland US, et al. The risk of getting worse: surgically acquired deficits, perioperative complications, and functional outcomes after primary resection of glioblastoma. World Neurosurg 2011;76:572–9.
20. Gulati S, Nordseth T, Nerland US, et al. Does daily tobacco smoking affect outcomes after microdecompression for degenerative central lumbar spinal stenosis?—A multicenter observational registry-based study. Acta Neurochirurgica 2015;157:1157–64.
21. Nygaard OP, Kloster R, Solberg T. Duration of leg pain as a predictor of outcome after surgery for lumbar disc herniation: a prospective cohort study with 1-year follow up. J Neurosurg 2000;92:131–4.
22. Rosenthal BD, Suleiman LI, Kannan A, et al. Risk factors for prolonged postoperative opioid use after spine surgery: a review of dispensation trends from a state-run prescription monitoring program. J Am Acad Orthop 2019;27:32–8.
23. Kalakoti P, Hendrickson NR, Bedard NA, et al. Opioid utilization following lumbar arthrodesis: trends and factors associated with long-term use. Spine (Phila Pa 1976) 2018;43:1208–16.
24. Lee YP, Farhan SD, Kiester D, et al. Variables affecting return to work after spinal surgery in a non-workers’ compensation population: a retrospective cohort study. J Am Acad Orthop Surg 2017;25:e282–8.
25. Lau D, Berger MS, Khullar D, et al. The impact of smoking on neurosurgical outcomes. J Neurosurg 2013;119:1323–30.
26. Sanden B, Forsth P, Michaelsson K. Smokers show less improvement than nonsmokers two years after surgery for lumbar spinal stenosis: a study of 4535 patients from the Swedish spine register. Spine (Phila Pa 1976) 2011;36:1059–64.
27. Madsbu MA, Salvesen O, Werner DAT, et al. Surgery for herniated lumbar disc in daily tobacco smokers: a multicenter observational study. World Neurosurg 2018;109:e581–7.
28. Shepard N, Cho W. Recurrent lumbar disc herniation: a review. Global Spine J 2019;9:202–9.
29. Vogl M, Wenig CM, Leidl R, et al. Smoking and health-related quality of life in English general population: implications for economic evaluations. BMC Public Health 2012;12:203.
30. Inelmen EM, Sergi G, Girardi A, et al. The importance of sexual health in the elderly: breaking down barriers and taboos. Aging Clin Exp Res 2012;24:31–4.
31. Basson R, Weijmar Schultz W. Sexual sequelae of general medical disorders. Lancet 2007;369:409–24.
32. Giannakakis C, Solheim O, Jakola AS, et al. Surgery for lumbar spinal stenosis in individuals aged 80 and older: a multicenter observational study. J Am Geriatr Soc 2016;64:2011–8.
33. Jakola AS, Sørlie A, Gulati S, et al. Clinical outcomes and safety assessment in elderly patients undergoing decompressive laminectomy for lumbar spinal stenosis: a prospective study. BMC Surg 2010;10:34.
34. Madsbu MA, Solberg TK, Salvesen O, et al. Surgery for herniated lumbar disc in individuals 65 years of age or older: a multicenter observational study. JAMA Surg 2017;152:503–6.
35. Kolotkin RL, Zunker C, Ostbye T. Sexual functioning and obesity: a review. Obesity (Silver Spring, Md ) 2012;20:2325–33.
36. Chan AK, Bisson EF, Fu KM, et al. Sexual dysfunction: prevalence and prognosis in patients operated for degenerative lumbar spondylolisthesis. Neurosurgery 2020;87:200–10.
37. Hagg O, Fritzell P, Nordwall A. Sexual function in men and women after anterior surgery for chronic lumbar back pain. Eur Spine J 2006;15:677–82.
38. Berg S, Fritzell P, Tropp H. Sex life and sexual function in men and women before and after total disc replacement compared with posterior lumbar fusion. Spine J 2009;9:987–94.
39. Deyo RA. Treatment of lumbar spinal stenosis: a balancing act. Spine J 2010;10:625–7.
40. Deyo RA, Mirza SK, Martin BI, et al. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. JAMA 2010;303:1259–65.
41. Forsth P, Olafsson G, Carlsson T, et al. A randomized, controlled trial of fusion surgery for lumbar spinal stenosis. N Engl J Med 2016;374:1413–23.
42. Solberg TK, Sørlie A, Sjaavik K, et al. Would loss to follow-up bias the outcome evaluation of patients operated for degenerative disorders of the lumbar spine?. Acta Orthop 2011;82:56–63.