Voitto Järvimäki

LUMBAR SPINE SURGERY, RESULTS AND FACTORS PREDICTING OUTCOME IN WORKING-AGED PATIENTS
VOITTO JÄRVIMÄKI

LUMBAR SPINE SURGERY, RESULTS AND FACTORS PREDICTING OUTCOME IN WORKING-AGED PATIENTS

Academic Dissertation to be presented with the assent of the Doctoral Training Committee of Health and Biosciences of the University of Oulu for public defence in Auditorium 1 and 2 of Oulu University Hospital (Kajaanintie 50), on 23 March 2018, at 12 noon

UNIVERSITY OF OULU, OULU 2018
Abstract

The aim of this study was to evaluate the results of lumbar spine surgery and determine which factors modify outcome. A follow-up questionnaire, the Beck Depression Inventory (BDI), the Short Form 36 Health Survey (SF-36) and the Oswestry Low Back Disability Questionnaire (ODI) were sent to working-aged patients who had undergone lumbar spine surgery in the Oulu University Hospital between June, 2005 and May, 2008. Those with a BDI ≥ 10 were further classified into either non-melancholic (NmDS) or melancholic depression (MDS) groups.

Potential spinal cord stimulation (SCS) candidates were interviewed via telephone.

The postal survey was sent to 814 patients, of which 537 (66%) replied. Of these, 361 had undergone disc surgery, 85 stabilizing surgery and 91 decompression. Pain intensity was milder, the frequency of pain more rare, functional disability minimal and quality of life better after disc surgery compared to stabilizing surgery and decompression, which are technically more demanding operations and the patients’ condition are often more serious.

Altogether, 213 patients presented with depressive symptoms (DS) defined as having a BDI ≥ 10, and these were further classified into NmDS (n = 153) and MDS (n = 60) subtypes. ODI differed between DS subtypes: those without DS had minimal, NmDS moderate and MDS severe functional disability. Pain was more frequent and more intense among DS patients. In particular, MDS patients suffered from pain, used more pain medication, but received less benefit from it.

Disc surgery patients were divided according to body mass index (BMI): normal, pre-obese and obese. Pre-obese and obese patients gained weight during the follow-up. Obese patients had more DS and a worse functional outcome than normal-weighted or pre-obese patients.

Of the entire cohort (n = 814), 21 patients received SCS. Eleven respondents underwent SCS treatment after they had replied. Features predicting SCS treatment were daily or continuous pain, higher pain intensity with predominant radicular pain, more severe pain-related functional disability, more DS and reduced benefit from pain medication. The time between lumbar surgery and implantation of a SCS device was extensive. Based on data from phone interviews, it appears that SCS was not offered to all potential candidates.

In conclusion, the outcome of lumbar spine surgery was good after disc surgery but less favourable after more demanding stabilizing surgery or decompression. DS, especially of the MDS subtype, and obesity were more often seen in patients with a poorer surgical outcome. SCS treatment was used late and only for patients with very severe pain.

Keywords: Beck depression inventory, chronic pain, decompression, disc surgery, lumbar spine surgery, Oswestry disability index, SF-36 health survey, spinal cord stimulation, spinal fusion
Järvimäki, Voitto, Lanneselkäkirurgian tulokset ja niihin vaikuttavat tekijät

Työikäisillä.

Oulun yliopiston tutkijakoulu; Oulun yliopisto, Lääketieteellinen tiedekunta

Acta Univ. Oul. D 1451, 2018

Oulun yliopisto, PL 8000, 90014 Oulun yliopisto

Tiivistelmä


Kaikkiaan 213 potilaalla oli depressio-oireita (DS, BDI ≥ 10) ja nämä luokiteltiin edelleen NmDS (n = 153) ja MDS (n = 60) alaryhmii. ODI erotti eri DS alatyyppeihin välillä: ei-DS-potilaila oli minimaalinen, NmDS-potilaila kohtuullinen ja MDS-potilaila vaikea toiminnallinen haitta. Kipua oli useammin ja voimakkaampana DS-potilaila. Erityisesti MDS-potilaat kärsivät kiuvoista, käyttävät enemmän kipulääkeitä ja hyötyvät niistä vähemmän.

Välilevytyräleikatut luokiteltiin painoindeksin (BMI) pohjalta normaaleihin, ylipainoihin ja lihaviin. Ylipainoiset ja lihavat lihoivat seuranta-aikana. Lihavilla potilailla oli enemmän masennusta ja huonompi toiminnallinen tulos verrattuna normaaleihin ja ylipainoinoihin.


Yhteenvetona voidaan todeta, että välilevytyäreikkausten jälkeen tulos oli hyvä ja vaativammin stabiloiva ja juurikanavan avarrusleikkauskun jälkeen heikompi. DS, ennekä MDS ja lihavuus korostuvat huonommin toipuneissa. TJS-hoitoa käytettiin vain vaikeimmille tapauksille ja odotusajat olivat pitkät.

Asiayan: Beckin depressioasteikko, juurikanavan avarrus, krooninen kipu, lannerangan kirurgia, lannerangan luudutus, Oswestryn toimintakykyasteikko, selkäydistimulaatio, SF-36 elämänlaatukysely, välilevytyrä poisto
To my dear ones

_Ei tule yrittää parantaa ruumista niin,
että sielu unohdetaan_ (Platon 350 eKr)
Acknowledgements

This study was carried out in the Pain Clinic at the Department of Anesthesiology, Oulu University Hospital during the years 2008–2017.

I wish to express my sincere gratitude to:

- Professor Seppo Alahuhta MD, PhD; my supervisor, chief and teacher, who provided optimum conditions and an encouraging atmosphere during the course of this study.
- Docent Maija Haanpää MD, PhD; my supervisor for her firm interest and constant help in the scientific planning, and for her pleasant co-work throughout the many phases of my research.
- MD, PhD Merja Vakkala; my supervisor who patiently guided this almost everlasting project and gave me the confidence to carry on during those days when I was ready to give up. Her input has been crucial to my development as a researcher and writer.
- Docent Heikki Antila MD, PhD and Docent Jari Siironen MD, PhD, who were the official reviewers of this work. Their valuable advice and constructive comments were crucial for my thesis
- BA Hannu Kautiainen deserves my special gratitude, not only for his aid and guidance with the statistics, but also for our numerous conversations over the years and his great input to the articles.
- Professor Hannu Koponen MD, PhD gave me valuable comments during the writing process in one of the articles.

I am sincerely grateful to Michael Spalding, MD, PhD for his valuable comments and his efficient and thorough language revision of the articles and thesis.

I wish to thank Docent Timo Salomäki MD, PhD and MD, PhD Juha Karinen for their valuable roles in the follow-up group.

I would thank all members of the staff in the Department of Anesthesiology for their effort in taking over my work while doing this thesis. I would like to thank the secretary Marita Telin in the University Hospital for her help with many practical issues. I would like to thank the personnel of the Pain Clinic and especially Lotta Juurikka, MD for her help in collecting the data. Finally, I wish to express my warmest gratitude to all the participants in these studies. These studies have been financially supported by the Health Care Foundation of North Finland and the funds of Rehabilitation Orton, Finland.

Oulu, January 2018

Voitto Järvimäki
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>Beck depression inventory</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>CBLP</td>
<td>Chronic back and leg pain</td>
</tr>
<tr>
<td>CLBP</td>
<td>Chronic low back pain</td>
</tr>
<tr>
<td>CT</td>
<td>Computer tomography</td>
</tr>
<tr>
<td>DS</td>
<td>Depressive symptoms</td>
</tr>
<tr>
<td>ESI</td>
<td>Epidural steroid injection</td>
</tr>
<tr>
<td>ICF</td>
<td>International classification of functioning, disability and health</td>
</tr>
<tr>
<td>ICD</td>
<td>International classification of diseases</td>
</tr>
<tr>
<td>LBP</td>
<td>Low back pain</td>
</tr>
<tr>
<td>MDS</td>
<td>Melancholic depression</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>NmDS</td>
<td>Non-melancholic depression</td>
</tr>
<tr>
<td>NRS</td>
<td>Numerical rating scale</td>
</tr>
<tr>
<td>NSAID</td>
<td>Non-steroidal anti-inflammatory drug</td>
</tr>
<tr>
<td>ODI</td>
<td>Oswestry disability index</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized controlled trial</td>
</tr>
<tr>
<td>SCS</td>
<td>Spinal cord stimulation</td>
</tr>
<tr>
<td>SF-36</td>
<td>The Short Form 36 Health Survey</td>
</tr>
<tr>
<td>SNRI</td>
<td>Serotonin-norepinephrine reuptake inhibitor</td>
</tr>
<tr>
<td>TCA</td>
<td>Tricyclic antidepressant</td>
</tr>
<tr>
<td>TENS</td>
<td>Transcutaneous electrical nerve stimulation</td>
</tr>
</tbody>
</table>
List of original publications

This thesis is based on the following four studies which are referred to in the text by Roman numerals I–IV:


Contents

Abstract ............................. 9
Tiivistelmä ........................... 10
Acknowledgements ............... 11
Abbreviations ...................... 12
List of original publications ........ 13
Contents ............................. 15
1 Introduction ....................... 17
2 Review of the literature ........ 19
   2.1 Non-pharmacological treatment of low back pain .................. 19
   2.1.1 Physical therapy / exercise ...................................... 20
   2.1.2 Psycho-Physical Therapy ......................................... 20
   2.1.3 Spinal manipulation therapy .................................. 20
   2.1.4 Transcutaneous electrical nerve stimulation ................. 20
   2.2 Pharmacological treatment of low back pain .................. 21
   2.2.1 Paracetamol ....................................................... 21
   2.2.2 Non-steroidal anti-inflammatory drugs ....................... 21
   2.2.3 Glucocorticoids ................................................... 22
   2.2.4 Weak opioids ..................................................... 22
   2.2.5 Strong opioids .................................................... 23
   2.2.6 Central acting muscle relaxants ............................... 23
   2.2.7 Gabapentinoids ................................................... 24
   2.2.8 Antidepressants .................................................. 25
   2.2.9 Ketamine ......................................................... 25
   2.3 Invasive treatments of low back pain ............................ 26
   2.3.1 Epidural block .................................................... 26
   2.3.2 Selective nerve root block ..................................... 26
   2.3.3 Facet joint block ............................................... 26
   2.3.4 Trigger point block .......................................... 27
   2.3.5 Acupuncture .................................................... 27
   2.3.6 Spinal cord stimulation ..................................... 28
   2.4 Surgery ......................................................... 28
   2.5 Depression and its role in CLBP ................................ 29
   2.6 Obesity and its impact on CLBP ................................ 30
3 Aims of the study ................. 33
4 Materials and methods ......... 35

15
4.1 Patients and data collection ................................................................. 35
4.2 Questionnaires .................................................................................... 35
  4.2.1 Follow-up questionnaire ............................................................... 35
  4.2.2 Oswestry disability index (ODI) ................................................... 36
  4.2.3 International Classification of Functioning, Disability and Health (ICF) ............................................................... 36
  4.2.4 The short form 36 health survey (SF-36) ........................................ 37
  4.2.5 The Beck depression inventory (BDI) .......................................... 38
  4.2.6 Telephone interview .................................................................. 38
4.3 Statistical methods ............................................................................ 39
5 Results .................................................................................................. 41
  5.1 Patients in the study ................................................................. 41
  5.2 Pain and pain-related disability (I) .................................................. 42
  5.3 Functional outcome (I) ................................................................. 43
  5.4 Quality of life (I) ........................................................................... 43
  5.5 Depressive symptoms (II) ............................................................. 44
  5.6 Pain medication (II) ...................................................................... 47
  5.7 Impact of weight in disc surgery (III) ............................................. 49
  5.8 Spinal cord stimulation (IV) .......................................................... 51
6 Discussion ............................................................................................ 55
  6.1 Patients .......................................................................................... 55
  6.2 Methodological considerations ...................................................... 55
  6.3 Outcome of disc surgery ............................................................... 56
  6.4 Outcome of stabilizing surgery and decompression ...................... 56
  6.5 Depressive symptoms after spinal surgery ...................................... 57
  6.6 Impact of weight on outcome of disc surgery ............................... 58
  6.7 Pain medication ............................................................................ 59
  6.8 Availability of spinal cord stimulators .......................................... 59
  6.9 Limitations of this study ............................................................... 60
7 Clinical implications and future perspectives ................................. 61
8 Conclusions ......................................................................................... 63
References ............................................................................................. 65
Original publications ............................................................................ 77
1 Introduction

Spinal disorders are a major and growing health and economic burden. The lifetime prevalence of low back pain is reported as over 70% (van Tulder et al. 2006). According to the Finnish Health 2011 Study, 41% of women and 35% of men had experienced low back pain during the last 30 days (Koskinen et al. 2012). A survey of chronic pain in Europe revealed that 19% of respondents had chronic pain and nearly half of it was located in the back (Breivik et al. 2006).

Spinal disorders are costly. Disability allowances amounting to 115 million euros were paid out due to spinal disorders in Finland in 2015, which accounts for 14% of all of Finland’s disability allowances (Statistical Yearbook of the Social Insurance Institution 2016). In 2015, musculoskeletal disorders were the second largest reason for disability pensions, comprising 32% of new pensions, and spinal disorders made up the largest subgroup (14% of new disability pensions) (Statistical yearbook of pensioners in Finland 2016). Disability pensions and paid expenditures related to spinal disorders decreased significantly during 1990–2010 due to nonmedical factors and legislative reforms. The costs were still prohibitive: spinal disorders generated 9372 million euros in extra costs during the period 1990–2010 in Finland due to disability pensions (Asklof et al. 2014, 2016).

LBP symptoms may derive from many potential anatomic sources, such as nerve roots, muscle, fascial structures, bones, joints and intervertebral discs (Deyo & Weinstein 2001). The major cause of back pain is degenerative disease of the spine (de Bruin et al. 2016). The intervertebral disc is the first structure affected, with a loss of height and decreased content of proteoglycans and water in the annulus and nucleus pulposus. This can cause discogenic pain. Disc degeneration may cause a tear in the annulus fibrosus and bulging of the nucleus pulposus into the spinal canal. This can cause neural structure compression and neurological symptoms. Degenerative changes in the intervertebral discs and facet joints narrow the space in which the neural structures travel and cause acquired stenosis. Spinal stenosis can also be congenital. Stenosis causes radicular pain because of decreased microcirculation of the nerve roots and spinal nerves (Raciborski et al. 2016). Spondylolysis refers to a defect in the pars interarticularis of the vertebra, which may be congenital or the result of a stress fracture. Spondylolisthesis refers to the anterior displacement of a vertebra compared to the one beneath it. This may occur as a result of spondylolysis (called isthmic spondylolisthesis) or as a result of degenerative disc disease, usually in the elderly, and may contribute to the narrowing of the spinal canal in spinal stenosis (Deyo & Weinstein 2001).
The Finnish current care guideline for treatment of low back pain emphasizes conservative treatment for all types of LBP conditions, except in well-defined cases requiring acute surgery (Low back pain: Current Care Guidelines 2015). Physical exercise, other non-pharmaceutical interventions and pain medication are recommended for sub-acute and chronic pain. Surgery is needed in carefully selected cases which are refractory to conservative treatment. The ministry of Social Affairs and Health of Finland maintains uniform criteria for access to non-emergency treatment, providing criteria for the most common surgeries - including lumbar spine surgery - to ensure uniform treatment throughout the country (Ministry of Social Affairs and Health 2010).

Lumbar spine surgery is a common procedure, which is performed in about 6000 patients per year in Finland. Disc surgery makes up the largest group, decompressions come second and stabilizing surgery third. The direct yearly cost of lumbar spine surgery is slightly over 20 million euros in Finland (Pohjolainen et al. 2007).

A national registry for the systematic evaluation of the long-term outcome of lumbar spine surgery is not yet available in Finland. The present study was undertaken in order to clarify the outcome of the most common types of lumbar surgery in working-aged patients in Northern Finland.
2 Review of the literature

The classification of chronic pain falls into three broad categories: pain due to tissue disease or damage (nociceptive pain), pain caused by somatosensory system disease or damage (neuropathic pain), and pain without a known somatic background. Different types of pain may occur separately or in combination in the same patient, and even at the same body site (e.g. radiating from or distributed into one or more lumbosacral roots) (Haanpää et al. 2009).

Approximately 85 percent of patients with isolated low back pain cannot be assigned a precise pathoanatomical diagnosis (Deyo & Weinstein 2001). The management of patients suffering from chronic pain is based on a long-term therapeutic relationship. The main objectives of the treatment are relief of pain, restoration of function, and improvement in quality of life. Treatment and rehabilitation need to be planned in agreement with the patient. Non-pharmaceutical interventions form the basics of the treatment, and pain medication is only used if non-pharmaceutical interventions don’t provide sufficient pain relief. Pharmacotherapy should be individually tailored according to the etiology and intensity of pain, comorbidities and psychosocial situation (Pain: Current Care Guidelines Abstract, 2015).

Intensive acute pain management may reduce the chronification of pain. Multimodal postoperative analgesia is mainly based on a combination of different analgesics and techniques (Devin & McGirt 2015).

In this review of the literature, essential non-pharmacological, pharmacological and invasive interventions for LBP are presented.

2.1 Non-pharmacological treatment of low back pain

Rehabilitation and patients self-care are the most important cornerstones of the treatment modality during recovery. The goals of rehabilitation include short-term pain relief, the ability to achieve relaxation, regain normal muscle function, increase mobility and encourage patients to move. For subacute LBP, mini-interventions consisting of a detailed assessment of the patient and individual recommendations and advice provided by a physician and physiotherapist were demonstrated to be effective in reducing sick-leave days and costs in a two-year follow up study (Karjalainen et al. 2004).
2.1.1 Physical therapy / exercise

Gradually increasing therapeutic exercise may improve functional outcome and reduce pain (Low back pain: Current Care Guidelines Abstract, 2015). A program that combines muscular strength, flexibility and aerobic fitness may be beneficial for rehabilitation in nonspecific CLBP (Gordon & Bloxham 2016). Passive massage therapy without simultaneous rehabilitation only provides benefits over the short-term (Furlan et al. 2015).

2.1.2 Psycho-Physical Therapy

Combined interventions aim at targeting psychological and physical factors contributing to a patient’s pain. This may involve multidisciplinary team pain management programs, yoga, functional restoration programs, graded activities, graded exposure, psychophysical physiotherapy, or exercise combined with behavioural informed interventions (relaxation, cognitive-behavioural therapy). According to a recent meta-analysis, combined interventions reduced pain and improved disability somewhat more than did physical therapy alone (O’Keeffe et al. 2016).

2.1.3 Spinal manipulation therapy

Spinal manipulative therapy has a significant short-term effect on pain relief and functional status, when combined with other interventions. Spinal manipulation is as effective as are the outcomes from general practitioner care, physiotherapy, exercises and back school. The modes of action are mechanical and neurophysiologic (Rubinstein et al. 2011). It has not been determined which subgroup of patients receives the most benefit from spinal manipulation. Current guidelines contraindicate manipulation in people with instability or severe progressive neurological deficit (Chou et al. 2016).

2.1.4 Transcutaneous electrical nerve stimulation

Transcutaneous electrical nerve stimulation (TENS) is a safe addition to the pharmacological treatments used in CLBP. According to a recent meta-analysis, the treatment of CLBP with TENS demonstrated a significant pain reduction and minimized pain medication usage (Jauregui et al. 2016).
2.2 Pharmacological treatment of low back pain

The selection of a pain medication should take into account the type of pain, the pathophysiological mechanisms of the pain in question, symptom profile, concomitant medical conditions and their medications, co-morbidities (e.g. sleep or mood problems), the cost of medication and the individual preferences of the patient. Combination therapy may be necessary in cases of mixed pain to target different components of pain. In the following sections, the most common pharmacological alternatives for the treatment of CLBP are introduced for both outpatient and perioperative care.

2.2.1 Paracetamol

Paracetamol is one of the most popular and most commonly used analgesic drugs in the world, but its exact mechanism of action remains unknown. Guidelines for LBP recommend it as the first-line analgesic for mild pain (Chou et al. 2007, Koes et al. 2010, Low back pain: Current Care Guidelines Abstract, 2015), but no high-quality evidence exists to support this. On the contrary, a large randomized study did not find any difference in recovery time between a placebo and paracetamol in acute LBP (Williams et al. 2014). In addition, paracetamol dose is very strictly limited due to its hepatotoxicity in chronic use.

Paracetamol is administered intravenously during anaesthesia and postoperatively. When used intravenously, it produces a higher plasma concentration faster, leads to higher levels in the cerebrospinal fluid, and is more effective (Lachiewicz 2013). According to a Cochrane review, patients receiving 1 g paracetamol intravenously during the postoperative period required 26% less opioids when compared to a placebo group (McNicol et al. 2016). In another study, 1 g paracetamol intravenously subsequent to spinal surgery improved the quality of postoperative analgesia, but its opioid-sparing effect was not as clear (Cakan et al. 2008, Grundmann et al. 2006).

2.2.2 Non-steroidal anti-inflammatory drugs

Non-steroidal anti-inflammatory drugs (NSAIDs) are recommended and widely used to treat acute and chronic LBP. The analgesic action of NSAIDs is based on their inhibition of the enzymes which synthesize prostaglandins and thus alleviate inflammation and relieve pain. Two types of NSAIDs are available and used to treat
back pain: non-selective and selective cyclo-oxygenase-2 inhibitors. A Cochrane review identified a significant effect induced by NSAIDs compared to placebos in CLBP (Enthoven et al. 2016, Low back pain: Current Care Guidelines 2015). On the other hand, NSAIDs have serious side effects (gastroenteral and vascular), for which reason it is very important to minimize dose and treatment times.

NSAIDs have an opioid-sparing effect of 30–40% postoperatively (Dahl et al. 2014a). After spinal surgery, a subgroup analysis revealed a greater reduction of morphine consumption in spinal fusion patients than in those undergoing discectomy or laminectomy (Jirarattanaphochai & Jung 2008, Jirarattanaphochai et al. 2008, Kesimci et al. 2011, Tunali et al. 2013). This difference in opioid use is probably related to the type of surgery performed; discectomy is a less extensive surgical procedure, and patients require less opioids, which makes the detection of a significant reduction in opioid use more difficult. Concern has been raised regarding impaired bone healing in association with the use of NSAIDs postoperatively. No clear evidence exists to support this concern (Mathiesen et al. 2014).

2.2.3 Glucocorticoids

The systemic use of glucocorticoids has no role in the treatment of CLBP. Glucocorticoids are often used to prevent postoperative nausea and vomiting, but their effects on pain are less well studied. Dexamethasone has been shown to reduce postoperative pain and the need for opioids in two meta-analyses (De Oliveira et al. 2011, Waldron et al. 2013). There are no RCTs of perioperative corticosteroid use in spinal surgery. Bednar et al. compared patients in a retrospective study, who received dexamethasone to those who did not after lumbar spine surgery. In this setting, dexamethasone (4 mg per 6 hours up to 48 hours) was administered in patients for whom a routine multimodal analgesia was not sufficient. Dexamethasone had minimal opioid-sparing effects, the length of stay was shortened by 25% and there were no side effects (Bednar et al. 2015). More RCTs are necessary to clarify the possible benefits of dexamethasone in spinal surgery.

2.2.4 Weak opioids

Weak opioids (codeine, tramadol, buprenorphine) are μ-opioid receptor agonists, and in addition, tramadol inhibits the reuptake of serotonin and noradrenalin. Weak
opioids are widely used in combination with paracetamol and NSAIDs. Guidelines for LBP are very restrictive with weak opioids and recommend thorough patients selection and follow up (Chou 2010, Low back pain: Current Care Guidelines Abstract, 2015). Because of the mechanisms of action (serotonergic, noradrenergic action and µ-receptor agonist) tramadol has an effect on both nociceptive and neuropathic pain, which makes it a logical selection in the treatment of pain of mixed origin (Finnerup et al. 2015). There is only low-quality evidence to show that weak opioids are more effective than a placebo at reducing pain and improving functional outcomes (Chaparro et al. 2013, Deyo et al. 2015). Weak opioids have well-recognised adverse effects (nausea, confusion, constipation) as well as the potential for misuse. Long-term use increases these risks.

Weak opioids are seldom strong enough to provide adequate pain relief during and shortly after major spinal operations. In the later postoperative phase, weak opioids may be used over the short-term period and under strict follow-up.

2.2.5 Strong opioids

Strong opioids are µ-opioid receptor agonists, which are mainly used for acute pain and cancer pain. They are not recommended for CLBP patients according to current care guidelines. A high quality systematic review and meta-analysis on this subject has recently been published (Abdel Shaheed et al. 2016). Strong opioids only provide a modest short-term relief from pain and their long-term effectiveness and safety are unknown (Abdel Shaheed et al. 2016, Chaparro et al. 2013). Complications of long-term opioid use include tolerance, hyperalgesia, obstipation, hormonal side effects and addiction (Deyo et al. 2015).

The perioperative and short-term postoperative use of strong opioids is crucial. Opioids don’t cover all postoperative pain mechanisms (e.g. neuropathic pain, bone pain), which is why multimodal analgesia is necessary. Current studies focus more on the opioid-sparing effects of non-opioids than on the effectiveness of the opioids themselves.

2.2.6 Central acting muscle relaxants

Muscle relaxants are commonly used drugs among patients with low back pain. Muscle relaxants can be divided into two main categories: antispasmodic and antispastic medication. Antispasmodics can be further classified into
benzodiazepines and non-benzodiazepines. There is evidence suggesting that muscle relaxants are effective in the management of nonspecific acute low back pain and that the different types of relaxants are equally effective (van Tulder et al. 2003, Sakai et al. 2008). The use of muscle relaxants is not associated with a more rapid functional recovery (Bernstein et al. 2004). Some guidelines recommend the use of muscle relaxants, but only for a short time in acute pain if there are muscle spasms (for example, the guideline from Finland: Low back pain: Current Care Guidelines Abstract, 2015). Some guidelines state that muscle relaxants should not be used because of the risk of physical and psychological dependence (van Tulder et al. 2006).

There are no studies on the use of central acting muscle relaxants perioperatively in lumbar spine surgery. Historically, we have used benzodiazepines as premedication, but there are no studies of their usefulness in this patients group.

2.2.7 Gabapentinoids

Gabapentinoids (gabapentin, pregabalin) are calcium channel alfa-2-delta ligands, which reduce the release of presynaptic transmitters and hence relieve neuropathic pain.

Radiculating LBP is the most common cause for neuropathic pain. Gabapentinoids are the first line medication for neuropathic pain together with tricyclic antidepressants and serotonin-noradrenalin reuptake inhibitor (SNRI) antidepressants (Gilron et al. 2013, Finnerup et al. 2015), although their efficacy in lumbar radicular pain is not confirmed by a RCT (Baron et al. 2010 Pain;150:420-7, Atkinson et al. 2016). Sakai et al. have studied pregabalin in elderly patients and found that it is effective in cases of chronic LBP accompanied with radicular pain (Sakai et al. 2015).

The perioperative use of gabapentinoids has been studied a great deal. There are good systematic reviews and meta-analyses which demonstrate that gabapentinoids are effective in reducing short-term postoperative pain, opioid consumption, and opioid-related adverse effects in general (Dahl et al. 2014, Tiippana et al. 2007). On the other hand, perioperative gabapentinoids do not prevent the development of chronic postsurgical pain according to a recent meta-analysis (Martinez et al. 2017).
2.2.8 Antidepressants

Tricyclic antidepressants (TCAs) and serotonin norepinephrine reuptake inhibitors (SNRIs) have been shown to have a moderate efficacy for neuropathic pain (Attal et al. 2010). A Cochrane Review from 2008 could find no evidence to support the use of antidepressants for patients with CLBP (Urquhart et al. 2008). Cawston et al. made an indirect comparison of the efficacy of duloxetine versus alternative oral therapies and reported no difference in efficacy between duloxetine and other oral pharmacological therapies (Cawston et al. 2013). In a placebo-controlled cross-over trial, Schukro et al. demonstrated that duloxetine was efficacious after four weeks of treatment in CLBP with a radicular component (Schukro et al. 2016). More high-quality clinical studies are necessary to elucidate this subject. Clinically depressive patients, with or without back pain, could benefit from antidepressant treatment.

There are no prospective studies on the pre- or perioperative use of antidepressants in lumbar spine surgery. One retrospective study suggested that - in cervical discectomy patients with depression - pre-treatment with antidepressants improves their perception, pain and functional disability (Elsamadicy et al. 2016). Depression is associated with chronic pain as well as with poor results for surgery (Linton & Bergbom 2011). Prospective studies on this treatment modality in lumbar spine surgery are needed.

2.2.9 Ketamine

Ketamine is an N-methyl-D-aspartate receptor antagonist. Low-dose ketamine for pain reduction during an exacerbation of LBP is sometimes used in emergency departments. There is only minimal evidence supporting its effectiveness, however (Sin et al. 2015).

Ketamine has been shown to be useful in reducing acute postoperative pain and opioid consumption (Bell et al. 2005). Its use in spinal surgery has been studied in opioid-dependent CLBP patients, but the results are still unclear. Low dose iv-ketamine (2 µg/kg/min) did not improve postoperative analgesia (Subramaniam et al. 2011). A higher dose (10 µg/kg/min), reduced opioid consumption without adverse effects (Loftus et al. 2010).
2.3 Invasive treatments of low back pain

Injection therapy is one of many treatments available for subacute and chronic LBP. The injection can be administered into different parts of the spine. Commonly used invasive treatments are epidural, nerve root, facet joint and muscle trigger point injections.

2.3.1 Epidural block

Interlaminar and transforaminal epidural steroid injections (ESI) (Figure 1) only provide short-term pain relief (2–4 weeks) for those with leg dominant pain and nerve root irritation. ESIs are not recommended for the treatment of CLBP according to Finnish or international guidelines (Chou 2010, Kreiner et al. 2014, Low back pain: Current Care Guidelines Abstract, 2015). According to a recent meta-analysis, epidural steroids are ineffective. Contrast-enhanced fluoroscopic guidance of ESIs and transforaminal ESIs are the focus of new studies, but results and terminology are still unclear (Manchikanti et al. 2016). Radicular symptoms in CLBP have multiple causes. ESI can be a useful tool both for relieving symptoms after surgery and preventing or delaying the need for surgery (Bicket et al. 2015).

2.3.2 Selective nerve root block

In selective nerve root block (Figure 1) steroids and local anesthetics are placed on a specific nerve root. The aim is to cover only the offending nerve root and not inject drugs into the epidural space. From an anesthetic point of view, it is conflicting that selective root blocks and transforaminal epidural blocks are compared together in reviews and meta-analyses (DePalma et al. 2005, Manchikanti et al. 2016). The Finnish current care guideline does not include any recommendations regarding nerve root block (Low back pain: Current Care Guidelines Abstract, 2015).

2.3.3 Facet joint block

Facet joints are considered to be a source of CLBP in 27–40% of the cases. The facet joint block (Figure 1) can be used as a diagnostic block, but there is only low-quality evidence for its therapeutic use (Datta et al. 2009).
Fig. 1. In the transforaminal epidural block, the needle is inserted into the epidural space through the bony opening of the exiting nerve root with X-ray guidance. 2. In the facet joint block, a small needle is inserted into the facet joint using X-ray guidance. 3. In the interlaminar epidural block, the needle is directed into the epidural space using the loss-of-resistance technique. 4. In nerve root block, the needle is placed with the help of X-ray guidance perineural just outside the bony opening of exiting nerve root.

2.3.4 Trigger point block

Pain and tenderness located in a muscle remote from the site of pain in a referred pattern are produced by myofascial trigger points. When trigger points are pressed firmly they produce pain. There is no strong evidence for or against the use of trigger point block in the treatment of CLBP. Some subgroups may benefit, but there is not yet enough published evidence to support this (Staal et al. 2008).

2.3.5 Acupuncture

According to a Cochrane review, acupuncture is more effective for pain relief and functional improvement for CLBP than placebo treatment but its effect is short-term only (Furlan et al. 2005). Acupuncture can be a useful supplement for other forms of conventional therapy for nonspecific low back pain (Yuan et al. 2008).
2.3.6 Spinal cord stimulation

The spinal cord stimulator delivers electrical stimuli to the spinal cord in order to control chronic pain. The mechanisms of action are not fully understood. In neuropathic pain, SCS alters local neurochemistry in the dorsal horn and suppresses central neuronal hyperexcitability (Oakley & Prager 2002). Unlike nociceptive pain, neuropathic pain is more severe, more likely to be chronic, and it is less responsive to analgesic drugs and other medical management (Haanpää et al. 2009).

The most common condition for which SCS is employed is postsurgical chronic back and leg pain (CBLP), formerly called failed back surgery syndrome, referring to cases with continuing pain after adequate lumbar surgical procedure (Epstein & Palmieri 2012). In carefully chosen CBLP patients with predominant radicular component, SCS can provide more effective pain relief than conventional medical care alone (Kumar et al. 2007). SCS was more effective than reoperation and patients referred for SCS compared to the outcome after reoperation (Kumar et al. 2007, North et al. 2005).

In 2009, a systematic review on SCS came to a cautiously optimistic conclusion in the Finnish Medical Journal: careful patient selection, avoidance of delays in treatment initiation, broad experience and good expertise in both spinal nerve stimulation and other treatment options are important factors in obtaining the most effective treatment for neuropathic pain patients (Paavola et al. 2009). SCS is an invasive treatment with an inherent risk of adverse events. Occasionally patients experience device complications, such as lead migration, lead breakage, or device malfunctions. Major complications, however, are rare (Shamji et al. 2015).

2.4 Surgery

Thorough patient selection is the basis for success in surgery. Selecting appropriate candidates can be challenging due to variabilities in diagnosis and clinical and radiographic findings. The clinical benefit of surgery in even well-selected groups of patients can vary and many patients may do as well long-term with conservative treatment. Surgical treatment may also carry significant risks and costs (Friedly et al. 2010).

Primarily, the preferred treatment for spinal disc herniation is conservative, unless there are indications for immediate surgery. These are: cauda equine syndrome, progressive neurological deficiency (motor or sensory) of the lower extremity, and extreme radicular pain resistant to treatment in radiologically
confirmed cases (Low back pain: Current Care Guidelines 2015). Lumbar disc surgery is considered if the clinical situation deteriorates during follow-up or disabling radiculating symptoms last longer than two months in cases of lumbar nerve root compression confirmed with MRI or CT scan. Stabilizing surgery is considered in patients with a disability in daily activities due to symptoms caused by lumbar instability in spite of adequate conservative treatment. Decompression is considered if conservative treatment for six month has not been beneficial for patients with lumbar spinal stenosis unable to walk more than short distances, disabling pain and impaired functional capacity in daily life (Ministry of Social Affairs and Health 2010).

In cases of disc herniation, surgical treatment provides faster short-term relief, but does not show a clear benefit over conservative treatment in the midterm and long-term follow-up (Gugliotta et al. 2016, Osterman et al. 2006, Peul et al. 2007, Weinstein et al. 2006). There is good evidence that surgery is more effective in alleviating symptoms in adults with degenerative spondylolisthesis and CLBP compared to conservative treatment for up to two years. In the long-term follow-up, this difference has not been observed to be as clear (Ekman et al. 2005, Moller & Hedlund 2000, Schulte et al. 2016, Wood et al. 2011). When patients with symptomatic spinal stenosis treated with decompression were compared to those receiving conservative treatment, it was demonstrated that the former maintain substantially greater improvement in pain and function through four years (Kovacs et al. 2011, Malmivaara et al. 2007, Slätis et al. 2011, Weinstein et al. 2007, 2010).

According to a registry study of operations in Finland (for the period 1995–2005), the number of disc surgeries has decreased by 27%, the number of decompressions has increased by 37%, and the number of stabilizing surgeries has tripled over that time period (Pohjolainen et al. 2007). This same phenomenon is seen internationally (Deyo et al. 2010).

2.5 Depression and its role in CLBP

Depression is a major public health problem and a main focus area in both primary care and psychiatry. The 12-month prevalence of depression is 5% among the Finnish population. It is almost twice as common in women compared to men (Pirkola et al. 2005). In depressive disorders, which are a broad and heterogeneous diagnostic group, the patient usually suffers from depressed mood, loss of interest and enjoyment, and reduced energy leading to loss of pleasure in most activities. Depression can be categorized into three varieties: mild, moderate and severe (THL
Only a minority of depressive patients seek treatment from health services and many patients with depressive symptoms remain unrecognized as physicians may have difficulties in identifying the disorder (Hämäläinen et al. 2008).

Self-report questionnaires measuring depressive symptoms have been used for screening for depression. The most widely used is the Beck Depression Inventory (BDI) which has 21 items consisting of symptoms and attitudes related to depression with the total score ranging from 0 to 63 (Beck et al. 1961). It has been validated in Finnish patients with suspected depressive disorder (Viinamäki et al. 2004). A classification of the depression state is illustrated in table 1. Using BDI, patients with depressive symptoms can be further divided into melancholic (MDS) and non-melancholic (NmDS) depressive symptom subgroups using items such as sadness, past failure, loss of pleasure, feelings of guilt, feelings of being punished, loss of interest, irritability, changes in sleeping patterns and changes in appetite (Ovaskainen et al. 2009, Seppälä et al. 2012, Vanhala et al. 2009).

Table 1. Classification of BDI.

<table>
<thead>
<tr>
<th>Cut-off points</th>
<th>Level of depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–9</td>
<td>minimal depression</td>
</tr>
<tr>
<td>10–18</td>
<td>mild depression</td>
</tr>
<tr>
<td>19–29</td>
<td>moderate depression</td>
</tr>
<tr>
<td>29–63</td>
<td>severe depression</td>
</tr>
</tbody>
</table>

Patients seeking care for CLBP often also report symptoms of depression. Depression is associated with the development of chronic pain as well as poor treatment results. On average, 65% of patients seeking care for depression have co-morbid pain problems and about half of the patients with chronic pain fulfill the criteria for depression (Bair et al. 2003, Linton & Bergbom 2011).

### 2.6 Obesity and its impact on CLBP

Overweight and obesity are defined as an excessive accumulation of fat. The body mass index (BMI) is commonly used as an index to classify overweight and obesity in adults (Revicki & Israel 1986). It is defined as a person’s weight in kilograms divided by the square of his weight in meters (kg/m²). According to a universal definition, a person is regarded as overweight if their BMI is greater than or equal to 25 and obese if their BMI is greater or equal to 30 (WHO 2016). The classification of BMI by the World Health Organization is shown in table 2.
### Table 2. The classification of BMI by the World Health Organization (WHO 2016).

<table>
<thead>
<tr>
<th>Classification of BMI</th>
<th>Cut-off points, kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt; 18.5</td>
</tr>
<tr>
<td>Normal range</td>
<td>18.5–24.9</td>
</tr>
<tr>
<td>Overweight</td>
<td>≥ 25.0</td>
</tr>
<tr>
<td>Pre-obese</td>
<td>25.0–29.9</td>
</tr>
<tr>
<td>Obese class I</td>
<td>30.0–34.9</td>
</tr>
<tr>
<td>Obese class II</td>
<td>35.0–39.9</td>
</tr>
<tr>
<td><strong>Obese class III</strong></td>
<td><strong>≥ 40.0</strong></td>
</tr>
</tbody>
</table>

In 2012, more than half of the Finnish population were at least overweight and every fifth one could be classified as obese. Men of working age had a mean BMI of 27.1 and women 26.0. Sixty-six percent of men and 46% of women were overweight, respectively, while obesity was equally common among sexes, at about 20%. Weight increases with age and reaches a maximum by retirement (THL 2016).

A heightened BMI is a major risk factor for a number of chronic diseases such as cardiovascular diseases, diabetes, musculoskeletal disorders and some cancers. According to a meta-analysis, overweight/obesity has a strong association with CLBP and sciatica (Shiri et al. 2010, 2014). There is an association between obesity and higher rates of complications after lumbar surgery (De la Garza-Ramos et al. 2014). Obese patients have increased resource utilization (Planchard et al. 2015) and unfavourable outcomes after spinal surgery (Seicean et al. 2014).
3 Aims of the study

1. To study the outcome of lumbar spine surgery performed in a Finnish population-based cohort of working-age patients. Aspects evaluated were pain profiles, functional outcome, health-related quality of life and depression (I).
2. To investigate how non-melancholic depression (NmDS) and melancholic depression (MDS) correlate in to the outcome of lumbar spine surgery (II).
3. To evaluate the impact of obesity on the outcome of lumbar disc surgery (III).
4. To analyse the incidence of spinal cord stimulation (SCS) as a treatment option after lumbar spine surgery in Northern Finland (IV).
4 Materials and methods

4.1 Patients and data collection

The Oulu University Hospital (OUH) provides specialist care for a population of 730,000, being the main centre for spinal surgery in Northern Finland. Only a small minority of spine operations (disc surgery in low risk patients) are performed in other smaller hospitals in the area. To investigate the results of lumbar spine surgery in OUH, patients were identified using ICD-10 procedure codes for lumbar spine operations during the period June 1st, 2005 to May 31st, 2008. Patients who underwent disc surgery, stabilizing surgery or decompression were included. Surgical procedures due to acute traumas were not included. Only patients of a working-age (18–65 years) were included. Each patient was only listed once, and the index operation was defined as the latest lumbar spine surgery during the above-mentioned period. Those patients who had undergone lumbar reoperation after June 1st, 2008 were excluded. Those with an insufficient capacity in Finnish language, major psychiatric illness, progressive neurological illness, progressive cancer, severe systemic illness or abuse problem were also excluded. The ICD-10 diagnosis code for spinal disease and any previous lumbar spine operations before the index surgery were recorded. The questionnaires and a consent form were sent to all traceable patients in September, 2009. Another set of questionnaires was sent to those who did not reply within a month, and if they had still not replied within two weeks of receiving the second mail, they were contacted by telephone to confirm their willingness to participate. Relevant clinical data, including information on the trial or implantation of SCS, were updated from patient records until the end of June, 2015.

The study protocol was approved by the local ethics committee and the patients provided their informed consent in writing.

4.2 Questionnaires

4.2.1 Follow-up questionnaire

The follow-up questionnaire included questions regarding the occurrence of pain (never, occasionally, daily or almost daily, and all the time), the average intensity of pain (on a numerical rating scale, NRS, 0–10) and pain-associated disability
Axial low back pain and radicular pain were assessed separately. Medications used regularly and occasionally for low back pain and their efficacy was noted. Patients were asked to record their weight (kg) and height (m), from which their BMI was calculated. Leisure-time physical activity was assessed by asking how often the individual exercised for over 30 minutes per week. Sleep disturbance caused by pain was queried using the options 0 = “not at all”, 1 = ”mild, wakens, but falls asleep again easily”, 2 = “moderate, sleep disturbed many nights a week” and 3 = “severe, sleep disturbed severely every night”.

4.2.2 Oswestry disability index (ODI)

The ODI contains ten items, each with six statements graded from zero (lowest disability) to five (greatest disability). The total score is calculated as a sum of each completed item and expressed as a percentage of the maximum number of possible points, i.e. related to the number of items the patient has answered (Fairbank & Pynsent 2000). Scores are defined by a scale according to the original publication: 0–20 minimal, 20–40 moderate and 40–60 severe disability. A score of 60–80 indicates a crippled patient and 80–100 indicates that the patient is either bedridden or is exaggerating their symptoms (Fairbank et al. 1980). The ODI has been validated in Finnish (Pekkanen et al. 2011).

4.2.3 International Classification of Functioning, Disability and Health (ICF)

The ICF is a framework for organising and documenting information on functioning and disability. It conceptualises functioning as dynamic interactions between a person’s health, environmental factors and personal factors. The ICF is also helpful in mixed methods research by providing common terminology for analysing and linking the content of quantitative and qualitative measures (Cieza et al. 2005, Sigl et al. 2006, WHO 2013). The ODI was linked to the ICF framework according to published guidelines (Cieza et al. 2005). The linking of the ODI to ICF is illustrated demonstratively in the paper published by Pekkanen et al. (2013) (Figure 2). The ten elements of ODI were linked to the ICF components for body functions and structures, activities and participation. Body functions were divided into “mental functions” and “sensory functions and pain”. Activity components were “mobility”, “self-care” and “interpersonal interactions and relationships”. Participations components were “mobility” and “community,
social and civic life”. The total score was expressed using a relative scale of zero to one hundred (Pekkanen et al. 2013).

4.2.4 The short form 36 health survey (SF-36)

The SF-36 is a self-administered 36-item questionnaire. It measures health status and outcomes for the following 8 health concepts: physical functioning (PF), role physical (RP), bodily pain (BP), social functioning (SF), mental health (MH), role emotional (RE), vitality (VT) and general health (GH). Item scores are coded, summed and transformed to a scale from 0 (worst possible health state measured by questionnaire) to 100 (best possible health state) for each variable. These eight

---

Fig. 2. Linking between the Oswestry Disability Index (ODI) items and the international Classification of Functioning, Disability and Health (ICF) (modified from Pekkanen et al. 2013).
domains were aggregated into two distinct summary components: mental and physical (Brazier et al. 1992, Jenkinson et al. 1993).

### 4.2.5 The Beck depression inventory (BDI)

The BDI is a 21-item self-report questionnaire for the assessment of possible depression and has been validated in Finnish (Beck et al. 1961, Beck and Steer 1988, Viinamäki et al. 2004). The cut-off point for increased depressive symptoms (DS) was 10, and has thereby been reported to be a feasible instrument for depression screening. In order to examine the effect of the subtypes of DS, we used a summary score of melancholic symptoms in BDI based on the DSM-IV defined criteria for melancholic depression (sadness, past failure, loss of pleasure, guilty feelings, punishment feelings, loss of interest, irritability, change in sleeping pattern and appetite), dividing the participants with increased DS into melancholic (MDS) and non-melancholic depressive symptom (NmDS) subgroups in a manner similar to that previously published (Ovaskainen et al. 2009, Seppälä et al. 2012, Vanhala et al. 2009).

### 4.2.6 Telephone interview

Telephone interviews were made by VJ and MV during September and October 2010. Patients were selected for phone interview as potential SCS candidates based on data from the follow-up questionnaire. The patients interviewed by telephone were those who had daily pain intensities (NRS) of 5–10 and whose radicular pain component was more dominant than their axial low back pain. Surgical, medical and other treatments and their outcomes, general health condition and working capacity were reviewed thoroughly over the course of the phone interview. After the structured phone interview, the researcher (VJ or MV) judged whether or not the patient was a candidate for SCS. Indications for SCS were a daily pain intensity (NRS) of 5–10 with a duration $\geq 6$ months despite appropriate non-invasive treatments, a dominant radicular pain component, no psychosocial contraindications for SCS (abuse problem, major psychiatric disorder, low cognitive capacity, on-going litigation process), no medical contraindications due to illnesses or their medication (e.g. anticoagulants), no indications for new lumbar surgery, and the patient’s own motivation for SCS treatment.
4.3 Statistical methods

The data is presented as means with standard deviations (SD) or as medians with an interquartile range (IOR) or as counts with percentages. Statistical significance for the hypothesis was evaluated using the chi-square test and generalized linear models (e.g. analysis of variance, regression analysis and logistic models). In the case of violation of the assumptions (e.g. non-normality), a bootstrap-type test and 95% confidence interval estimations were used. A possible nonlinear relationship between ODI and the BDI was assessed using regression analysis with quadratic term. The SCS incidence rates (per 1000 patient-years with 95% confidence intervals (CI)) were calculated assuming a Poisson distribution. Crude and adjusted estimates of SCS incidence were calculated using Poisson regression models, or negative binomial regression models when appropriate. The assumptions of overdispersion in the Poisson model was tested using the Lagrange multiplier test. We also estimated the cumulative incidence of SCS using the cumulative incidence function, which accounts for the competing risk of mortality. The normality of the variables was tested using the Shapiro-Wilk W test. Correlation coefficients were calculated by the Spearman method. The Stata 14.1, StataCorp LP (College Station, TX, USA) statistical software package was used for the analyses.
5 Results

5.1 Patients in the study

During the study period June 1st, 2005 to May 31st, 2008, lumbar spine operations due to non-traumatic lumbar disease were performed in 1180 patients. Of these, 11 had passed away by the beginning of this study. Of the surviving patients, 273 were excluded due to age, 43 due to other diseases, 28 due to a subsequent lumbar spine surgery after the index operation, 7 due to severe abuse problem and 4 due to insufficient capacity in the Finnish language. Hence the postal survey was mailed to 814 patients, of whom 537 (66%) replied. The respondents and the non-respondents were compared regarding gender, age and type of surgery. The only difference between respondents and non-respondents was age (the respondents were older, 45 years vs. 42 years). The demographic and clinical characteristics of the respondents are presented in Table 3.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Disc surgery</th>
<th>Stabilizing surgery</th>
<th>Decompression surgery</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of males (%)</td>
<td>214 (59)</td>
<td>30 (35)</td>
<td>49 (44)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>42 (10)</td>
<td>48 (10)</td>
<td>55 (8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>26.8 (4.2)</td>
<td>27.3 (5.4)</td>
<td>29.8 (5.8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Index operation first, n (%)</td>
<td>317 (88)</td>
<td>69 (82)</td>
<td>82 (90)</td>
<td>0.18</td>
</tr>
<tr>
<td>Diagnosis, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disc disorder with radiculopathy (M51.1)</td>
<td>357 (99)</td>
<td>11 (13)</td>
<td>9 (10)</td>
<td></td>
</tr>
<tr>
<td>Other intervertebral disc degeneration (M51.3)</td>
<td>4 (1)</td>
<td>16 (19)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Spinal stenosis (M48.0)</td>
<td>1 (0.3)</td>
<td>15 (18)</td>
<td>80 (88)</td>
<td></td>
</tr>
<tr>
<td>Spondylolisthesis (M43.1)</td>
<td>0 (0)</td>
<td>20 (24)</td>
<td>1 (1)</td>
<td></td>
</tr>
<tr>
<td>Postsurgical musculoskeletal disorder (M96)</td>
<td>0 (0)</td>
<td>23 (27)</td>
<td>1 (1)</td>
<td></td>
</tr>
</tbody>
</table>

Of the respondents, 361 (67%) underwent disc surgery, 85 (16%) stabilizing surgery and 91 (17%) decompression. Males dominated slightly in the disc surgeries and decompressions, while more females underwent stabilizing surgeries. The disc surgery group was the youngest (mean age 42 years) and the decompression group was the oldest (mean age 55 years). BMI was highest in the decompression group. The index operation was their first lumbar surgery in 87% (n = 468), compared to being the second lumbar surgery in 12% (n = 64). More
frequent lumbar operations were very rare; in four patients the index operation was their third and in one patient his fourth lumbar surgery. The follow-up time (median, IQR) was 31 (23, 39) months for disc surgery patients, 31 (22, 42) months for stabilizing surgery patients and 33 (22, 41) months for decompression patients, with no significant difference between the groups (p = 0.89).

5.2 Pain and pain-related disability (I)

The occurrence of pain is presented in Figure 3. Only a small minority of the patients was completely pain-free (1% in the stabilizing surgery group, 6% in the decompression group and 9% in the disc surgery group). Axial pain was slightly more intense than radicular pain. Pain was milder in the disc surgery group compared with the stabilizing surgery and decompression groups: mean (SD) axial pain with 0–10 NRS was 4.0 (2.3), 4.7 (2.4) and 4.8 (2.3) respectively (p = 0.002) and radicular pain 3.5 (2.6), 4.2 (2.8), 4.5 (2.6) respectively (p < 0.001). Pain-associated disability (with 0–10 NRS) was less severe in disc surgery group [4.6 (2.7)] compared to stabilizing surgery [5.8 (2.7)] or decompression [5.7 (2.3)] (p < 0.001).

Fig. 3. Occurrence of pain according to the type of surgery groups. Whiskers represent 95% confidence intervals.
5.3 Functional outcome (I)

The total ODI score (mean, SD) indicated minimal functional disability in the disc surgery group [20 (17)], moderate functional disability in the stabilizing surgery and decompression groups [35 (17) and 32 (17), respectively] (p < 0.001 after adjusting for age and sex). Figure 4 represents the distribution of ODI in the three surgery groups. The majority of the disc surgery patients had minimal disability. Moderate disability dominated in the stabilizing surgery and decompression groups.

![Fig. 4. Oswestry disability index according to the type of surgery. The box shows the distance between the quartiles, with the median marked as a line, and the whiskers show the 5th and 95th percentiles. A score of 0–20 indicates minimal disability, 20–40 moderate, 40–60 severe, 60–80 very severe disability and a score 80–100 a bedridden or exaggerating patient.](image)

5.4 Quality of life (I)

The results of the SF-36 scales in the three surgical groups are presented in Figure 5. The results for the disc surgery group were the best in most of the measurement methods. The physical component summary score (mean, SD) was 42 (11) in the
disc surgery group, 34 (10) in the stabilizing surgery group and 34 (10) in the decompression group (p < 0.001 after adjustment for age and sex). There was no significant difference in the mental component summary scores between the groups.

Fig. 5. The age- and sex-adjusted mean of SF-36 scales in the three surgical groups.

5.5 Depressive symptoms (II)

There were signs of depressive symptoms (BDI ≥ 10) in 116 (32%) cases after disc surgery, in 46 (54%) cases after stabilizing surgery, and in 51 (56%) cases after decompression surgery (p < 0.001 after adjusting for age, gender and follow-up time). Altogether 213 of 537 patients (39%) displayed depressive symptoms. Figure 6 shows the gender-specific occurrence of DS. Females in the disc surgery group displayed more DS. When DS patients were further analysed, we observed 153 (28%) patients with NmDS and 60 (11%) with MDS. The clinical characteristics of patients without DS (BDI < 10), with NmDS and with MDS are illustrated in Table
4. Males dominated in the BDI < 10 group (59%) and females in the MDS group (62%). Patients without DS were younger than patients with NmDS or MDS. NmDS patients had a higher mean BMI than the other groups. There were relatively fewer cases of disc surgery and more cases of stabilizing and decompression surgery in the NmDS and MDS groups, and these latter two groups had a higher rate of reoperations.

![Image of Fig. 6](https://example.com/fig6.png)

**Fig. 6.** Age- and follow-up time adjusted prevalence of depressive symptoms (depressive symptoms, Beck ≥ 10) according to the type of surgery. Whiskers indicate 95% confidence intervals.

The mean value for BDI in the NmDS group was 17.6 and 19.9 in the MDS group, with no significant difference between them. Sleep disturbances were significantly more common among DS patients compared to patients without DS. When comparing DS subtypes, MDS patients had significantly more disturbed sleep compared to NmDS patients (p = 0.033).

There was a significant difference in functional disability between the DS groups. MDS patients had a mean ODI of 41, which is in the lower limits for severe disability. NmDS patients showed a moderate (ODI score of 36) and patients without DS a minimal (ODI score of 16) disability.
Table 4. Clinical characteristics of patients with (BDI ≥ 10) and without (BDI < 10) depressive symptoms. Patients with depressive symptoms are divided into non-melancholic (NmDS) and melancholic (MDS) subgroups. Results after adjustment for age, gender and follow-up time.

<table>
<thead>
<tr>
<th>Variables</th>
<th>BDI &lt; 10</th>
<th>NmDS</th>
<th>MDS</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of males, n (%)</td>
<td>190 (59)</td>
<td>81 (53)</td>
<td>23 (38)</td>
<td>0.013</td>
</tr>
<tr>
<td>Age, years, mean (SD)</td>
<td>44 (11)</td>
<td>47 (10)</td>
<td>48 (10)</td>
<td>0.003</td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>26.7 (4.0)</td>
<td>28.6 (5.6)</td>
<td>27.8 (6.1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Index operation, first, n (%)</td>
<td>293 (90)</td>
<td>126 (82)</td>
<td>48 (80)</td>
<td>0.012</td>
</tr>
<tr>
<td>Follow-up time, months, mean (SD)</td>
<td>31 (10)</td>
<td>31 (10)</td>
<td>32 (11)</td>
<td>0.84</td>
</tr>
<tr>
<td>Surgery, n (%)</td>
<td>245 (76)</td>
<td>84 (55)</td>
<td>32 (53)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Disc surgery</td>
<td>39 (12)</td>
<td>34 (22)</td>
<td>12 (20)</td>
<td></td>
</tr>
<tr>
<td>Stabilizing surgery</td>
<td>40 (12)</td>
<td>35 (23)</td>
<td>16 (27)</td>
<td></td>
</tr>
<tr>
<td>Diagnosis, n (%)</td>
<td>255 (79)</td>
<td>89 (58)</td>
<td>33 (55)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Disc disorder with radiculopathy (M51.1)</td>
<td>6 (2)</td>
<td>10 (7)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>Other intervertebral disc degeneration (M51.3)</td>
<td>43 (13)</td>
<td>36 (24)</td>
<td>17 (28)</td>
<td></td>
</tr>
<tr>
<td>Spinal stenosis (M48.0)</td>
<td>11 (3)</td>
<td>8 (5)</td>
<td>2 (3)</td>
<td></td>
</tr>
<tr>
<td>Spondylolisthesis (M43.1)</td>
<td>9 (3)</td>
<td>10 (7)</td>
<td>5 (8)</td>
<td></td>
</tr>
<tr>
<td>Postsurgical musculoskeletal disorder (M96.0)</td>
<td>4.0 (2.9)</td>
<td>17.6 (6.8)</td>
<td>19.9 (10.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Beck index, mean (SD)</td>
<td>48 (15)</td>
<td>72 (47)</td>
<td>38 (63)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>High frequency of pain², n (%)</td>
<td>129 (40)</td>
<td>124 (81)</td>
<td>53 (88)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>ODI, mean (SD)</td>
<td>16 (15)</td>
<td>36 (15)</td>
<td>41 (18)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Leisure time physical activity, n (%)</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>60 (20)</td>
<td>36 (26)</td>
<td>14 (25)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>225 (73)</td>
<td>92 (66)</td>
<td>34 (61)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>22 (7)</td>
<td>11 (8)</td>
<td>8 (14)</td>
<td></td>
</tr>
<tr>
<td>Regular pain medication, n (%)</td>
<td>231 (71)</td>
<td>143 (93)</td>
<td>52 (87)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Response to pain medication (NRS 0–10), mean (SD)</td>
<td>6.5 (2.3)</td>
<td>5.8 (2.3)</td>
<td>5.6 (2.5)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

¹ from moderate to severe, ² more than once a week

NmDS and MDS patients suffered from pain more frequently than patients without DS: 88% of MDS patients and 81% of NmDS patients had pain more than once a week compared to 40% of patients without DS. There were significant differences in the mean intensity of local LBP, radiculating leg pain and pain-related disability (Figure 7).
5.6 Pain medication (II)

The nine most commonly used pain-killers reported by the respondents are presented in Table 5. NSAIDs were the most common (47%) followed by weak opioids (31%) and paracetamol (19%). Strong opioids were used by 3% of the patients.

Differences were observed in the use of pain medication between groups. After disc surgery 83 (23.1%) patients had no regular medication, 202 (56.3%) had one and 74 (20.6%) two or more regular pain medication in use. The regular use of pain medication was more common after stabilizing and decompression surgery. After stabilizing surgery, 5 subjects (6.0%) had no medication, 30 (35.7%) had one and 49 (58.3%) two or more regular pain medication in use. After decompression surgery the corresponding numbers were 10 (11.4%), 41 (46.6%) and 37 (42.0%), respectively (p < 0.001).

Regular pain medication was estimated according to BDI (BDI < 10, NmDS and MDS). Regular medication for pain was frequent in all groups, being most common in the NmDS patients’ group. The mean response to pain medication (NRS...
0–10) was best in the BDI < 10 group and worst in the MDS patients’ group. There were no differences in the use of NSAIDs between the groups. The use of weak opioids was significantly more common in the NmDS and the MDS groups. The use of paracetamol was highest in the MDS group. Gabapentinoids were used most commonly in both DS groups. The use of strong opioids was rare in the entire population, and their use was highest in the NmDS group (Table 5, Figure 8).

Fig. 8. Use of the nine most common regular pain medications in the different groups of depressive symptoms (adjusted for age, gender and follow-up time).
Table 5. The nine most common regular pain medications in the total study population and divided into the different groups of depressive symptoms.

<table>
<thead>
<tr>
<th>Regular pain medication</th>
<th>Number of users, total n = 537</th>
<th>BDI &lt; 10 n = 324</th>
<th>NnDS n = 153</th>
<th>MDS n = 60</th>
<th>P-value¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSAID²</td>
<td>254 (47)</td>
<td>153 (47)</td>
<td>75 (49)</td>
<td>26 (43)</td>
<td>0.74</td>
</tr>
<tr>
<td>Weak opioids</td>
<td>168 (31)</td>
<td>68 (21)</td>
<td>71 (46)</td>
<td>29 (48)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Paracetamol</td>
<td>100 (19)</td>
<td>45 (14)</td>
<td>34 (22)</td>
<td>21 (35)</td>
<td>0.008</td>
</tr>
<tr>
<td>Gabapentinoids</td>
<td>62 (12)</td>
<td>20 (6)</td>
<td>31 (20)</td>
<td>11 (18)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Centrally acting muscle relaxants</td>
<td>50 (9)</td>
<td>23 (7)</td>
<td>23 (15)</td>
<td>4 (7)</td>
<td>0.015</td>
</tr>
<tr>
<td>Tricyclic antidepressants</td>
<td>45 (8)</td>
<td>19 (6)</td>
<td>19 (12)</td>
<td>7 (12)</td>
<td>0.058</td>
</tr>
<tr>
<td>Strong opioids</td>
<td>16 (3)</td>
<td>2 (1)</td>
<td>12 (8)</td>
<td>2 (3)</td>
<td>0.003</td>
</tr>
<tr>
<td>SNRI³-antidepressants</td>
<td>10 (2)</td>
<td>1 (1)</td>
<td>8 (5)</td>
<td>1 (2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Sodium channel blockers</td>
<td>4 (0.7)</td>
<td>0 (0)</td>
<td>4 (3)</td>
<td>0 (0)</td>
<td>0.061</td>
</tr>
</tbody>
</table>

¹ adjusted for age, gender and follow-up time, ² Non-Steroidal Anti-Inflammatory Drug, ³ Serotonin-Norepinephrine Reuptake Inhibitor

5.7 Impact of weight in disc surgery (III)

The mean BMI was 26.6 in the disc surgery group. Patients were divided into three groups according to BMI: BMI < 25: Normal, BMI ≥ 25 and < 30: Pre-obese, BMI ≥ 30: Obese (Table 6). Males dominated in the pre-obese (66%) and obese (62%) groups. Pre-obese and obese patients gained weight during the follow-up, while those with a normal weight remained at their baseline weight. The index operation was the first one for 92% of normal, 88% of pre-obese and 80% of obese patients with a tendency towards a higher prevalence of reoperation among the obese patients. According to the BDI, normal-weighted and pre-obese patients had no depression, but obese patients had higher scores indicating mild mood disturbances. According to the ODI scores, normal-weighted and pre-obese patients had minimal functional disability, but the obese had a moderate functional disability. There was a strong positive relationship between ODI and BDI scores (Spearman correlation 0.67, 95% CI: 0.61 to 0.73). Figure 9 shows the relationship between ODI and BDI according to different BMI groups. The association was strongest in the most obese patients. There were no significant differences in pain frequency, intensity, or location (axial or radicular), disability or sleep in the different BMI groups.
Table 6. Comparison of normal-weighted, pre-obese and obese disc surgery patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal (BMI &lt; 25)</th>
<th>Pre-obese (BMI ≥ 25)</th>
<th>Obese (BMI ≥ 30)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of males, (%)</td>
<td>62 (49)</td>
<td>108 (66)</td>
<td>40 (62)</td>
<td>0.010</td>
</tr>
<tr>
<td>Age, years, mean (SD)</td>
<td>41 (10)</td>
<td>43 (10)</td>
<td>42 (9)</td>
<td>0.26</td>
</tr>
<tr>
<td>Weight gain, kg, mean (SD)</td>
<td>-0.9 (4.8)</td>
<td>1.6 (4.2)</td>
<td>2.4 (7.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Weight change, %, median (IQR)</td>
<td>0 (-3, 3)</td>
<td>2 (-1, 5)</td>
<td>2 (-2, 7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>The first lumbar operation was the index operation¹, n (%)</td>
<td>117 (92)</td>
<td>143 (88)</td>
<td>52 (80)</td>
<td>0.051</td>
</tr>
<tr>
<td>High frequency of pain², n (%)</td>
<td>46 (36)</td>
<td>53 (33)</td>
<td>28 (43)</td>
<td>0.32</td>
</tr>
<tr>
<td>NRS, mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low back pain</td>
<td>3.5 (2.4)</td>
<td>3.7 (2.4)</td>
<td>4.2 (2.7)</td>
<td>0.15</td>
</tr>
<tr>
<td>Radiculating pain</td>
<td>3.3 (2.6)</td>
<td>3.0 (2.6)</td>
<td>3.5 (3.1)</td>
<td>0.52</td>
</tr>
<tr>
<td>Disability</td>
<td>4.0 (2.8)</td>
<td>4.2 (2.7)</td>
<td>4.8 (3.1)</td>
<td>0.21</td>
</tr>
<tr>
<td>Sleep disturbances³</td>
<td>88 (69)</td>
<td>112 (69)</td>
<td>48 (74)</td>
<td>0.74</td>
</tr>
<tr>
<td>Regular medication, n (%)</td>
<td>25 (20)</td>
<td>3 (19)</td>
<td>18 (28)</td>
<td>0.32</td>
</tr>
<tr>
<td>Beck, mean (SD)</td>
<td>8.0 (8.5)</td>
<td>7.6 (8.0)</td>
<td>11.2 (10.5)</td>
<td>0.035</td>
</tr>
<tr>
<td>Leisure time physical activity, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.61</td>
</tr>
<tr>
<td>Low</td>
<td>26 (20)</td>
<td>37 (23)</td>
<td>15 (23)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>67 (53)</td>
<td>95 (58)</td>
<td>34 (52)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>34 (27)</td>
<td>31 (19)</td>
<td>16 (25)</td>
<td></td>
</tr>
<tr>
<td>ODI, mean (SD)</td>
<td>20.3 (16.3)</td>
<td>18.6 (16.9)</td>
<td>26.4 (19.9)</td>
<td>0.011</td>
</tr>
<tr>
<td>Observation time, months, median (IQR)</td>
<td>33 (24, 40)</td>
<td>31 (24, 41)</td>
<td>29 (20, 33)</td>
<td>0.039</td>
</tr>
</tbody>
</table>

¹ the latest lumbar disc surgery during the study period, ² more than once a week, ³ every disturbances from moderate to severe were included

Fig. 9. The relationships between Oswestry Disability Index and BDI (Beck Depression Inventory) according to BMI group. The association was strongest in the most obese patients. The line shows estimated quadratic relations with 95% confidence intervals.
5.8 Spinal cord stimulation (IV)

In the entire lumbar spine surgery cohort (respondents and non-respondents n = 814) a total of 6741 person-years were followed up in 459 men and 350 women. During the follow-up [median 8.4 years (IQR 7.7–9.2)], 21 patients [3.0% (95% CI: 0.7 to 4.8)] underwent SCS implantation. The total incidence of SCS was 3.12 per 1000 person-years (95% CI: 2.03 to 4.78). The corresponding numbers for women and men were 3.75 (95% CI: 2.08 to 6.78) and 2.62 (95% CI: 1.41 to 4.88), respectively. The age- and diagnosis-adjusted incidence rate was 1.33 (95% CI: 0.55 to 3.22).

The success of SCS treatment was evaluated using patient records from these 21 SCS patients. Three stimulators were removed after the trial period and three shortly (2 to 8 months) after implantation. Fifteen (71%) received benefit from and continued to use the SCS. Eight patients continued or returned to work whereas 7 have retired. Two patients were reported to gain excellent pain relief from the SCS and were able to discontinue all pain medication. Modifications in pain medication were not routinely documented. Complications were rare (no hematomas or infections, one post-spinal headache, five lead revisions, one completely replaced device, two devices removed because the need for MRI). The mean time to implantation of the stimulator after the index surgery was 65 months (min 26, max 93 months). The cumulative incidence was constant up to nine years (Figure 10).

Fig. 10. Cumulative incidence of SCS. Grey area show 95% confidence intervals.
The postal survey was replied to by 537 patients (66%). Eleven of them had received SCS treatment subsequent to their reply. Features which predicted SCS implantation were daily or continuous pain, higher pain intensity with a predominantly radicular pain, more severe pain-related functional disability, more depressive symptoms and less benefit from pain medication (Table 7).

Table 7. Predictive factors for SCS implantation. Comparison of respondents who did or did not have a SCS device implanted during the follow-up period after they had responded to the survey. Two patients had already received an implant at the time of the questionnaire and their results were excluded from this comparison.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Without SCS</th>
<th>With SCS</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 526</td>
<td>n = 11</td>
<td></td>
</tr>
<tr>
<td>Number of male, (%)</td>
<td>288 (55)</td>
<td>6 (55)</td>
<td>0.99</td>
</tr>
<tr>
<td>Age, years, mean (SD)</td>
<td>45 (11)</td>
<td>43 (8)</td>
<td>0.39</td>
</tr>
<tr>
<td>BMI1, mean (SD)</td>
<td>27.3 (4.8)</td>
<td>28.9 (6.1)</td>
<td>0.31</td>
</tr>
<tr>
<td>Index operation first, n (%)</td>
<td>459 (87)</td>
<td>9 (82)</td>
<td>0.64</td>
</tr>
<tr>
<td>Type of surgery, n (%)</td>
<td></td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>Disc surgery</td>
<td>355 (66)</td>
<td>6 (55)</td>
<td></td>
</tr>
<tr>
<td>Stabilizing surgery</td>
<td>83 (16)</td>
<td>2 (18)</td>
<td></td>
</tr>
<tr>
<td>Decompression</td>
<td>87 (17)</td>
<td>3 (27)</td>
<td></td>
</tr>
<tr>
<td>Occurrence of pain, n (%)</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>None</td>
<td>40 (8)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Occasionally</td>
<td>191 (37)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Daily</td>
<td>243 (47)</td>
<td>4 (36)</td>
<td></td>
</tr>
<tr>
<td>All the time</td>
<td>46 (9)</td>
<td>7 (64)</td>
<td></td>
</tr>
<tr>
<td>Pain intensity (NRS2), mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axial low back pain</td>
<td>4.2 (2.3)</td>
<td>5.8 (2.3)</td>
<td>0.031</td>
</tr>
<tr>
<td>Radicular pain</td>
<td>3.7 (2.7)</td>
<td>6.3 (1.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>Disability (NRS), mean (SD)</td>
<td>4.9 (2.7)</td>
<td>7.4 (1.6)</td>
<td>0.003</td>
</tr>
<tr>
<td>ODI3, mean (SD)</td>
<td>24 (18)</td>
<td>49 (9)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BDI4, mean (SD)</td>
<td>9.2 (8.7)</td>
<td>22.1 (10)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BDI ≥ 10, n (%)</td>
<td>201 (38)</td>
<td>10 (91)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Response to pain medication, (NRS 0–10), mean (SD)</td>
<td>6.2 (2.3)</td>
<td>4.0 (1.4)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

1 Body Mass Index, 2 Numerical Rating Scale, 3 Oswestry Disability Index, 4 Beck Depression Inventory

There were 110 respondents whose pain profiles fulfilled the criteria for a phone interview. According to patient records, four of these had been operated on subsequent to the index operation, two had passed away and four were already undergoing SCS when answering the survey. One hundred patients were interviewed via telephone. Fourteen of these appeared to be potential SCS
candidates. Eleven patients received SCS after they had responded to the survey. Two of these were classified as potential candidates according to the interview, nine patients were chosen otherwise. Twelve patients who appeared to be potential SCS candidates during the phone interview in 2010 were not in any SCS treatment pathway as of 2015 (Table 8).

Table 8. Number of potential SCS candidates according to the phone interview in 2010 compared to number of implanted SCS devices until 2015.

<table>
<thead>
<tr>
<th>SCS candidate</th>
<th>SCS implanted</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>514</td>
<td>9</td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>526</td>
<td>11</td>
</tr>
</tbody>
</table>
6 Discussion

6.1 Patients

The main focus of this study was to examine working-age (18–65 years) patients. This age-restriction led to the exclusion of 23% of the original surgical cohort (273 out of 1180 patients). The disc surgery group was the youngest (mean age 42 years) and the decompression group the oldest (mean age 55 years), while the mean age for those patients undergoing fusion surgery was 48 years. This reflects the natural course of degenerative spine disorders.

6.2 Methodological considerations

The importance of questionnaire surveys in medicine is great. As a research tool, questionnaires are inexpensive and quick methods. They may aid in defining the incidence of disease and can be used to investigate quality of life and need for health services. Questionnaires complement data included in patient records as information is collected in a systematic way. Questionnaires can be used in all medical investigations as a source of information regardless of research method (Eaden et al. 1999).

Questions should be explicit and technically simple. They can be open or closed types. Open-ended questions are more difficult to analyse but encourage qualitative responses. Dichotomous questions (a yes/no answer) are used in quantitative studies. They allow a numerical value to be attached to the response and are associated with significant reproducibility and reliability. Accurate data collection can be achieved, however, using all these types of questions (Eaden et al. 1999).

In the present study, the self-made questionnaire included closed questions which allowed responders to choose among a set of provided response alternatives, were completed by open-ended questions with the possibility to comment on the question and numerical scales. A self-made questionnaire was used to identify the type, intensity and location of pain and pain related disability (Haanpää et al. 2009). ODI, BDI, IA and SF-36 have all been validated in Finnish. Telephone interviews were carried out by two investigators in a structured way.

To facilitate an acceptable response rate, those patients who had not filled in and returned the questionnaire forms within a month were sent another set of
questionnaires. If they had not replied to these in a further two weeks, they were approached via telephone by one of the investigators.

6.3 Outcome of disc surgery

Only 9% of the patients were completely pain free after disc surgery. Mean pain intensity was 4/10 according to NRS. This is more than in a Swedish study, in which the VAS was 22/100 at the 1-year point (Strömqvist et al. 2013). We had no record of preoperative pain levels and it is not known if the patient material or indications are the same between Sweden and Finland. The outcome was good regarding functional capacity and quality of life. There is no published data on the outcome of discectomies in working-aged patients. Dewing et al. reported similar functional outcomes of lumbar microdiscectomy in a younger (19–46 years) population (Dewing et al. 2008). Häkkinen et al. reported a similar functional outcome in adults (> 17 years) after a one-year follow-up. Our results are likewise in line with those reported in the Swedish Swespine register, functional disability was minimal and quality of life good after disc surgery (Strömqvist et al. 2009, Strömqvist et al. 2013).

6.4 Outcome of stabilizing surgery and decompression

Stabilizing surgery and decompression are more demanding surgery. Patients are older and their condition often more serious than when compared to disc surgery. The outcome after stabilizing surgery and decompression was less favourable than that after disc surgery when we evaluated pain, functional capacity and quality of life. Patients frequently reported suffering from pain: 74% in the stabilizing surgery group and 70% in the decompression group had constant or daily pain. The mean pain intensity was moderate (NRS 4.2–4.8). Pain intensity was higher than the VAS reported in the Swedish register study at 1-year point (VAS 27–31/100) (Strömqvist et al. 2013). Radicular pain was somewhat milder than axial pain, which is in agreement with the fact that spinal surgery mainly alleviates radicular pain.

After stabilizing surgery and decompressions, patients achieved moderate functional capacity according to the ODI scores recorded. This is in agreement with previously published studies both after stabilizing surgery (Andersen et al. 2008, Brox et al. 2006, Glassman et al. 2006) and after decompressions (Forsth et al. 2016, Jones et al. 2014, McGregor & Hughes 2002, Sigmundsson et al. 2015). Functional outcomes reported in the 2012 Swedish spine register report were also
similar to our results at the 1- and 2-year follow-up: disc patients had minimal functional disability, while the functional outcome was moderate after decompression and stabilizing surgery (Strömqvist et al. 2013). Our study population was of a working-age, and the mean age in our decompression group was 55 years. Spinal stenosis is very common in elderly patients, and the patients’ mean age has been higher in previous studies, so the results are therefore not directly comparable.

Quality of life according to SF-36 was significantly poorer after stabilizing surgery and decompressions compared to disc surgery. This difference was mainly observed in the physical components. A summary of the mental component results did not differ significantly between the different surgery groups. Our physical components summary results were slightly worse compared to other studies (Andersen et al. 2008, Sigmundsson et al. 2015), but the results are not directly comparable due to age differences.

6.5 Depressive symptoms after spinal surgery

There was stronger correlation for depressive symptoms (BDI > 10) after stabilizing surgery (54%) and decompression (56%) compared to disc surgery (32%). Depressive symptoms were associated with poorer functional outcome and pain relief after lumbar spine surgery. In this study, we had no preoperative information about depression. Patients who need stabilizing surgery or decompression often suffer from a more serious and chronic pain condition compared to disc surgery patients. Previous studies have demonstrated that depression is one of the strongest prognostic indicators for a poor outcome after spinal surgery (Hagg et al. 2003, LaCaille et al. 2005, Pakarinen et al. 2014, Sinikallio et al. 2011, Trief et al. 2006, Wahlman et al. 2014).

Depression can be divided into two main subgroups: melancholic (MDS) and non-melancholic (NmDS) depression (Lamers et al. 2010). These two depression types have different symptom profiles. NmDS is marked by fatigue, increased appetite and weight gain, mood reactivity and interpersonal rejection sensitivity. MDS is characterized by anhedonia, non-reactive mood, and symptoms of insomnia, loss of appetite, mood variation and impaired concentration (Penninx et al. 2013). Melancholic depression is considered to be a more multifaceted biological condition (Fried & Nesse 2015, Penninx et al. 2013). In the literature, the majority of depressive individuals are of the MDS type (Lamers et al. 2010,
Lamers et al. 2012). In our results, the distribution of depressive symptoms was different after lumbar surgery - the majority being of the NmDS type.

To our knowledge, this is the first study to examine the role that different depression subtypes have in modifying the outcome of spinal surgery. MDS patients had a poorer outcome as compared to NmDS patients or patients without depression. MDS patients had more pain and more pain-interference with function. They used more, but had less relief from pain medication.

6.6 Impact of weight on outcome of disc surgery

Disc surgery patients were divided into three groups according to BMI: normal-weighted, pre-obese and obese. There were no significant differences in intensity, frequency or localization of pain between groups. Our observation is in agreement with the previous study of Tomasino et al. in patients undergoing minimally invasive spinal surgery (Tomasino et al. 2009). In the present study, differences could be seen when psychological and functional capacity was compared: functional disability, depressed mood and social activities were worst among obese patients.

Obese patients received higher BDI scores, which indicate mild mood disturbances. There are studies which show that patients undergoing herniated disc surgery are often affected by depression, and that postoperatively the depression status improves significantly with pain relief (Farzanegan et al. 2011, Lebow et al. 2012, Lobner et al. 2012). Farzanegan et al. did not find an association between BMI and postoperative depression, but they employed a lower BMI cut-off-point (25) than we had (Farzanegan et al. 2011). In our study, a difference in BDI could only be observed in the truly obese patients (BMI > 30); pre-obese patients displayed results similar to the normal-weighted.

Functional capacity was significantly worsened in the obese group according to the ODI scores. Rihn et al. have reported similar results (Rihn et al. 2013). Obese and pre-obese patients gained weight during the follow-up. When functional outcome was further analysed with ICF in our study, every component that was movement-related was minimized in obese patients: mobility, self-care and interpersonal interactions and relationships.

There was a tendency towards a higher reoperation rate in the obese patients’ group. Obese patients have a higher risk for the development of CLBP and disc degeneration (Shiri et al. 2010). Obesity is associated with surgical complications and a higher reoperation rate (Jiang et al. 2014, Seicean et al. 2014). In future,
obese patients will present for disc surgery more frequently. The increased risk for morbidity should be considered when deciding whether or not to operate.

6.7 Pain medication

The use of pain medication was in agreement with the Finnish Current Care Guideline for the treatment of low back pain (Low back pain: Current Care Guidelines Abstract, 2015). The three most commonly used pain medications were non-steroidal anti-inflammatory drugs (NSAID), weak opioids and paracetamol, in that order. Nearly half of the patients used NSAIDs, one third used weak opioids and one fifth used paracetamol. Depressive patients used pain medication on a more regular basis than did the non-depressive. This could be seen in the use of paracetamol, weak opioids, tricyclic antidepressants, gabapentinoids (gabapentin, pregabalin) and central acting muscle relaxants.

The use of strong opioids was rare (3%). It was most common in the NmDS group, of which 8% used strong opioids. Systematic reviews have demonstrated scant evidence of efficacy in the use of strong opioids for CLBP (Deyo et al. 2015). Opioids have a short-term analgesic efficacy, but the long-term effectiveness and safety of opioids are unknown. The regular use of strong opioids may cause more harm than benefits. In this material, the prevalence of the regular use of strong opioids was adequately low. The use of muscle relaxant was common (9%), though there is only weak evidence as to its efficacy (Bernstein et al. 2004).

6.8 Availability of spinal cord stimulators

There was a relatively low incidence of SCS for surgically operated CBLP patients, and this was targeted to the most difficult pain conditions, with good outcome and few complications. Features which predicted SCS implantation were daily or continuous pain, higher pain intensity with predominant radicular pain, more severe pain-related functional disability, more depressive symptoms and a lesser benefit from pain medication. According to our results, patient selection was compatible with international criteria (Gybel et al. 1998), but patient selection was rather strict. Also, according to the phone interview, it appeared that there are potential SCS candidates among this cohort which have been excluded from SCS treatment.

The mean waiting time for SCS in our hospital was 65 months which is about the same as in a retrospective analysis of 437 SCS patients in Canada (Kumar et al. 2014). The cumulative incidence of SCS was constant up to nine years. It has
previously been demonstrated that the long-term success rate of SCS is inversely proportional to the time interval between the beginning of the chronic pain syndrome and the implantation time. Efficacy for SCS exceeds 85% if implantation occurs within 2 years of symptom onset (Kumar et al. 2014). Very few of our patients received SCS within two years of the index operation in this region.

6.9 Limitations of this study

The strengths of our study include a large study population from a geographically defined area and a high response rate to postal questioning. The weaknesses of our study are its cross-sectional setting, the lack of a control group, the limited number of measurements and the lack of preoperative information regarding pain, ODI, DS and quality of life. Surgical techniques and postoperative rehabilitation programs were not standardized. Although the initial number of lumbar surgery patients was high, the number of SCS patients was low and this somewhat impairs any comparison. The success of the SCS treatment was evaluated via patient records. Documentation was largely operation-orientated and possible changes in pain profile, medication, functional disabilities, quality of life and/or mood disturbances were not systematically documented.
7 Clinical implications and future perspectives

A nationwide systematic register is needed to follow the outcomes of lumbar spine surgery patients. This register could serve as a monitor of surgical activities, and enable the observation of changes in trends regarding indications, techniques and treatments utilized as well as outcome.

Depressive symptoms should be kept in mind when patients are being scheduled for lumbar spine surgery. Those with depressive symptoms might benefit from well-tailored rehabilitation programme both pre- and postoperatively.

A strategy to rehabilitate and activate obese patients before and after lumbar disc surgery might improve the outcome. Possible methods could be individualized psycho-physiotherapy and encouragement to increase physical activity. Other lumbar spine surgery patients would probably also benefit from this strategy.

It appears SCS treatment is only used for the treatment of very serious pain conditions in our region. This treatment option is not a prominently known option in the patients’ treatment pathway and it may be possible that it is not being offered to all potential candidates. A regional strategy should be implemented to reach these patients in time.
8 Conclusions

1. Half of disc surgery patients had no or negligible pain postoperatively, whereas almost 2/3 suffered from daily pain after stabilizing surgery and decompressions. Axial pain was slightly more intense than radicular pain and pain intensity was lowest in disc surgery patients. Functional outcome and quality of life were good after disc surgery and moderate after stabilizing surgery and decompressions. Depressive symptoms were more usual after stabilizing surgery and decompression than they were in disc surgery patients.

2. Both non-melancholic (NmDS) and particularly melancholic depressive symptoms (MDS) were associated with poorer outcome after lumbar spine surgery. MDS patients had more pain and more pain interference with function. MDS patients used more pain medication, but had less of a response to regular pain medication.

3. Obesity had an impact on outcome in lumbar disc surgery. Obese patients had more mood disturbances and a higher rate of functional disability compared to the normal-weighted and pre-obese. Pre-obese and obese patients gained weight during the follow-up time.

4. Patient selection for the SCS treatment was performed according to international criteria. This treatment option was only used for very serious cases and might not be available for all potential candidates. There were not more re-operations before SCS implantation, but the waiting times were still too long.
References


**Original publications**


The original publications have been reproduced with the kind permission of the copyright holders.

Original publications are not included in the electronic version of the dissertation.
1435. Ramsay, Hugh (2017) Predictors of psychosis risk and neurocognitive deficits
1436. Kuitunen, Hanne (2017) DLBCL, primary and secondary central nervous system involvement, treatment and prophylaxis
1437. Filizova, Svetlana (2017) Incidence of schizophrenia and associations of schizophrenia and schizotypy with early motor developmental milestones
1438. Käräjämäki, Aki (2017) Non-alcoholic fatty liver disease (NAFLD) : perspectives to etiology, complications and lipid metabolism
1440. Hagnäs, Magnus (2018) The association of cardiorespiratory fitness, physical activity and ischemic ECG findings with coronary heart disease-related deaths among men
1441. Huhtaniska, Sanna (2018) The association between antipsychotic and benzodiazepine use with brain morphology and its changes in schizophrenia
1442. Sundquist, Elias (2018) The role of tumor microenvironment on oral tongue cancer invasion and prognosis
1449. Kajula, Outi (2017) Periytyvän rintasyöpäalttiusmutaation (BRCA1/2) kantajamiesten hypoteetteetin perinnöllisyysneuvontamalli

Book orders:
Granum: Virtual book store
http://granum.uta.fi/granum/
Voitto Järvimäki

LUMBAR SPINE SURGERY, RESULTS AND FACTORS PREDICTING OUTCOME IN WORKING-AGED PATIENTS