Corticosteroids in Lumbar Disc Surgery

ANDERS LUNDIN
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Abstract

In a prospective randomised double-blind study eighty patients with MRI verified lumbar disc herniation and corresponding clinical findings underwent microscopic disc removal. The patients were peroperatively given systemic and local corticosteroids or placebo, and followed for 2 years. The hospital stay and time to return to full-time work was significantly shorter in the treatment group. Pain measured as worst pain during the last week was also lower in the corticosteroid group. The results indicate that peroperative treatment with corticosteroids reducing pain and improves the functional outcome in patients operated for lumbar disc herniations.

To evaluate whether thermal quantitative sensory testing (QST) is applicable in the study of sensory dysfunction in lumbar disc herniations 66 patients with disc herniations underwent thermal QST. We found that thermal QST reflects sensory dysfunction in patients with lumbar disc herniations. However, thermal QST seems to have a poor predictive value for identifying the anatomic location of a herniated lumbar disc.

Quantitative sensory testing (QST) was used to detect damage to the myelinated A-delta fibres (cold sense) and the unmyelinated C-fibres (warmth sense). Corticosteroids combined with surgery in lumbar disc surgery improved the normalisation for the warmth disturbance compared to the control group.

A prospective analysis was performed on the predictive value of preoperatively determined lumbar lordosis and flexion for pain and disability in patients treated by microscopic lumbar disc surgery. Preoperative hyperlordosis correlated to more pain postoperatively (p=0.004). In patients with hypoflexion there was an association between hyperlordosis and moderate or severe pain postoperatively (p<0.001). The same outcomes were found for DRI. The stiff and straight back indicates a good outcome of lumbar disc surgery concerning pain and disability.

Keywords: lumbar disc herniation, corticosteroids, outcome, thermal quantitative sensory testing, QST, VAS, disability rating index, DRI, microscopic discectomy

Anders Lundin, Department of Surgical Sciences, Akademiska sjukhuset, Uppsala University, SE-75185 Uppsala, Sweden

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List of papers

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### Abbreviations

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<tr>
<td>CNS</td>
<td>Central nervous system</td>
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<tr>
<td>DRI</td>
<td>Disability Rating Index</td>
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<tr>
<td>QST</td>
<td>Quantitative sensory testing</td>
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<tr>
<td>TNF</td>
<td>Tumor necrosis factor</td>
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<tr>
<td>VAS</td>
<td>Visual analogue scale</td>
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<tr>
<td>VAS-N</td>
<td>Pain right now</td>
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<td>VAS-W</td>
<td>Worst pain during the past week</td>
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Introduction

Sciatica, defined as a pain in the leg extending below the knee and following a dermatome, with or without concomitant disturbance of the sensibility muscle function or reflexes will, in most cases, have its cause in a lumbar disc herniation. The diagnosis is confirmed by the use of a CT-scan or MRI. The cause of the pain is not fully understood but both the mechanical effects of the herniated disc on the affected nerve and the chemical factors released from the disc seem to contribute to the condition[1, 2]. In addition, the impact of psychological factors on the experience of pain is significant[3]. Thus, the factors causing sciatica might be divided into mechanical, chemical and psychological.

Mechanical

During the first period following the discovery by Mixter and Barr [4] of a herniated disc as a cause of sciatica, the mechanism behind the pain was regarded to be mechanical pressure caused by the nucleus pulposus on the nerve root. A peripheral nerve that sustains pressure will change its morphology and function [5] and so will also a spinal nerve root [6]. The development of better methods in diagnosing disc herniation such as CT-scan and MRI raised the question regarding other pain mechanisms, since by means of these new methods, it became apparent that it was possible to have disc herniation without pain and vice versa.[7]. It was also noticed during operation using local anaesthesia, that sciatica could be produced by pressure of an inflamed nerve root[8].

Chemical

During the last decades more and more research has focused on the chemical impact on the nerve to explain the pain. Saal and co-workers [9] found very high levels of Phospholipase-A2 in the discs of patients who underwent surgery for radiculopathy. This enzyme plays an important role in the inflammatory cascade. It influences the production of prostaglandins and leukotrienes and also activates the platelets[10]. The inflammatory process releases cytokines e.g. interleukins and TNF and these substances can influence the immunological response in order to diminish the herniation and to initiate the pain in the nerve root[11]. In animal experimental studies, nucleus pulposus placed on the dorsal root ganglion caused clearly negative responses on the nerve root conduction [12]. This disturbance could be dimin-
ished by the use of blocking substances, e.g. corticosteroids. Lately some studies have indicated that systemically administered TNF-blocking agents given to patients with lumbar disc herniations dramatically reduce the symptoms of sciatica [13].

Psychological
The psychological influence on the experience of pain in general, and to low back pain in particular, has been confirmed by a number of studies [3, 14]. Depression has been shown to be correlated to a less favourable outcome in lumbar disc surgery in some studies [15, 16]. Depression and anxiety seem to increase the level of cytokines, which can cause pain in the central nervous system[17].

Treatment
When discussing the natural course of sciatica, as well as the results of different treatments, it is essential to consider that any result will be dependent on a number of factors including patient selection and outcome measures. Patient-related factors such as duration of disease, age, sex and work related compensation issues are all important for the result[18]. Similarly, factors related to the disease itself, e.g., concomitant sensory or motor deficit, type of sequestration (if any) will have effects on the prognosis for recovery[19]. Finally, treatments may --at least to some extent --modify the course of the disease[20].

The natural course.
The patients with a lumbar disc herniation will, in most cases, be relieved from pain during the first three months without any specific treatment [21] [22].

Conservative treatments
A great number of conservative, i.e. non-surgical, treatments have been proposed for lumbar disc herniation ranging from physiotherapy and acupuncture to electromagnetic fields and other treatment modalities put forward by complementary medicine. However, none of those treatments have been shown to alter the natural cause of symptoms although some have temporary effects on pain and function[23]. However, a number of investigations have determined that long standing severe pain causes a number of adverse effects, and a less favorable long-term outcome[24-26]. One explanation for this is the sensitization induced in the nervous system by long-standing pain[27]. The risk of a less positive long-term outcome is one reason for considering surgical intervention in patients who suffer from severe sciatica for more than 10-12 weeks.
Surgery
In selected groups of patients with disc herniation, the results of surgery are very good \cite{28} The most important factor for a positive outcome is the perioperative finding of a sequestered disc herniation \cite{29}. The main goal of surgery is, of course to alleviate pain, but the function in terms of return to work, and regaining normal activity is also important. One difficulty in determining the outcome is the influence of psychological factors caused by the pain itself.
Surgery may affect the disease in a number of ways: by relieving the mechanical pressure, by removing the source of chemical influence, or by altering the immunological response to the herniated disc, but also by causing additional trauma to the nerve and soft tissues \cite{30}. In addition, surgery has profound psychological effects \cite{19, 31}.

Corticosteroids
Epidural and/or systemic administration of steroids has been used with favourable results following lumbar disc surgery in some studies \cite{32-36}, but not in all \cite{37-39}. The rationale behind this treatment has been to reduce postoperative pain by reducing the inflammatory reaction to the surgical trauma, and to reduce late scar formation. In addition, in experimental investigations corticosteroids have been shown to counteract a reduction in nerve conduction velocity caused by the nucleus pulposus \cite{12}.

Purpose
The overall purpose of the current investigation was to study whether or not corticosteroids given perioperatively can modify the effects of lumbar disc surgery on symptoms of sciatica, disability and nerve function. Over and above this, we wanted to analyse effects on nerve function measured as QST, and also the predictive value of preoperative lumbar configuration and mobility with regard to regaining function.
Aims of the present study

- To study the effects on disability and pain by peroperatively given corticosteroids in lumbar disc surgery.
- To determine the time-course for disability and pain following lumbar disc surgery.
- To evaluate the use of quantitative sensory testing (QST) to determine nerve function disturbances in patients operated for lumbar disc herniation.
- To evaluate the predictive value of lumbar mobility and lumbar configuration for disability and pain in patients operated for lumbar disc herniation.
Patients and methods

Patients
From October 1994 through November 1998, eighty-five patients suffering with sciatica were invited to participate in prospective randomised double-blind study at Örebro University Hospital. The inclusion criteria were MRI-verified lumbar disc herniation on L3 to S1 levels, no previous surgery at the affected level, duration of sciatica less than 12 months, clinical presentation of sciatica consistent with MRI findings, and age between 18 and 65 years. Five patients were not included, one declined to participate, three had a possible rift of the dural sac during surgery, and one patient was missed in the randomisation procedure.

Randomisation procedure
Randomisation was performed by a closed envelope technique during surgery at the point in time when the herniated disc had been identified and evacuated.

Corticosteroid or placebo treatment
In the treatment group each patient received 250 mg Solu-Medrol® intravenously and 160 mg Depo-Medrol® intramuscularly. Before closure of the wound, a free fat transplant soaked in 80 mg Depo-Medrol® was placed on the dural sac. In the control group the same procedure was performed but sodium chloride was given instead of Depo-Medrol® and Solu-Medrol®.

Follow-up
All patients underwent a clinical examination before surgery and at 2, 6, 12, 26, 52 and 104 weeks postoperatively, rating their pain with the Visual Analog Scale (VAS) and function with the Disability Rating Index (DRI). The patients were followed clinically during their hospital stay (usually 3-5 days) and then at 3, 6, 12 and 24 months.

Pain
The pain was assessed on the visual analog scale ranging from 0 (no pain) to 100 (worst pain possible) documenting pain just now (VAS-N) and worst pain during the past week (VAS-W)[40, 41]
Impairment
The Disability Rating Index (DRI)[42] was used to assess the perceived disability. It consists of 12 items concerning physical function in a self-administered form.

Anxiety and depression
The Hospital Anxiety and Depression Scale[43] was used to assess the level of anxiety and depression. It is a self-assessment scale consisting of 14 items.

QST
Thermal quantitative sensory testing was performed for determining the thresholds for cold, warmth and heat pain with a modified Marstock thermo-stimulator operating on the Peltier principle (Thermotest, Somedic AB, Stockholm, Sweden). This method is influenced to some extent by the pain perceived by the patient, but when we used the unaffected leg as a control, the error was possibly diminished.

Sensibility
Pin-prick testing using a needle was used. The asymptomatic leg was used as a control.

Warmth, a metallic roll that was warmed-up using warm water and the asymptomatic leg was used as a control.

Cold, a metallic roll that was chilled using cold water and the asymptomatic leg was used as a control.

Sick-leave
Data concerning sick-leave compensation was collected from the social security registry. The data was dichotomised into one group with full-time work and one with some extent of sick leave compensation.

Complications
Complications and adverse effects arising from the treatments were registered during the hospital stay and during the follow-ups. Specifically wound healing, discitis, signs of thrombo-embolic complications, and recurrence of symptoms of sciatica were searched for.
Summary of Papers

Paper I

Background
Sciatica is often combined with decreased sensory function indicative of nerve root injury. Thermal quantitative sensory testing (QST) provides a tool to detect decreased function in different types of nerve fibres. The thinly myelinated A-delta fibres conducting cold sensation and unmyelinated C-fibres conducting warmth and heat-pain can be analysed separately. QST was applied to study the time course in recovery of sensory dysfunction after lumbar disc surgery.

Methods
QST was performed by determining perception thresholds for cold, warmth and heat-pain with a modified Marstock thermo-stimulator operating on the Peltier principle (Thermotest, Somedic AB, Stockholm, Sweden). Eighty consecutive patients with lumbar disc herniations were included in the study. Due to thermode failure, ten patients could not be examined before operation and one patient declined to participate. The study group consisted of 36 men and 33 women, the mean age was 41 years (26-59 years) and mean duration of sciatica was 4.5 months (0-12). The location of the herniated disc was L3/L4 in 3 patients, L4/L5 in 23 patients and L5/S1 in 43 patients. The three patients with L3/L4 disc herniations were not included in the study.

Results
Using three-way analysis of variance we found, significant differences for both levels of herniation (L4/L5 and L5/S1), all three temperature modalities between all dermatomes as well as between the side of the herniated disc and corresponding asymptomatic side. When using discriminant analysis for the purposes to correctly classify the level of the disc herniation only 48% of the L4/L5 herniations and 71% of the L5/S1 were correctly classified. We conclude that QST seems to be a valuable tool in documenting nerve disturbance in lumbar disc herniation, and QST can be used in longitudinal studies concerning changes in the injured nerve root. However, the method had a poor predictive value for identifying the anatomic location of a herniated lumbar disc.
Paper II

Background
Earlier studies in both animals and patients, have shown the importance of inflammation and of cytokines for the symptoms in lumbar disc herniation. Previous studies have indicated a beneficial effect by steroids in surgery for lumbar disc herniations. The purpose of this study was to determine whether or not perioperative treatment using corticosteroids improves the clinical outcome in lumbar disc surgery.

Methods
Eighty adult patients with MRI-verified lumbar disc herniation and clinical findings corresponding to the radiological level underwent microscopic disc removal to evaluate the outcome of perioperatively administered corticosteroids in a prospective randomised double-blind study. In the treatment group the patient received 250 mg Solu-Medrol® intravenously and 160 mg Depo-Medrol® intramuscularly. Before closure of the wound, a free fat transplant soaked in 80 mg Depo-Medrol® was placed on the dural sac. In the control group the same procedure was performed but sodium chloride was given instead of Depo-Medrol® and Solu-Medrol®. All patients underwent a clinical examination before surgery and at 2, 6, 12, 26, 52 and 104 weeks postoperatively, rating their pain with the Visual Analog Scale (VAS) and function with Disability Rating Index (DRI).

Results
The postoperative hospital stay was significantly shorter (p=0.01) in the treatment group (1.7 days) compared to the control group (2.3 days). Time back to full-time work was also significantly shorter in the treatment group (p=0.003). VAS W (Worst Pain during last week) was significantly lower in the treatment group (p=0.02). Postoperative spondylitis occurred in one patient in the control group. No adverse effects of the corticosteroids effect were seen. This study showed that perioperatively administered corticosteroids improved the outcome of microscopic disc surgery in terms of length of hospital stay and time back to full-time work. The results also indicate that corticosteroid treatment reduces pain and improves functional outcome.

Paper III

Background
The use of quantitative sensory testing (QST) can detect damage to the myelinated A-delta fibres (cold sense) and the unmyelinated C-fibres (warmth sense).
Methods
To study whether or not the use of corticosteroids combined with surgery alleviates the damage to the nerve fibres in lumbar disc herniation, we analysed a subgroup of patients from a double-blind randomised controlled study comparing corticosteroids versus saline peroperatively in microscopic lumbar disc surgery (paper II). QST was performed prior to surgery and after 2 weeks and 2 years.

Results
In the corticosteroid group we saw a statistically significant normalization of QST for the warmth disturbance as compared to the control group. This effect was not detected for the cold disturbance. The use of corticosteroids combined with surgery seems to protect some of the damage to the C-fibres in lumbar disc herniation.

Paper IV
Background
The range of motion of the lumbar spine has been shown to correlate to the type of disc herniation and to be an indicator for the outcome after lumbar disc surgery. Postoperatively the pain will be reduced during the first months and the stiffness will remain during the same period. The range of motion has been correlated to the degree of pain. A positive correlation has also been described between the lumbar lordosis and the range of motion.

Methods
A prospective analysis was performed on the predictive value of the preoperatively measured lumbar lordosis and flexion on pain and disability after lumbar disc surgery. The study population was recruited from a double-blind randomised controlled study comparing preoperatively administered corticosteroids versus saline in microscopic lumbar disc surgery (paper II). Debrunner’s Kyfometer was used to measure lumbar lordosis and flexion preoperatively, and postoperatively after two weeks, six weeks, three months, six months, twelve moths and two years. At these points in time pain (VAS) and disability (Disability Rating Index, DRI) were also measured.

Results
Preoperative hyperlordosis (<-20 degrees) correlated to more severe pain postoperatively (p=0.004), while hyperflexion (>24 degrees) did not (p=0.125). In patients with hypoflexion (<24 degrees) there was an association between hyperlordosis and severe pain postoperatively (p<0.001). In contrast, patients with hyper flexion showed no such association (p=0.646). The same outcomes were found for DRI. The stiff and straight back indicates a favourable outcome of lumbar disc surgery concerning pain and disability.
postoperatively. The normalization of the lumbar lordosis and flexion continues during the first six months after surgery similar to DRI, while pain reaches the two-year level already after two to six weeks postoperatively.
Results and general discussion

The main goal for both conservative treatment and surgery in lumbar disc herniation is the alleviation of pain. However, this lumbar disc herniation is not a uniform condition, but entails a number of components that may give rise to considerable variation in symptoms, signs and also in prognosis. A disc herniation may have effects on the nerves both by direct compression[1] and via chemical influence[2]. In addition, the herniation may vary in size and form and also in the rate of development[44]. Thus, we have to deal with a continuum of herniations ranging from minute discontinuities in the annulus fibrosus to sequestrated ruptures that will also change over time. The leakage of chemical factors through the annulus fibrosus may start before the protrusion has occurred and may directly affect the nerve root. Thus, symptoms indicating nerve root disturbance may occur without detectable herniation of the disc[2]. On the other hand, nerve injury can also be caused by a disc protrusion without any leakage of chemical factors[1]. This variation in the mechanism behind the symptoms of sciatica may, at least in part, be the reason for the different outcomes after surgery as well as after conservative treatment.

It seems logical to choose surgery when the main mechanism causing pain is root compression, and to use pharmaceutical treatment when inflammation is the main source of pain. The essential issue, then, is to distinguish between these two pathogenic mechanisms. The clinical presentation of sciatica could be one way to obtain information on the mechanism behind the symptoms, e.g., crossed Lasègue’s sign is one indicator of a sequestrated disc. Also, sensory disturbances promoted by different types of nerve fibres may add valuable information concerning the mechanism of nerve injury[45].

Despite successful results in the majority of patients in some cases, the condition will deteriorate and the patient will be at the risk of developing persisting pain. Several clinical studies have been conducted with the purpose of determining clinical signs predicting a good/bad outcome of surgery[19]. However, a single reliable sign does not (yet) exist so we have to look for patterns or combinations of clinical signs. The combination of an MRI-finding of a significant disc herniation, a positive crossed Lasègue’s sign, a typical distribution of pain in the leg, a decreased range of movement in the lumbar spine, and pain remaining after 6-12 weeks despite conservative treatment.
treatment seem to indicate favourable outcome of surgery[29]. The extirpa-
tion of the herniated disc decompresses the nerve and affects the release of
chemical factors at the same time.

Based on the fact that lumbar disc surgery, in spite of high success rates,
does not cure all patients in combination with current knowledge on the dual
mechanism behind sciatica, it seemed logical to sustain decompressive sur-
gery with pharmaceutical treatment[32]. An attempt to reduce the negative
effects caused by chemical factors could be the use of local and systemical
corticosteroids since these drugs possess well-known anti-inflammatory
properties. In addition, the nerve root will probably be further compromised
both mechanically and by the post-traumatic inflammatory response
called by the surgical procedure. Corticosteroids will also have effects on
the response to this additional trauma.

To address these questions we conducted a randomised double-blind study
on 85 patients scheduled for lumbar disc surgery comparing peroperative
local and systemic corticosteroids with placebo treatment. Our main finding
was the positive outcome concerning pain, hospital stay and return to full-
time work in the corticosteroid group compared with placebo treated pa-
tients. In addition, we studied the predictive value of a number of preopera-
tive clinical findings for the outcome, and found that patients with a straight
and stiff lumbar spine had significantly better outcomes in terms of disability
and pain. The disturbance in nerve function was analysed by measurement of
thresholds for warmth and cold and we found that corticosteroids seemed to
protect the C-fibres from damage to a larger extent than the A-delta fibres.

Pain
To measure pain we chose the pain variable of VAS. In spite of the fact that
VAS is a continuous numerical variable the different positions on the scale
do not necessarily reflect identical measures between patients or for the same
patient at different levels of pain, i.e., a difference between 1 and 2 on the
VAS scale might signify a different outcome than the difference between 7
and 8. However, this measure is widely used and provides valuable informa-
tion concerning perceived pain. In addition, to some extent these factors
were controlled for since we used repeated measurements to determine the
time-course for the outcomes. The results were analysed using repeated
measurements ANOVA. We used two types of pain scales, VAS-N in which
the patient assessed the pain just now, and VAS-W in which the worst pain
during the last week was noted. The purpose of this was to assess the pain
comprehensively since pain is one of the most important outcomes after
lumbar disc surgery. Both measures showed the same pattern, but a signifi-
cant difference between the treatment and control groups was noted for
VAS-W, while no such difference was found for VAS-N. This difference
between the two VAS measures may be explained by two factors. Firstly the pain level for VAS-W is higher which makes the measurement of improvements easier. Secondly, the VAS-W is probably influenced by pain treatment such as analgesic drugs to a much lesser extent.

The pain, measured as VAS-W, was alleviated to a greater extent in the corticosteroid group. One explanation for this finding might be that the C-fibres are restituted to a greater extent as noted by the more rapid normalization of the ability to sense warmth in corticosteroid-treated patients in Paper III. The C-fibres are involved in the pain perception, and the protecting effect of the corticosteroids might diminish the perceived pain. Another possible mechanism might be that the corticosteroids produce a general, positive effect on well being during the first days after surgery. Similar effects have been observed in other types of surgery[46] and after whiplash injury[47], and this promotes quicker rehabilitation. Since we used both a local and a systemic administration of the corticosteroids it is not possible to determine which of these treatment modalities that is mainly responsible for these effects. However, the finding that positive effects remain in the steroid group after two years indicates fundamental differences in the healing process following surgery such as inhibition of the innervations[48] of the disc or in the formation of scar tissue. The importance of cortisone on scarring is, however, questioned. Also, the relevance of scaring as a cause of persisting pain in the back or in sciatica is questioned[49]. We did not perform any postoperative MRI examinations so we cannot draw any conclusions concerning the development of fibrous/scar tissue following surgery.

Nerve disturbance
With the aid of QST we could show that disc herniation altered the thresholds for perception of warmth, cold and heat pain on the affected leg compared with the unaffected leg. This finding was in accordance with earlier studies [50, 51] and it implicated a possible way of determining the type of nerve disturbance which had developed in the patients with sciatica, and to follow the reconstitution of function after surgery. The use of the patient’s unaffected leg for reference seems appropriate, especially when repeated measurements are performed, since considerable individual variation occurs[52]. One possible confounding factor can be afferent influence on the CNS that affects the nerve root on the unaffected side [53]. When we followed the development of the disturbance of warmth sense we detected a more rapid restoration in the corticosteroid group compared to the control in this modality mediated by the C-fiber, which indicates a protective effect by the corticosteroids.
Impairment
Perceived disability is, naturally, closely connected to the pain level, but it will also be influenced by several other factors, for instance, the information and restrictions given to the patient postoperatively. Another mechanism might be the degree of fear-avoidance behaviour[54]. DRI has been validated to the Oswestry scale[55], which is one of the most commonly used, and was found to have a high degree of agreement. The DRI questionnaire provides information the extent to which the patient perceives disability when performing twelve daily activities. We used DRI in the same manner as the VAS to try to detect possible differences between the treatment and control groups. We found a similar pattern as for pain, but differences were not statistically significant.

Hospital stay
The length of hospital stay after surgery may be explained by several factors, e.g. pain, disability and interventions from the medical staff. Since we used a randomised and blinded study design these factors are controlled for. Thus, the shorter hospital for the treatment group may be attributed to the corticosteroid treatment, similar findings has been shown in other studies[32]. The most probable explanation for this outcome is the reduced pain found in the treatment group. A possible confounder might be the gender, but when controlling for this parameter the results were still in favour for the corticosteroid group.

Return to work
Return to full-time work is connected to diminished pain and disability. This might explain the beneficial outcome in the steroid group, where the patients returned to full time work earlier. The fact that there was a higher proportion of females in the control group was controlled for, and this did not alter this outcome.

Predictors
When analysing predictors for good outcome in lumbar disc surgery it is necessary to evaluate the pattern of clinical symptoms and signs combined with the radiological findings, rather than attempting to find one single predictor. The decision to perform surgery must rest upon as much relevant information as possible. Naturally, not all information has the same significance. The MRI or CT scanning is crucial in combination with the clinical presentation. The most valid physical sign seems to be the Laségue crossed sign[18]. However, the absence of this sign would not be an (absolute) contra-indication to surgery. Thus, it may be concluded that the clinical investigation has as a goal to provide information on a number of factors that are of importance for prediction of the outcome for the patient, and thereby to help in the decision to perform surgery – or to abstain.
**Lordosis and lumbar flexion**
The association between a good outcome for the group of patients with a stiff and erect lumbar spine preoperatively might indicate a more competent response of the lumbar spine muscles of these patients, which could be a positive factor during the restitution after surgery. Another possible explanation could be that the sequestered disc, with a favourable outcome, gives this clinical sign[29].

**Anxiety and depression**
The level of anxiety and depression measured by the use of HAD could not separate the patients who displayed an inferior outcome in our study. One explanation could be the small study population (Type II error) and/or a selection bias by the inclusion criteria that excluded patients who had suffered from sciatica for more than 12 months, (mean duration 4.5 months). This criterion diminishes the risk in development of secondary effects on the mental health.

**Overall outcomes**
The restitution of lordosis and flexion of the lumbar spine occurs at a slower rate than the alleviation in pain. To some extent, this indicates that the pain is not the only factor restricting lumbar flexion. The reduction in perceived disability mimics the restitution of lumbar lordosis and flexion, indicating an association between mechanical and muscle-related factors during the postoperative period.

**Complications**
One possible adverse effect using corticosteroids peroperatively can be a higher risk of infections postoperatively [56]. In our study we detected one case of discitis six months postoperatively in a 61-year old male. This patient belonged to the control group. The patient was treated with antibiotics for 6 months and the pain was normalized to VAS-N 6, VAS-W 9 two years postoperatively. Another risk could be a higher incidence of relapsing disc herniation. We detected four patients with recurrent disc herniation, two in each group. Three of the patients did not need further surgery, while one (from the control group) was reoperated due to persisting sciatica 10 months after the primary discectomy. One 31-year old female in the control group developed a postdiscectomy syndrome with disabling pain in back and leg and underwent a posterior lumbar interbody fusion 20 months postoperatively. Thus in our study population we could not detect any severe complication in the treatment group.
Clinical Implications of this Thesis
In light of the positive results of corticosteroids in microscopic lumbar disc surgery in the present study, in combination with a similar finding by other authors, we have altered our treatment protocol for this group of patients to include peroperative corticosteroids. We have utilized this protocol for more than two years and found no adverse effects.

Weakness of this Study
One apparent weakness of this thesis is the inherent limitations caused by the strict selection of patients. Since all patients belong to a selected group with clearly defined symptoms of sciatica, in combination with MRI or CT-verified diagnosis of a herniated disc, all conclusions must be limited to similar patients. In this group of well-defined patients with lumbar disc herniations, the results will be good after surgery. In spite of this limitation it is important to point out that the corticosteroids did appear to have beneficial effects irrespective of the intensity of pain and extent of disability preoperatively, making some degree of generalization justified.

Future Research
An obvious topic for future studies concerns the long-term results at ten or more years after surgery. A ten-year follow-up is planned. Several previous studies have indicated that the positive results of lumbar disc surgery tend to diminish with time, probably as a consequence of a progressive degenerative disease of the lumbar spine[20]. On the other hand, speculation can be made as to whether or not the possible influence of steroids on the in-growth of nerve endings into the disc might have a protective effect on low back pain even in the long-term[48]. Also, inhibitory effects on the formation of scar tissue may be beneficial for the long-term outcome.

Another topic for further studies is the verification and further analysis of the mechanism(s) behind the protective effects on nerve tissue by corticosteroids. The findings of selective protective effects by corticosteroids on the C-fibres is highly interesting and provides the basis for further research both on the effects caused by chemical factors on different types of nerves—on ways to protect the nerves from injury—and to enhance healing.
Conclusions

- Using a double-blind, prospective and randomized study design with 80 patients operated for a verified lumbar disc herniation we found that locally and systemically administered corticosteroids peroperatively in lumbar disc surgery results in:
  - Shorter hospital stay
  - Earlier return to full time work
  - Diminished postoperative pain measured as worst pain during the past week (VAS-W)
  - No negative side effects

- QST analyses shows that both A-delta fibres and C-fibres can be damaged in lumbar disc herniations.

- Corticosteroids seem to protect the damage of the C-fibres more than that of the A-delta fibres, and the protective effect on the C-fibres are remains after two years

- Pain rapidly decreases following discectomy, and the pain level reached at two weeks after surgery still remains after two years in most patients.

- The perceived disability continues to improve during the first six months after lumbar disc surgery

- The combination of hypolordosis and hypoflexion preoperatively is a good prognostic sign for the outcome two years after lumbar disc surgery

- The improvement in lumbar flexion, and the restitution of lumbar lordosis, continues during the first six months postoperatively.
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