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Clinical Study

Do patients with lumbar spinal stenosis benefit from decompression of levels with adjacent moderate stenosis? A prospective cohort study from the NORDSTEN study

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Abstract

BACKGROUND: Lumbar spinal stenosis (LSS) is characterized by pain that radiates to the buttocks and/or legs, aggravated by walking and relieved by forward flexion. There is poor correlation between clinical symptoms and severity of stenosis on MRI, and multilevel stenosis has not been described to present worse symptoms or treatment outcomes, compared with patients with single-level stenosis. In patients with one level with severe stenosis combined with an adjacent level with moderate stenosis, the surgeon must decide whether to decompress only the narrowest level or both, to achieve the best possible outcome. The potential benefits of performing surgery on an adjacent moderate stenosis is debated, and the scientific evidence in scarce.

PURPOSE: The aim of the present study was to investigate whether patients with a level of adjacent moderate stenosis, along with an index stenosis, benefitted from a dual-level decompression

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(DLD) compared with a single-level decompression (SLD). Furthermore, to investigate whether DLD patients had longer duration of surgery and hospital stay, higher rates of complications and/or lower rate of reoperations compared with SLD patients.

STUDY DESIGN: Prospective cohort study.

PATIENT SAMPLE: We analyzed data from the Norwegian Degenerative Spondylisthesis and Spinal Stenosis study- Spinal Stenosis Trial (NORDSTEN-SST). In this randomized multicenter study, 437 patients were included, evaluating clinical outcomes of three different surgical treatment options for LSS. Patients with degenerative spondylolisthesis were excluded.

METHOD: Based on preoperative MRI, the present analysis included all patients who had a moderate stenosis (defined as Schizas B or C) in addition to a predefined index stenosis (the level with the smallest cross-sectional area). We compared patients who, based on the surgeons' choice, received a dual-level decompression, with those receiving a single-level decompression.

OUTCOME MEASURES: The primary outcome was mean change in the Oswestry Disability Index (ODI) score from baseline to 2-year follow up. Secondary outcomes were proportion of success (30% reduction in ODI score), the Numeric Rating Scales for back and leg pain (NRS), the EuroQol 5-dimensional questionnaire utility index (EQ-5D), the Zurich Claudication Questionnaire (ZCQ), the Global Perceived Effect (GPE)-scale, duration of surgery, duration of hospital stay, perioperative complications and reoperation rates.

RESULTS: Among the 222 patients, included in the analysis, 108 underwent DLD and 114 underwent SLD. There was no difference in change scores for any of the investigated patient-reported outcomes between the groups after 2 years. However, the DLD group had longer duration of surgery and longer length of hospital stay. There was no difference in reoperation rates or perioperative complications.

CONCLUSION: This study, alongside the NORDSTEN-LSS trial on patients with adjacent moderate stenosis as well as an index stenosis, showed no superior clinical effectiveness for dual-level surgery compared with single-level surgery.

Keywords: Adjacent level stenosis; Decompression; Lumbar spinal stenosis; Multilevel spinal stenosis; Surgical treatment

Introduction

Lumbar spinal stenosis (LSS) is characterized by pain and discomfort that radiates to the buttocks and/or legs, associated with diminished space for neural and vascular elements in the lumbar spine. The symptoms are commonly aggravated by walking and relieved by forward flexion [1]. Previous studies have shown that there is poor correlation between clinical symptoms and severity of stenosis found on Magnetic Resonance Imaging (MRI) [2−4]. Thus, the reduced space may or may not be related to symptoms.

LSS is the most common indication for spine surgery among the elderly, and surgical rates are increasing in the Western world due to an ageing population [5,6]. Narrowing of the spinal canal may occur at one or multiple levels of the lumbar spine. According to a review conducted in 2014, 40% of patients with clinically diagnosed LSS had multilevel, moderate to severe stenosis on MRI [7].

The decision on whether to operate on LSS patients is based on many parameters including patient morbidity, previous surgery, clinical presentation, and MRI findings. For cases of multilevel spinal stenosis, the surgeon also has to decide how many levels to decompress in order to achieve the best possible clinical outcome. The benefit of performing surgery on a moderately stenosed level is debated, and scientific evidence is scarce, with only a few studies reporting on this topic. Interestingly, these studies report favorable outcomes for multilevel LSS patients undergoing single-level decompression [8−10].

The aim of the present study was to investigate whether patients with a level with moderate stenosis, along with an index stenosis level (defined as the narrowest level), would benefit more from a dual-level decompression (DLD) compared with a single-level decompression (SLD). Furthermore, we examined whether the DLD patients had a longer duration of surgery and hospital stay, higher rate of complications, and/or lower rate of reoperations compared with the SLD patients.

Material and method

Patient recruitment

Data were collected from the Norwegian Degenerative Spondylisthesis and Spinal Stenosis study - Spinal Stenosis Trial (NORDSTEN-SST). This study is a large multicenter randomized trial evaluating clinical outcomes of different surgical treatment options for LSS. A total of 437 patients were included in the NORDSTEN-SST, recruited between February 2014 and October 2018. All patients underwent 3 months of conservative treatment, and only nonresponders

were included in the trial. Patients with degenerative spondylolisthesis were not included. A detailed description of the patients included in the NORDSTEN-SST, with inclusion and exclusion criteria, is reported in a previous publication [11] and in the study protocol [12].

The present study included patients with dual-level stenosis from NORDSTEN-SST. The index level was defined as the level with the most severe stenosis, that is, the smallest cross-sectional area, measured on preoperative MRI. An adjacent moderate stenosis was defined as a level located in direct connection to the index level with a narrowing classified as Schizas grade B or C. The patients were divided into two groups based on whether one or two levels of surgery were performed: dual level decompression (DLD) and single level decompression (SLD). Patients that did not have an index level stenosis *and* an adjacent moderate stenosis were excluded (Figure). The decision whether to perform DLD or SLD were decided on the discretion of the surgeon responsible for the operative treatment.

Radiological assessment

The MRI examinations included axial and sagittal T2-weighted and sagittal T1-weighted images. An MRI was obtained for all patients in the six months prior to surgery. Levels L2–L5 were examined and the images were evaluated by three investigators – two orthopedic surgeons and one radiologist. The MRI examinations were deidentified without any link to demographics or clinical symptoms. An inter- and intraobserver agreement analysis was carried out to validate the measurements for the first 102 cases, and it was concluded that adequate agreement existed [4].

To define the index level, the Dural Cross-sectional Sac Area (DSCA) was measured in mm^2 prior to surgery. The Schizas grading system was used for qualitative grading of each level in order to define the moderate adjacent level. The Schizas grading system is a well evaluated morphological grading system, ranging from A-D (where D is most stenotic), used to describe the severity of LSS on MRI [13].

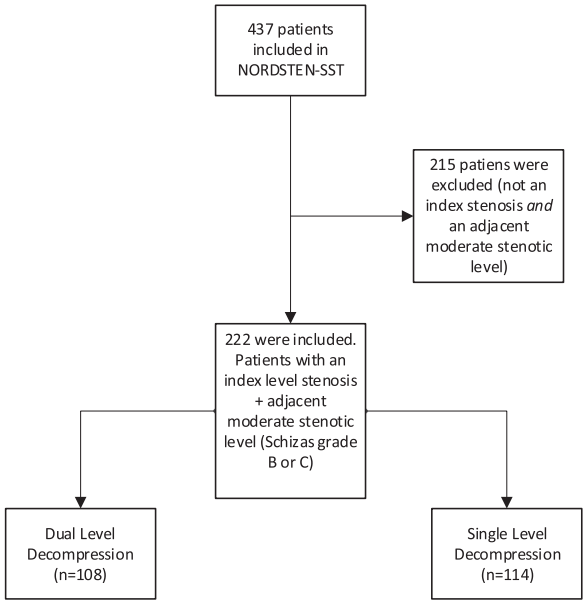

Figure. Flowchart.

Primary outcome

Primary outcome was defined as mean change in Oswestry Disability Index (ODI) score from baseline to 2 years after surgery. The ODI is a validated outcome measure in spinal surgery, and the most widely used [14]. There are 10 questions in the ODI questionnaire that relate to pain and daily life. Response categories range from no pain-related disability (0) to worst possible pain-related disability (5). An index ranging from 0 to 100 is generated from the score, where 0 represents no disability and 100 represents the worst disability possible [14]. The patients in this study completed the Norwegian validated version 2.0 at baseline and at 3, 12, and 24 months after the surgical procedure.

Secondary outcomes

The proportion of patients who reduced their ODI score by 30% from baseline (proportion of success) was added as secondary outcome. A change in ODI of 30% was considered a clinically important improvement [15,16]. Additionally, to address clinical outcomes and general health, we used the Numeric Rating Scales for back and leg pain (NRS), EuroQol 5-dimensional questionnaire utility index (EQ-5D-3L), Zurich Claudication Questionnaire (ZCQ), and Global Perceived Effect (GPE) scale.

NRS is an eleven-point numeric scale which ranges from 0 (no pain) to 10 (the worst pain imaginable). It individually addresses the back pain and leg pain that the patient has experienced within the last week. It is the simplest, most commonly used pain scale, and is validated for research [17].

EQ-5D-3L is a generic scale for the evaluation of health-related quality of life. It rates 5 domains: mobility, self-care, activity, pain, and anxiety. The score ranges from −0.59 (worst possible) to 1.0 (best possible). The EQ-5D-3L is validated for the Norwegian population [18]. The corresponding UK value set for calculating scores was used.

Zurich Claudication Questionnaire is a lumbar spinal stenosis specific questionnaire. It addresses symptom severity, physical activity, and patient satisfaction. Patients' responses range from 1 to 4 on the physical activity scale and the patient satisfaction scale. The symptom severity scale ranges from 1 to 5. For all scales, 1 is the best option [19].

The GPE scale is a scoring system recommended for clinical trials investigating chronic pain conditions. It has seven response categories, ranging from 1 (completely recovered) to 7 (worse than ever) [20].

Other secondary outcomes were duration of surgery, duration of hospital stay, perioperative complications, and reoperation rates.

Statistics

Standard descriptive statistics were presented using means and standard deviations (SD) or median and interquartile ranges (IQR) for continuous variables, and absolute and relative frequencies for categorical variables. The distribution of variables was compared between the two treatment groups using independent t-tests for continuous variables and chi-square tests for categorical variables. Mean differences in clinical outcome measure scores were calculated for both groups and compared using t-tests. Furthermore, to control for potential confounding, we estimated linear regressions where we controlled for patients' baseline sex, age, body mass index (BMI), smoking status, Schizas grade, Lee score, and Pfirrmann score. We also adjusted for the baseline measurement of each of the outcome variables. Adjusted means of each clinical outcome variable were then calculated from the fitted models setting the values of all confounding factors to their sample mean. When the clinical outcome was dichotomous, more than 30% reduction in ODI, we compared proportions using a chi-square test and estimated a multivariable logistic regression adjusting for the same set of confounders as listed above. Again, adjusted proportions/probabilities were predicted from the model at the means of all other covariates. Lastly, surgical outcomes (duration of surgery, duration of hospital stay, perioperative complications, and reoperation rates) were compared between groups by simple means or proportions, accompanied by t-tests or chi-square tests. Significance level was set to 5% throughout. All analyses were done using Stata version 16.1.

Results

Patient recruitment/baseline data

Among the 437 patients in the NORDSTEN-SST study, 222 met the inclusion criteria for the present analysis. Of these 222 patients, 108 underwent dual-level decompression and 114 underwent single-level decompression.

Median age in the total cohort was 68 (IQR 62-73) years. Mean BMI was 28.1 (SD 4.5). The cohort comprised 116/222 (52.3%) men, and 42/222 (19.0%) individuals who smoked regularly.

The mean baseline pain and function scores for the total cohort were ODI 38.7 (SD 14.8); EQ5D 0.38 (SD 0.32); ZCQ symptoms 3.4 (SD 0.57); ZCQ function 2.5 (SD 0.53); NRS back pain 6.4 (SD 2.28) and NRS leg pain 6.5 (SD 2.1). Further, in the cohort, 43/222 (19.4%) had concomitant foraminal stenosis and 140/222 (63.1%) had severe disc degeneration, Pfirrmann grade 4-5.

The proportion of Schizas C at the adjacent level was significantly different for the DLD and SLD groups, -56,5% versus 14% respectively. There was also a slightly lower ZCQ symptom severity score in the SLD group (Table 1).

Primary and secondary outcomes

There were no significant differences in primary outcome for the two groups. Similar adjusted mean changes in ODI score were seen between baseline and 2-year follow-up, −18.0 (−21.2 to −14.8 95% CI) and −19.8 (−22.9 to −16.7 95% CI) respectively for the DLD and SLD groups (p=.45). The proportion of success was also similar, 72.0 % (62.5% to 81.5%) in the DLD group and 71.0% (61.6% −80.3%) in the SLD group (p=.89).

The other secondary changes in pain and symptom scores at 2-year follow-up were not statistically significantly different, neither before or after adjusting for baseline characteristics (Tables 2a and 2b). In the total cohort, there was a mean improvement in the EQ-5D-3L of 0.31 (0.25−0.36 95% CI); mean change in ZCQ symptom score was -0.98 (−1.09 to −0.86 95% CI); mean change in ZCQ physical activity score was −0.84 (−0.93 to −0.75 95% CI). For NRS, the mean improvement for the whole cohort

Table 1
Baseline characteristics

Characteristics	Dual-level decompression (n=108)	Single-level decompression (n=114)	p-value
Age, median (IQR)	68 (63.5 - 74)	67.5 (60 − 73)	.70
Men	55 (50.9%)	61 (53.5%)	.70
Smoking	20 (18.5%)	22 (19.5%)	.86
BMI, mean (SD)	28.2 (4.3)	27.9 (4.6)	.70
ODI, mean (SD)	40.6 (16.0)	36.8 (13.3)	.06
EQ-5D, mean (SD)	0.34 (0.32)	0.42 (0.31)	.08
ZCQ, mean (SD)			
Symptom severity	3.49 (0.57)	3.26 (0.56)	<.05
Physical activity	2.59 (0.53)	2.47 (0.53)	.08
NRS (IQR)			
Back pain	6.30 (2.33)	6.40 (2.24)	.76
Leg pain	6.53 (2.12)	6.45 (2.15)	.75
Foraminal stenosis, proportion	21 (19.4%)	22 (19.3%)	.98
Disc degeneration (proportion Pfirrmann 4-5)	66 (61.1%)	74 (64.9%)	.56
Proportion of Schizas C in adjacent level	61 (56.5%)	16 (14.0%)	<.001

Table 2a
Outcomes

Outcomes	Dual-level decompression	Single-level decompression	p-value
Change ODI score (n=211)	−19.4 (−22.9 to −15.9)	−18.7 (−21.6 to −15.8)	.75
Proportion of success (30 % reduction ODI score)	78 (72.2%)	81 (71.1%)	.85
Change in EQ-5D score (n=186)	0.31 (0.23−0.38)	0.31 (0.23−0.38)	1
Change in ZCQ symptom score (n=209)	−1.02 (−1.20 to −0.84)	−0.93 (−1.07 to −0.80)	.44
Change in ZCQ physical function score (n=209)	−0.82 (−0.96 to −0.67)	−0.86 (−0.97 to −0.74)	.66
Change in NRS back pain score (n=207)	−2.42 (−3.01 to −1.81)	−2.78 (-3.33 to −2.23)	.37
Change in NRS leg pain score (n=205)	−3.29 (−3.89 to −2.68)	−3.53 (−4.07 to −2.99)	.55
GPE score (n=212)	1.28 (1.14−1.42)	1.32 (1.15−1.50)	.70

Table 2b
Outcomes - adjusted means/proportions

Outcomes	Dual-level decompression	Single-level decompression	p-value
Change ODI score	−18.0 (−21.2 to −14.8)	−19.8 (−22.9 to −16.7)	.45
Proportion of success (30% reduction ODI score)	72.0% (62.5%−81.5%)	71.0 % (61.6%−80.3%)	.89
Change in EQ-5D score	0.29 (0.22−0.35)	0.32 (0.26−0.38)	.44
Change in ZCQ symptom score	−0.98 (−1.15 to −0.81)	−0.96 (−1.13 to −0.79)	.90
Change in ZCQ physical function score	−0.77 (−0.90 to −0.64)	−0.89 (−1.01 to −0.76)	.24
Change in NRS back pain score	−2.42 (−3.00 to −1.85)	−2.71 (−3.28 to −2.15)	.51
Change in NRS leg pain score	−3.29 (−3.86 to −2.72)	−3.51 (−4.07 to −2.96)	.59
GPE score	1.27 (1.10−1.44)	1.33 (1.16−1.49)	.66

was −3.4 (−3.8 to −3.0 95% CI) for leg pain and −2.6 (−3.0 to −2.2 95% CI) for back pain.

The DLD group had significantly longer mean duration of surgery than the SLD group, 131.4 (121.5 − 141.4) minutes versus 85.4 (79.0−91.8) minutes, respectively (p=<.05). Duration of hospital stay was also significantly longer in the DLD group with 3.56 (3.02−4.09) days versus 2.76 (2.34−3.19) days in the SLD group (p=<.05).

In the whole cohort, 25/222 (11%) of the patients had a perioperative complication, 13 patients (12.0%) in the DLD group and 12 patients (10.5%) in the SLD group (p=0.72). In total, 13/222 (5.9%) patients required reoperations within the 2-year follow-up period: 5/108 (4.6%) in the DLD group and 8/114 (7%) in the SLD group (p=.45). Further examination of these reoperations revealed that 2 patients in the DLD group and 1 patient in the SLD group were reoperated because of adjacent level stenosis (Table 3).

Discussion

The main finding in the present study was that there were no differences in change scores for the investigated patient-reported outcomes between the groups defined as Dual-Level Decompression versus Single-Level Decompression after 2-year follow-up. The DLD group had longer duration of surgery and longer length of hospital stay. No difference in reoperation rates was detected within the follow-up period, and, interestingly, we did not detect a higher level of reoperations because of adjacent level stenosis in the SLD group within the follow-up period.

The results from the present study, in which 222 patients were analyzed, correspond with previous studies [21−23] where patients with multilevel stenosis have been reported to have similar rates of postoperative improvement compared with patients with single-level stenosis. These studies have suggested that multilevel LSS should not affect the

Table 3
Additional Secondary Outcomes

Outcomes	Dual-level decompression	Single-level decompression	p-value
Duration of surgery, min	131.4 (121.5−141.4)	85.4 (79.0−91.8)	<.05
Duration of hospital stay, days	3.56 (3.02−4.09)	2.76 (2.34−3.19)	<.05
Perioperative complications, %*	13 (12.0%)	12 (10.5%)	.72
Reoperation within first 24 mo, n	5 (4.6%)	8 (7%)	.45
Reoperations adjacent level, n	2	1	

* Dural tear, postoperative hematoma, postoperative infection, change in neurologic status, venous thromboembolism, cardiovascular, urological or respiratory complications, operated on wrong side/level, other specified complications.

surgical outcome if each compressed level is adequately addressed during surgery. However, to our knowledge, there are only a few studies that have specifically investigated single-level decompression in patients with an adjacent stenotic level.

Ulrich et al [9] conducted a prospective multicenter cohort study in 2017 [9], and included 141 patients with at least three levels of "moderate" or "severe" stenosis. In this study, 108 patients underwent a multilevel decompression and 33 patients underwent a single-level decompression. At 12- and 24-month follow-up, Spinal Stenosis Measure symptom and function scores were significantly less favorable in the multilevel decompression group. They found no significant differences in secondary outcomes. Although there are many similarities with our study, making a direct comparison is challenging because the degree of stenosis was not qualitatively graded using Schizas score in the study by Ulrich et al [9], which only included patients with at least three stenotic levels. The number of reoperations was not reported within this study.

In 2021, Yoshikane et al [10] published a retrospective cohort study in which they included 128 patients with multilevel LSS treated with endoscopic bilateral single-level decompression. They reported that 77.9% of the patients had "excellent" or "good" outcomes at 24-month follow-up, evaluated with the Japanese Orthopedic Association Back Pain Evaluation Questionnaire and NRS. However, 10.2% of the patients underwent a reoperation at a mean of 20 months (range 4−52 months) after the initial surgery. A different surgical technique was used than in our study, and the follow-up period was somewhat longer, which makes it difficult to compare their results with our reoperation rate (4.6% in the DLD group and 7% in the SLD group).

A strength of the present study is that it is based on data from a randomized study with high internal validity. Further, a larger number of patients were included than in previous studies, especially in the single-level decompression group. Other strengths are that patients with concomitant degenerative spondylolisthesis were excluded, the two groups being compared had similar baseline characteristics, the follow-up rate was high, and validated outcome measures were used.

The results of the primary outcome were supported by the findings of the secondary outcomes analyses and baseline characteristics and improvement rates are in line with a previous prospective cohort study from the Norwegian Registry for Spine Surgery [24]. Moreover, there were a limited number of exclusion and inclusion criteria which contributes to the external validity.

Limitations

We compared the results after dual- and single-level surgery in a cohort of patients with spinal stenosis. Patients were not randomized, and different surgeons decided whether their partients should receive dual or single-level surgery, probably based on MRI findings and personal opinion rather than a thorough clinical evaluation. We were not able to adjust for all possible confounders, and we do not know whether our results would have been similar if all patients had single-level surgery. Randomized trials are needed before a conclusion on this topic can be reached.

The DLD group had a higher level of Schizas C in the adjacent level at baseline compared with the SLD group. As previously stated, there is poor correlation between severity of stenosis on MRI and clinical symptoms, and in this study we chose to classify both Schizas B and C as moderate stenosis. The difference in Schizas distribution was adjusted for by estimating multivariable regressions in order to control for this potential confounding factor.

A 2-year follow-up period is probably insufficient to support any definitive conclusions. However, the follow-up of this cohort is ongoing, with the next data collection point at 5 years. It will be interesting to compare the patient-reported outcomes over time, and to find out if there is any difference in reoperation frequency between the groups. Follow-up MRIs after 3 months and 2 years may also reveal whether progression of stenosis has occurred in the adjacent level. Furthermore, we cannot extend our conclusions to patients with >2 levels of stenosis.

Additionally, it is unclear how lateral recess stenosis may have affected the outcome. In this study we have used the Schizas score and Dural Cross-sectional Sac Area to describe central spinal stenosis. Lateral recess stenosis has not been accounted for.

Conclusion

This study, alongside the NORDSTEN-LSS trial, on patients with adjacent moderate stenosis as well as an index stenosis, showed no superior clinical effectiveness for dual level decompression compared with single level decompression at 2-year follow-up. Dual level decompression was associated with longer duration of surgery and longer length of hospital stay.

Ethics approval

The NORDSTEN-SST trial protocol was approved by The Regional Committee for Medical and Health Research Ethics of Central Norway (REC Central), project identifier 2011/2034.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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