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Additional operation rates after surgery for degenerative spine diseases: minimum 10 years follow-up of 4705 patients in the national Swedish spine register

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ABSTRACT

Objectives To identify rates of additional operation after the index operation for degenerative lumbar spine diseases.

Design Retrospective register study.

Setting National outcome data from Swespine, the National Swedish spine register.

Participants A total of 4705 patients who underwent one-level surgery for degenerative disk disease (DDD) or lumbar spinal stenosis (LSS) with or without degenerative spondylolisthesis (DS) between 1 January 2007 and 31 December 2010 were followed from 1 January 2007 to 31 December 2020 to record all cases of additional lumbar spine operations.

Interventions One-level spinal decompression and/or posterolateral fusion for degenerative spine diseases.

Primary outcome measures Number of additional operations.

Results Additional operations were more common at adjacent levels for patients with LSS with DS treated with decompression and fusion whereas additional operations were more evenly distributed between the index level and the adjacent levels for DDD treated with fusion and LSS with and without DS treated with decompression only. For patients younger than 60 years, treated with decompression and fusion for LSS with DS, the additional operations were evenly distributed between the index level and the adjacent levels.

Conclusions There are different patterns of additional operations following the index procedure after surgery for degenerative spine diseases. Rigidity across previously mobile segments is not the only important factor in the development of adjacent segment disease (ASD) after spinal fusion, also the underlying disease and age may play parts in ASD development. The findings of this study can be used in the shared decision-making process when surgery is a treatment option for patients with degenerative lumbar spine diseases as the first operation may be the start of a series of additional spinal operations for other degenerative spinal conditions, either at the index level or at other spinal levels.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The patients were followed for a minimum of 10 years.
⇒ Data were obtained from a national database with high stable coverage.
⇒ We recognise the inherent limitations of register data.
⇒ The study is limited by the lack of radiographic data.

INTRODUCTION

Additional operations following the index procedure after surgery for degenerative spine diseases are common, previous studies have indicated that the cumulative risk for additional operations is approximately 20%.[1–3] Interestingly, previous studies have suggested that surgery for different degenerative spine diseases present different patterns of additional operations. The randomised controlled trials (RCTs) of Ghogawala *et al*[4] and Försth *et al*[5] reported that the patterns of additional operations after surgery for lumbar spinal stenosis (LSS) with degenerative spondylolisthesis (DS) were different for decompression only and decompression and fusion. For decompression only, the additional operations were performed mostly at the index level whereas for decompression and fusion the additional operations were performed at adjacent segments. One possible cause for additional operations at adjacent segments is that increased rigidity across previously mobile segments introduced by spinal fusion results in accelerated degeneration of the adjacent segment[6] whereas decompression without fusion may increase the risk of index-level additional operations because of instability at the slipped segment.[4] However, for degenerative disk disease (DDD), Phillips *et al*[7] reported that the additional operations in most cases were performed at the index level. This means that rigidity across

previously mobile segments is not the only important factor in the development of accelerated degeneration of the adjacent segment. Other possible causes for additional operations at adjacent segments are superior-level facet joint violation (pedicle screw or screw head is within the facet joint) that might induce degenerative changes in the facet joint, leading to the development of adjacent segment disease (ASD)[8 9] or failure to restore appropriate lumbar lordosis which may accelerate ASD.[10] The purpose of the current study was to identify patterns of additional operations after surgery for common degenerative lumbar spine disease. We used the National Swedish spine register (Swespine) to identify additional spinal operations for degenerative conditions of the lumbar spine over a minimum 10-year follow-up period. Swespine was launched in 1992 and covers 90% of the spine units in Sweden. The 1-year follow-up rate is 70%–75%.[11] The register includes data on diagnoses, surgical procedures, complications and patient-reported outcome measures. The surgeon is responsible for submitting data about the surgery.

MATERIALS AND METHODS

Study design

This was a register study based on data from Swespine, the National Swedish spine register.

Patients

From Swespine, we obtained data on all patients who underwent one-level surgery for DDD or LSS with or without DS between 1 January 2007 and 31 December 2010. The patients were followed from 1 January 2007 to 31 December 2020 to record all cases of additional lumbar spine operations. The index surgeries were posterolateral fusion (PLF), decompression and PLF or decompression only. All smokers were excluded.

Statistical analysis

Data are presented as means with SD or 95% CIs, number, rates and frequencies. Bootstrapping was used to calculate CIs.[12] R V.3.6.3 was used for data processing (R Foundation for Statistical Computing, Austria).

Patient and public involvement

The patients and the public were not involved in the design, recruitment, conduct or dissemination plans of this research.

RESULTS

We identified 4705 patients who underwent one-level surgery for degenerative spine diseases between 1 January 2007 and 31 December 2010; 266 underwent PLF for DDD, 788 underwent decompression and PLF for LSS with DS, 395 underwent decompression only for LSS with DS and 3256 underwent decompression only for LSS without DS. The baseline characteristics of the patients who did and did not undergo additional surgeries are presented in table 1 and online supplemental table S1. The demographic data of patients who did and did not undergo additional surgery were similar.

For DDD, 55% of the patients had their first additional operation at the same level as the index procedure whereas 20% had their first reoperation at an adjacent level only. For LSS with DS treated with decompression and PLF (all ages), the corresponding numbers were 21% and 46%, respectively, for LSS with DS treated with decompression only the numbers were 42% and 25%, respectively, and for LSS without DS treated with decompression only the numbers were 40% and 25%, respectively. For patients, younger than 60 years, treated with decompression and PLF for LSS with DS, 40% of the patients had their first additional operation at the same level as the index procedure whereas 27% had their first reoperation at an adjacent level only (online supplemental tables S2A–S2E).

The differences in additional operation rates between the index level and adjacent levels were statistically significant for LSS with DS treated with decompression and PLF (all ages), and LSS without DS treated with decompression only (table 2). The additional operation rates at the adjacent levels were statistically significantly higher for LSS with DS treated with decompression and PLF

Table 1 Baseline characteristics for patients that underwent lumbar spinal surgery between 2007 and 2010 that required subsequent additional operations

	DDD	LSS with DS fusion, all ages	LSS with DS fusion, age <60 years	LSS with DS decompression	LSS without DS decompression
n	40	157	33	81	557
Age (years), mean (SD)	45.7 (9.89)	62.9 (8.88)	50.9 (5.14)	67.6 (9.37)	64.1 (10.7)
BMI (kg/m^2), mean (SD)	26.4 (3.15)	27.2 (4.27)	26.9 (3.83)	26.7 (4.37)	27.9 (3.92)
Women, n (%)	12 (30)	109 (69.4)	22 (66.7)	50 (61.7)	234 (42)
Follow-up time (years), mean (SD)	12 (1.0)	11.6 (1.0)	11.6 (1.0)	12.1 (1.0)	12 (1.1)

For LSS with DS, data for all patients as well as data for the subgroup of patients younger than 60 years are presented.
BMI, body mass index; DDD, degenerative disk disease; DS, degenerative spondylolisthesis; LSS, lumbar spinal stenosis.

Table 2 Data for the first additional operation for patients that underwent lumbar spinal surgery between 2007 and 2010 and then were followed between 2007 and 2020

	Additional operation at index level only		Additional operation at adjacent level only	
	% (95% CI) (n/total)	Mean time to reop (95% CI)	% (95% CI) (n/total)	Mean time to reop (95% CI)
DDD	8.27 (5.26 to 11.7) (22/266)	2.91 (1.61 to 4.51)	3.01 (1.13 to 5.26) (8/266)	5.27 (2.88 to 7.91)
LSS with DS fusion, all ages	4.19 (2.92 to 5.58) (33/788)	2.15 (1.37 to 3.06)	8.88 (6.98 to 10.9) (70/788)	5.12 (4.42 to 5.86)
LSS with DS fusion, age <60 years	6.02 (3.24 to 9.26) (13/216)	1.9 (0.939 to 3.28)	4.17 (1.85 to 6.94) (9/216)	5.81 (3.64 to 8.05)
LSS with DS decompression	8.61 (6.08 to 11.4) (34/395)	3.02 (2.14 to 4)	5.06 (3.04 to 7.34) (20/395)	4.78 (3.17 to 6.54)
LSS without DS decompression	6.88 (6.02 to 7.77) (224/3256)	2.69 (2.37 to 3.03)	4.36 (3.69 to 5.1) (142/3256)	4.77 (4.26 to 5.29)

DDD, degenerative disk disease; DS, degenerative spondylolisthesis; LSS, lumbar spinal stenosis.

(all ages) compared with DDD treated with PLF and LSS without DS treated with decompression only (table 2). There were no statistically significant differences in additional operation rates between patients, younger than 60 years, treated with decompression and PLF for LSS with DS, and patients with DDD treated with PLF and patients with LSS without DS treated with decompression only (table 2).

The most common first additional operations were implant extraction (DDD) and decompression (LSS with or without DS). The most common causes for the first additional operation were implant-related pain (DDD) and spinal stenosis (LSS with or without DS). The overall additional operation rates were 15% (DDD), 20% (LSS with DS treated with decompression and PLF), 21% (LSS with DS treated with decompression only) and 17% (LSS without DS treated with decompression only) (online supplemental tables S2A–S2E).

There was a trend towards shorter times to additional operations at the index level compared with the times to additional operations at adjacent levels. The differences were statistically significant for LSS with DS treated with decompression and PLF and LSS without DS treated with decompression (table 2).

DISCUSSION

In this paper, we report patterns of additional operations for degenerative lumbar spine diseases. We found that the additional operations were more common at adjacent levels for patients with LSS with DS treated with decompression and fusion whereas additional operations were more evenly distributed between the index level and the adjacent levels for DDD treated with fusion and LSS with and without DS treated with decompression only. However, for patients younger than 60 years, treated with decompression and PLF for LSS with DS, the additional operations were evenly distributed between the index level and the adjacent levels.

Additional operations at adjacent levels because of ASD have been a topic of discussion for many years but the cause of ASD remains unknown. One common explanation for ASD development is that increased rigidity across previously mobile segments introduced by spinal fusion results in accelerated degeneration of the adjacent segment.[6] Bydon *et al*,[13] however, reported a 10% additional operation rate at adjacent segments 4 years after decompression only for degenerative lumbar disease, implying that rigidity across previously mobile segments is not the only contributing factor to the development of ASD. Our study confirms the findings of Bydon *et al*,[13] we found, for example, similar additional operation rates at the index and the adjacent levels for LSS with DS treated with decompression only. Furthermore, we found that additional operations at the adjacent levels were more common than after spinal fusion for LSS with DS than after spinal fusion for DDD. Thus, it seems like patients fused for LSS with DS are more predisposed to the development of ASD than patients fused for DDD, which suggests that increased rigidity of the spinal segments is not the only contributing factor to the development of ASD. However, we also found that age seems to be an important factor as patients fused for LSS with DS before the age of 60 has similar additional operation rates at the index level and the adjacent levels as the DDD patients. Also Sears *et al*[14] found that increasing age was a risk factor for ASD that required further surgery. In contrast, Radcliff *et al*[15] found no association between age and the reoperation rate, and Mesregah *et al*[9] found no association between age and ASD.

Two subanalyses from the Spine Patient Outcome Research Trial report data on additional operations pointing in the same direction as our results.[16 17] The additional operation rate at the index level was lower for LSS with DS treated with decompression and fusion (67% instrumented fusion and 22% uninstrumented fusion) compared with LSS without DS treated with decompression only (22.5% vs 33%).

Theoretically, for LSS with DS, decompression without fusion may increase the risk of index-level additional operations because of instability at the slipped segment.[4] However, our data could not verify any increased risk for additional operations at the index level compared with LSS with or without DS, as the patterns for decompression only for LSS with or without DS were very similar.

The overall additional operation rates were similar for all four clinical scenarios (15%–21%). The additional operation rate for LSS with DS treated with fusion was higher than the rate reported by the RCT of Ghogawala *et al*[4] possibly due to the longer follow-up period in our study. However, Ghogawala *et al*[4] reported a higher rate of additional operations for LSS with DS treated with decompression only. In contrast, the RCT by Försth *et al*[5] reported similar reoperation rates for both scenarios. The rates reported by Försth *et al*[5] are similar to ours. The RCT by Austevoll *et al*[18] reported lower rates of reoperations compared with our study, although, after only 2 years of follow-up. The patterns of additional operations reported by Ghogawala *et al*[4] and Försth *et al*[5] were similar to ours, that is, additional operations primarily at the index level for decompression only and additional operations at adjacent levels for decompression and fusion. Furthermore, our results confirm the results of Radcliff *et al*[15] that lumbar fusion is not associated with an increased reoperation rate compared with decompression only.

For patients fused for DDD, a retrospective study by Malter *et al*[19] reported an additional reoperation rate similar to ours. In a systematic review of fusion surgery for DDD, Phillips *et al*[7] reported a reoperation rate of 12.5%, 9.2% of these at the index level, that is, the same pattern of additional operations as suggested by our data.

The overall rates of additional operations for LSS, with or without DS, were 20%–22%. These rates were similar to those reported in previous large retrospective studies.[16 20 21] This is important from the perspective of patient information and shared decision-making. Patients who are offered spine surgery should be informed that one in five patients requires additional surgery over a course of 10 years. Therefore, the first operation may be the start of a series of additional spinal operations for other degenerative spinal conditions, either at the index level or at other spinal levels.

Although our study identified patterns for additional surgery in common degenerative spinal diseases it failed to identify the exact cause for additional surgery. Disk degeneration undoubtedly has a hereditary component with variable penetrance which probably implies an inherent risk of additional surgery. However, we could not account for the magnitude of this hereditary component.

A higher preoperative body mass index (BMI) has been identified as an important risk factor for the development of ASD.[9] Since there were only minimal differences in BMI between the groups in our study (table 1), BMI differences do not explain the different patterns found in our data.

We found that the mean time to the first additional operation at adjacent levels was approximately 5 years for all diagnoses. This means that the standard follow-up time of 2 years used by many spine surgery RCTs is too short to evaluate treatment effects on ASD.

Our findings should be evaluated in the light of several limitations. First, we recognise the inherent limitations of register data, such as a lack of confounder information, missing data or unknown data quality.[22] Second, no radiographic data were available in this study precluding analysis of radiographic factors associated with the development of ASD. Third, we deliberately kept the statistical analysis of our data simple, as it provides a clear message. We lack information about many factors, both clinical and radiological, which would lead the surgeon to undertake different types of additional operations.

CONCLUSION

There are different patterns of additional operations following the index procedure after surgery for degenerative spine diseases. Rigidity across previously mobile segments is not the only important factor in the development of ASD after spinal fusion, also the underlying disease and age may play parts in ASD development. The findings of this study can be used in the shared decision-making process when surgery is a treatment option for patients with degenerative lumbar spine diseases as the first operation may be the start of a series of additional spinal operations for other degenerative spinal conditions, either at the index level or at other spinal levels.

Contributors AJ and FGS designed the study. AJ analyzed the data. AJ and FGS interpreted the data. AJ wrote the manuscript with contributions from FGS. AJ and FGS approved the final version of the manuscript. AJ is the guarantor of the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by The study was approved by the Swedish Ethical Review Authority. Reference number: 2022-02709-1. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available from the National Swedish spine register (Swespine) after approval by the Swedish Ethical Review Authority and according to the regulations in the General Data Protection Regulation and the Swedish Patient Data Act. Data were pseudonymised before the authors accessed them for the purpose of this study.

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