

# De novo spine surgery as a predictor of additional spine surgery at the same or distant spine regions

## Erstoperationen an der Wirbelsäule als Prädiktor für weitere Eingriffe an der gleichen oder einer entfernten Wirbelsäulenregion

### Abstract

**Introduction:** Degenerative spine disorders are steadily increasing parallel to the aging of the population with considerable impact on cost and productivity. In this paper we study the prevalence and risk factors for multiple spine surgery and its impact on cost.

**Methods:** Data on 1,153 spine surgery inpatients operated between October 2005 and September 2008 (index spine surgery) in regard to the number of previous spine surgeries and location of surgeries (cervical or lumbar) were retrospectively collected. Additionally, prospective follow-up over a period of 2-5 years was conducted.

**Results:** Retrospectively, 365 (31.7%) patients were recurrent spine surgery patients while 788 (68.3%) were de novo spine surgery patients. Nearly half of those with previous spine surgery (51.5%) were on different regions of the spine.

There were no significant differences in length of stay or hospital charges except in lumbar decompression and fusion (LDF) patients with multiple interventions on the same region of the spine. Significant differences ( $P < .05$ ) in length of stay (5.4 days vs. 7.4 days) and hospital charges (\$55,477 vs. \$74,878) between LDF patients with one previous spine versus those with  $\geq 3$  previous spine surgeries on the same region were noted.

Prospectively, the overall reoperation rate was 10.4%. The risk of additional spine surgery increased from 8.0% in patients with one previous spine surgery (index surgery) to 25.6% in patients with  $\geq 4$  previous spine surgeries on different regions of the spine (including index surgery).

After excluding patients with previous spine surgeries on different regions of the spine, 17.2% of reoperated patients had additional spine surgery on a different spine region. The percentage of additional spine surgery on a distant spine region increased from 14.0% in patients with one spine surgery to 33.0% in patients with two spine surgeries on the same region. However, in patients with three or more spine surgeries on the same spine region there were no interventions on a distant spine region during the follow-up period.

**Conclusion:** De novo spine surgery is associated with an increased incidence of additional spine surgery at the same or distant spine regions. Large prospective studies with extended follow-up periods and multifaceted cost-outcome analysis are needed to refine the appropriateness of spine surgery.

**Keywords:** multiple spine surgery, spine region, cost

### Zusammenfassung

**Einführung:** Wirbelsäulenerkrankungen nehmen parallel zur Alterung der Bevölkerung ständig zu mit beachtlichen Auswirkungen auf Kosten und Produktivität. In diesem Artikel werden die Prävalenz und die Risi-

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kofaktoren für mehrfache Wirbelsäulenoperationen und ihr Einfluss auf die Folgekosten untersucht.

**Methoden:** Eine retrospektive Analyse von 1.153 Krankenhauspatienten nach Wirbelsäulenoperationen im Zeitraum von Oktober 2005 bis September 2008 auch in Bezug auf vorausgegangene Wirbelsäulenoperationen und deren Lokalisation (Hals- oder Lendenwirbelsäule) wurde erstellt. Zusätzlich wurden die Nachuntersuchungen über 2–5 Folgejahre erfasst.

**Ergebnisse:** Rückblickend hatten 365 (31,7%) der Patienten wiederholte chirurgische Eingriffe an der Wirbelsäule, während bei 788 (68,3%) Patienten der operative Eingriff erstmalig erfolgte. Etwa bei der Hälfte (51,5%) der Patienten mit wiederholten Wirbelsäulenoperationen wurden diese in verschiedenen Bereichen durchgeführt.

Es gab keine signifikanten Unterschiede bei der Dauer des Klinikaufenthaltes oder bei den Klinikkosten außer bei Patienten mit lumbaler Dekompression und Fusion (LDF) mit mehrfachen Eingriffen im gleichen Operationsbereich. Signifikante Unterschiede ( $P < 0,05$ ) wurden gefunden beim Dauer des Klinikaufenthalts (5,5 Tage versus 7,4 Tage) und bei den Krankenhauskosten (55.477 \$ versus 77.877 \$) zwischen LDF-Patienten mit einer vorherigen Wirbelsäulenoperation verglichen mit Patienten mit drei und mehr vorausgegangenen Operationen in demselben Wirbelsäulenbereich.

Prospektiv lag die Häufigkeit erneuter Operationen durchschnittlich bei 10,4%. Das Risiko einer zusätzlichen Wirbelsäulenoperation stieg von 8,0% bei Patienten mit einer vorausgegangenen Wirbelsäulenoperation (Indexoperation) auf 25,6% bei Patienten mit 4 und mehr chirurgischen Eingriffen an verschiedenen Regionen der Wirbelsäule (incl. Indexoperation).

Nach Ausschluss aller Patienten mit vorausgegangenen Wirbelsäulenoperationen in verschiedenen Wirbelsäulenbereichen hatten 17,2% der erneut operierten Patienten eine zusätzliche Operation in einem anderen Wirbelsäulenbereich. Der Prozentsatz der zusätzlichen chirurgischen Eingriffe in einem entfernten Wirbelsäulenbereich lag bei Patienten mit einer Wirbelsäulenoperation bei 14% und stieg auf 33% bei Patienten mit zwei Operationen im selben Bereich. Jedoch gab es bei Patienten mit drei und mehr chirurgischen Eingriffen in der gleichen Wirbelsäulenregion während der Beobachtungsperiode keine weiteren Operationen in einer anderen Region.

**Schlussfolgerung:** Eine Erstoperation an der Wirbelsäule ist assoziiert mit einer erhöhten Häufigkeit von weiteren Wirbelsäulenoperationen im gleichen oder einem anderen Wirbelsäulenbereich. Große prospektive Studien mit längeren Beobachtungsperioden und Kosten-Nutzen-Analysen sind erforderlich, um die Angemessenheit von Wirbelsäulenoperationen in geeigneter Form bewerten zu können.

**Schlüsselwörter:** mehrfache Wirbelsäulenoperation, Wirbelsäulenbereiche, Kosten

## Introduction

Vertebral column difficulties are an ubiquitous penalty for the upright posture of our species. Increasingly aggressive surgical intervention has been introduced to ameliorate such difficulties resulting in substantial rise in the rate and cost of spine surgery, especially in the United States [1], [2], [3], [4], [5], [6], [7]. To study the prevalence and risk factors for multiple spine surgery in our patient population we conducted the following inquiry.

## Methods

The clinical records of 1,153 spine surgery inpatients operated between Oct 2005 and Sep 2008 were retrospectively reviewed and their clinical course prospectively followed. The index surgery was lumbar microdiscectomy (LMD) in 235 cases, anterior cervical decompression and fusion (ACDF) in 696 and lumbar decompression and fusion patients (LDF) in 222 cases (Figure 1). Recurrent

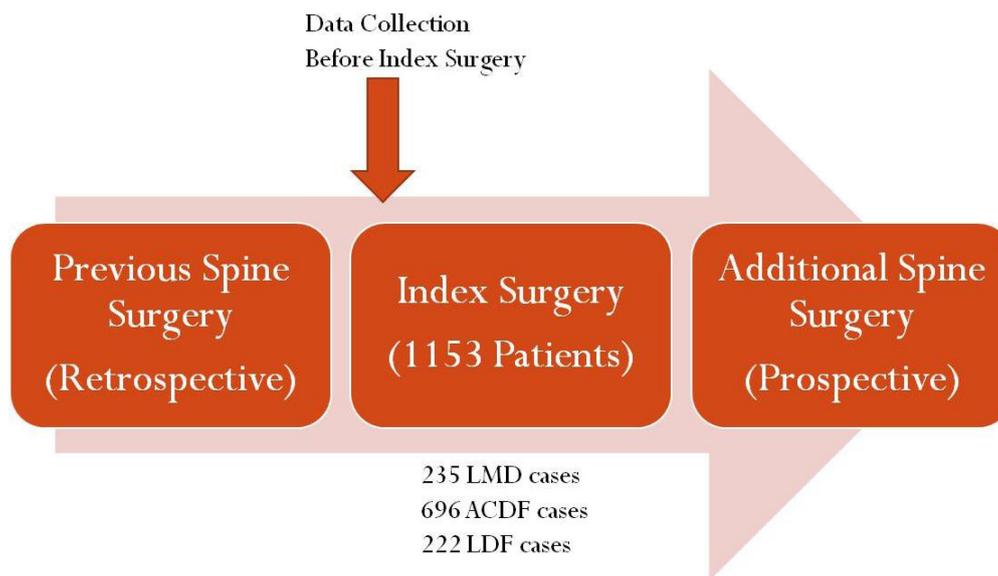


Figure 1: Study structure in relationship to index surgery

Table 1: Studied variables

Variable	Type	Values
Type of index surgery	nominal	LMD, ACDF, LDF
Patient classification	nominal	de novo, recurrent
Number of previous spine surgeries	scale	0–10
Number of previous spine surgeries	nominal	0, 1, 2, ≥3
Variability of previous spine surgery	nominal	all same region (cervical or lumbar), different regions (cervical & lumbar)
Additional spine surgery	nominal	yes, no
Variability of additional spine surgery	nominal	all same region (cervical or lumbar), different regions (cervical & lumbar)
Age	scale	years
Gender	nominal	male, female
BMI	scale	kg/m <sup>2</sup>
Obesity	nominal	nonobese, obese class I, obese class II, obese class III
Preoperative opioid use	nominal	yes, no
Preoperative antidepressant use	nominal	yes, no
Employment status	nominal	employed, unemployed

patients were defined as those with previous spine surgery and de novo patients were those with no previous spine surgery.

Data on patient demographics, number of previous spine surgeries, location of surgery, number of additional spine surgeries during the follow-up period of 2-5 years (prospective), opioid and antidepressant use were collected (Table 1). Over half of the cohort (53%) was females. The average age was 56±15 for LMD patients, 53±11 for ACDF patients and 56±12 for LDF patients. Regression analysis was applied with the help of SPSS v16.

## Results

### Age, gender and number of previous spine surgeries (PSS)

De novo patients were slightly younger than recurrent patients. The average age of de novo patients was 53 years while the average age of patients with 1, 2 and ≥3 was 55, 58 and 57 years. There was no significant difference in gender distribution between de novo and recur-

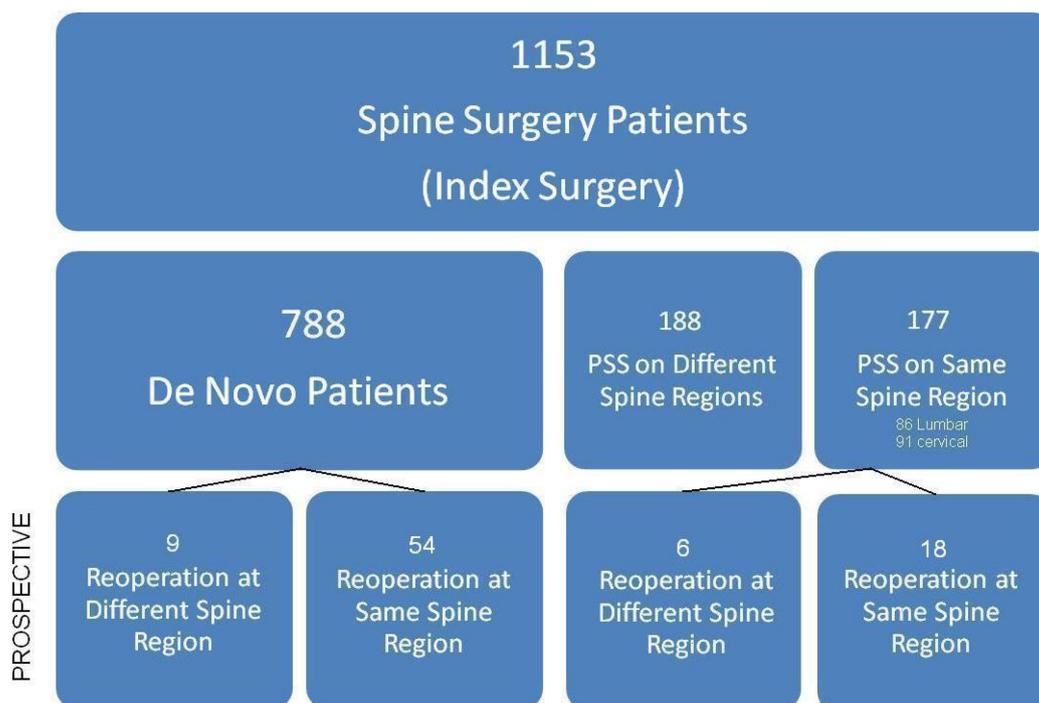


Figure 2: The distribution of patients in the retrospective and prospective branches of the study

rent patients (53.6%, 53.9%, 45.5% and 51.9% females, respectively).

## Prevalence of recurrent patients

Overall, 365 (31.7%) patients were recurrent spine surgery patients while 788 (68.3%) were de novo spine surgery patients (Figure 2). The prevalence of previous spine surgeries increased with age, from 18.4% in patients less than forty to 37.4% in patients older than sixty five. As per type of index surgery, 31.9% of LMD patients, 27.2% of ACDF patients and 45.5% of LDF patients had previous spine surgery. LDF patients older than 40 years had the highest prevalence of previous spine surgery (47.4%).

## Differences between de novo and recurrent patients

Significant differences were noted between de novo and recurrent patients in average age (53 years vs. 56 years,  $P < .05$ ), percentage of patient over 65 years of age (16.4% vs. 21.1%,  $P < .01$ ), percentage of patients on antidepressants (27.0% vs. 34.2%  $P < .05$ ) and percentage of patients with osteoporosis (1.9% vs. 4.9%,  $P < .01$ ).

## Number and location of previous spine surgeries

The majority of recurrent patients (235) had one previous spine surgery; a smaller group (77) had two previous spine surgeries and a minority (54) had three or more spine surgeries. Overall, 11.3% had two or more PSS and 16.3% had previous surgical interventions on more than

one region of the spine, i.e. nearly half of recurrent patients (177) had previous spine surgeries on the same spine region (Figure 2). Specifically, 63.6% of patients with two previous spine surgeries had surgery on different regions of the spine and 81.1% of those with  $\geq 3$  previous spine surgeries had surgery on different regions of the spine. Among these patients (with previous spine surgery), LDF patients 40 years of age and younger had the highest prevalence of previous spine surgery on different regions of the spine (87.5%). Patients with  $\geq 3$  previous spine surgeries had a higher percentage of osteoporosis (11.1% vs. 1.9%) and rheumatoid arthritis (3.7% vs. 1.1%) compared with de novo patients.

## Factors affecting the number of previous spine surgeries

Regression analysis using the number of previous spine surgeries as the dependent variable and type of index surgery, spine region (same, variable), age, gender, obesity, antidepressant-opioid use and employment as predictors showed that previous spine surgery on two different spine regions (cervical and lumbar) is the most significant predictor of the number of previous spine surgeries ( $t=23.396$ ,  $P=0.000$ ). Other important factors were type of index surgery, age and opioid use. Patients with 0, 1, 2,  $\geq 3$  previous spine surgeries had opioid use rates of 47.2%, 49.2%, 50.7% and 68.5% respectively.

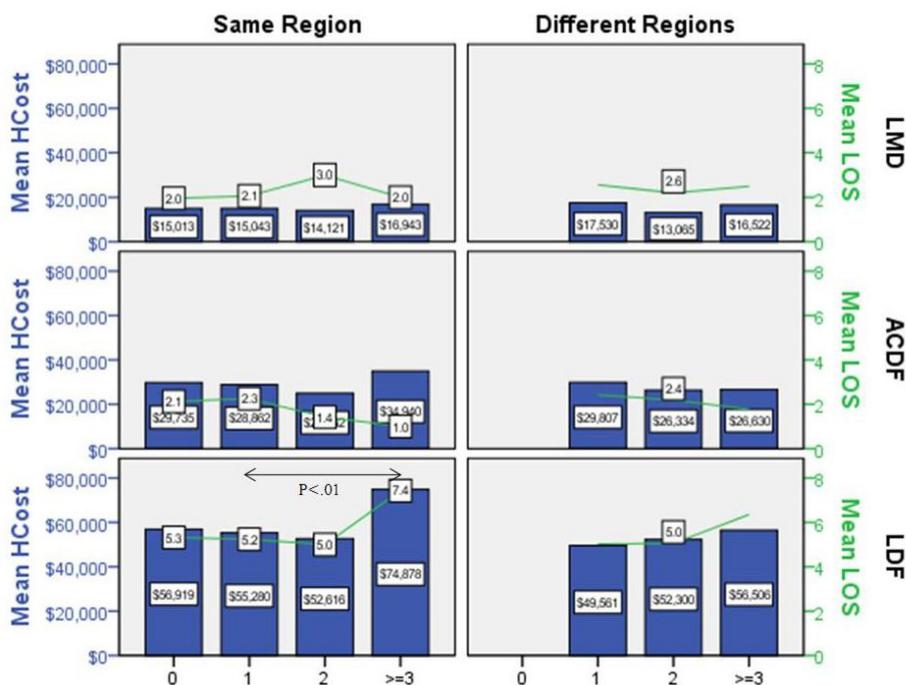


Figure 3: Hospital length of stay and charges per type of index surgery, number of previous spine surgeries and location of surgery

### The impact of the number of previous spine surgeries on hospital charges

There were significant differences ( $P < .01$ ) in length of stay (5.2 days vs. 7.4 days) and hospital charges (\$55,280 vs. \$74,878) between LDF patients with one previous spine versus those with  $\geq 3$  previous spine on the same region (Figure 3).

### Impact of previous spine surgery on the rate of additional spine surgery

Overall, 10.4% of patients came back for additional spine surgery within the follow-up period of 2–5 years (Figure 4). This was reasonably consistent with the literature (Table 2).

Patients with more PSS and those with PSS in different regions of the spine were more likely to come for additional spine surgery. The risk of additional spine surgery increased from 8.0% in patients with one previous spine surgery (index surgery) to 25.6% in patients with  $\geq 4$  previous spine surgeries on different regions of the spine (including index surgery, Figure 5). These numbers are significantly higher than the risk of spine surgery in the general population, 201 per 100,000 [6] (Figure 5). Regression analysis showed age, employment status and number of previous spine surgeries to be the most important predictors of return for additional spine surgery (Yes/No).

### Impact of previous spine surgery on the rate of additional spine surgery on a distant region

After excluding patients with previous spine surgeries on different spine regions, we calculated the risk of additional spine surgery on a distant spine region from the remaining cohort (965 patients). We found that 17.2% of reoperated patients had additional spine surgery on a distant spine region. The percentage of additional spine surgery on a distant spine region increased from 14.0% in patients with one spine surgery to 33.0% in patients with two spine surgeries on the same region. However, in patients with three or more spine surgeries on the same spine region there were no additional surgeries on a distant spine region during the follow-up period (Figure 6).

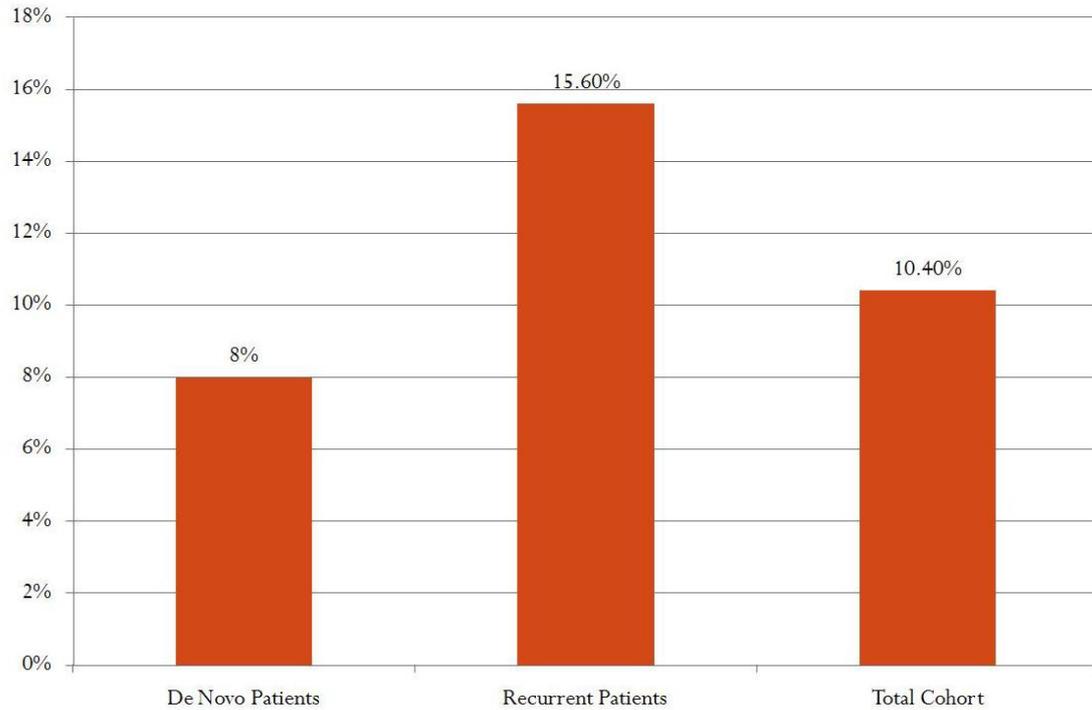


Figure 4: The risk of future spine surgery per patient classification

Table 2: Reoperation rates in the literature

Authors	Year	Location	Follow-up (years)	Reoperation	Index surgery/diagnosis
Katz et al. [12]	1991	USA	1.0	6.0%	LD+/-F
Hirabayashi et al. [13]	1993	Japan	4.5	7.5%	lumbar microdiscectomy
Deyo et al. [14]	1993	USA	4.0	10.2%	LD
			4.0	11.9%	LDF
Tuite et al. [15]	1994	USA	4.6	15.0%	LD
Katz et al. [16]	1996	USA	8.1	23.0%	LD+/-F
Hu et al. [17]	1997	Canada	4.0	9.5%	back surgery
Malter et al. [18]	1998	USA	5.0	14.6%	LD
			5.0	18.2%	LDF
Katz et al. [19]	1999	USA	1.0	5.9%	LD+/-F
Atlas et al. [20]	2001	USA	5.0	19.0%	open discectomy
Österman et al. [21]	2003	Finland	11.0	14.0%	lumbar discectomy
Jansson et al. [22]	2004	Sweden	10.0	10.0%	lumbar disk herniation
Jansson et al. [23]	2005	Sweden	10.0	11.0%	LD+/-F
Atlas et al. [24]	2005	USA	10.0	23.0%	LD
Häkkinen et al. [25]	2007	Finland	5.0	10.2%	lumbar disk herniation
Martin et al. [26]	2007	USA	4.0	14.0%	LD+/-F
Berg et al. [27]	2009	Sweden	2.0	10.0%	LDF

LD: lumbar decompression (laminectomy)

LDF: lumbar decompression and fusion

LD+/-F: lumbar decompression with or without fusion

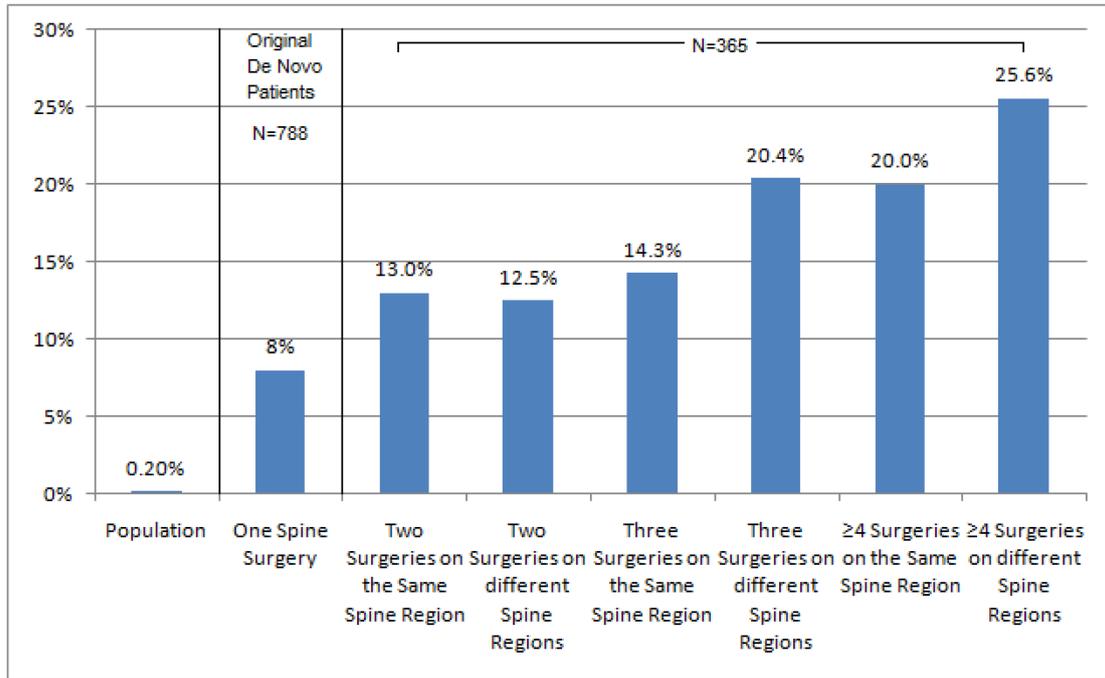


Figure 5: The risk of future spine surgery in the general population vs. patients with a history of spine surgery (index surgery included)

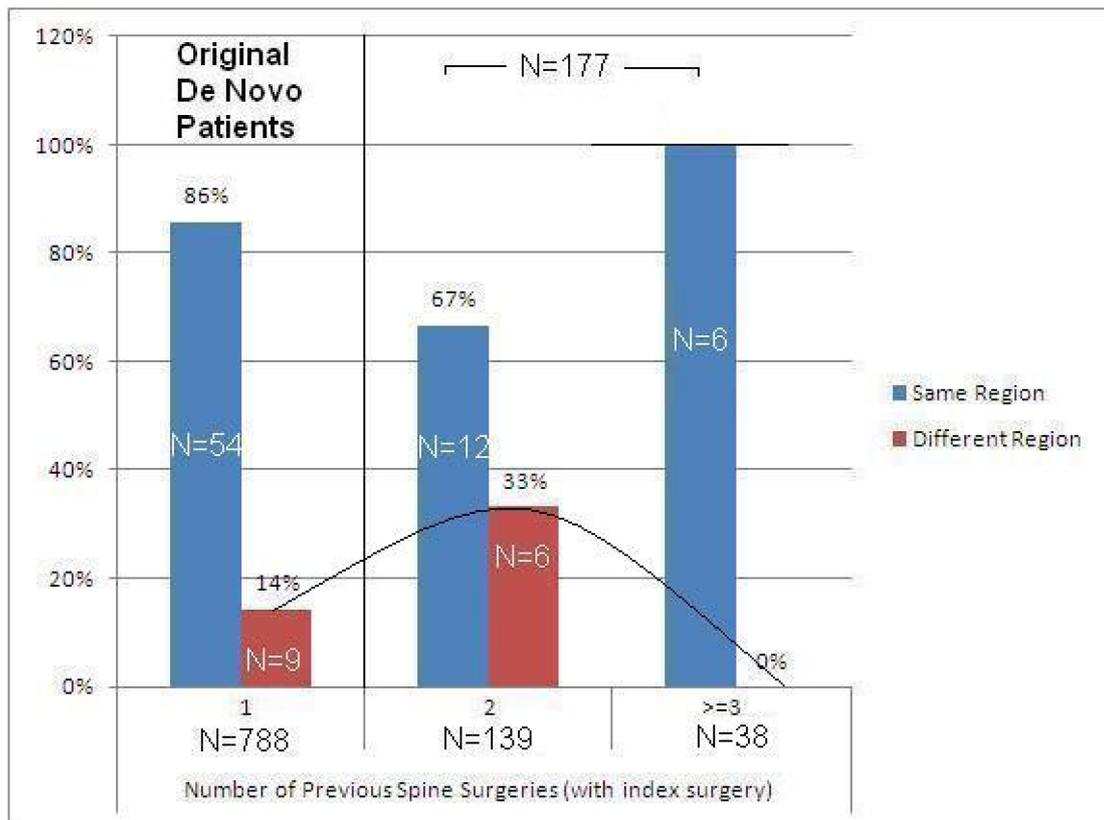


Figure 6: The risk of future spine surgery on the same and distant spine regions based on the number of previous spine surgeries (same region cohort)

## Discussion

Our study is not without its limitations. The follow-up period is relatively short and uneven for all patients. Additionally, a substantial number of patients may have been lost to follow-up. Our clinical outcome analysis only reflected reoperation rates ignoring other outcome parameters such as pain, function, neurological exam as well as work and disability status. We limited our economic impact analysis to hospital cost which represents a small part of the total healthcare cost of spine disease patients that also includes physician fees, rehabilitation costs and disability compensation. Large prospective studies with extended follow-up periods and cost-outcome analysis are needed to objectively study the cost-benefit of spine surgery.

With these caveats aside, our study suggests that the more frequent the individual spine operations the greater the likelihood of repeat surgery either at the same level or at a distant site. In cases of reoperation on the same spine region, the greater the number of spine surgeries the higher the hospital cost and length of stay; otherwise hospital cost and length of stay are fairly similar.

It is well established that surgery at one level of the spine is associated with an increased risk of repeated surgery at that same or adjacent level due mainly to recurrence of the initial spine pathology [8]. As stated earlier, our study suggests that the risk of surgical intervention on a distant site also increases. Several reasons may exist for such a finding. Firstly, the patient undergoing surgery at a different geographical site may be afflicted with a diffuse osseous disease such as osteoporosis. Indeed, such a factor did exist in our study cohort. Osteoporosis is increasing in magnitude with the aging population especially in women. Such patients are prone to develop painful and debilitating spinal deformities which are difficult to treat leading to multiple surgical interventions [9]. Another explanation might be that surgical intervention on one segment of the spine may change spine biomechanics predisposing to new spine difficulties at a distant area. While the presence of such altered biomechanics at adjacent levels is well documented [10]. However, the impact of spine surgery on distant biomechanics of the spine is less clear [11]. Additionally, patients who undergo spine surgery may develop analgesic dependency which predisposes them to request surgery at additional levels. Similarly, patients with recurring vertebral column pain, having obtained relief from earlier operative intervention, may seek surgical treatment more willingly than patients from the general population.

Importantly, the assessment of our patient cohort suggests that a substantial proportion of patients are predisposed to multiple spine surgeries on different regions of the spine – a variable that is not commonly analyzed in reported outcome of spine procedures. If additional spine surgery at a distant spine region is causally connected to initial spine surgery then most present day outcome evaluation and risk-benefit analysis of de novo spine surgery is excessively optimistic. Understanding clinical

dynamics in this group may have significant input in promoting therapeutic efficiency and improving surgical outcome.

## Notes

### Competing interests

The authors declare that they have no competing interests.

### Award

This paper was awarded *First Place Eposter in the Category of Socioeconomic* at the 2011 American Association of Neurological Surgeons Annual Meeting, Denver, Colorado.

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