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ORIGINAL ARTICLE

Reoperation following lumbar spinal surgery: costs and outcomes in a UK population cohort study using the Clinical Practice Research Datalink (CPRD) and Hospital Episode Statistics (HES)

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Abstract

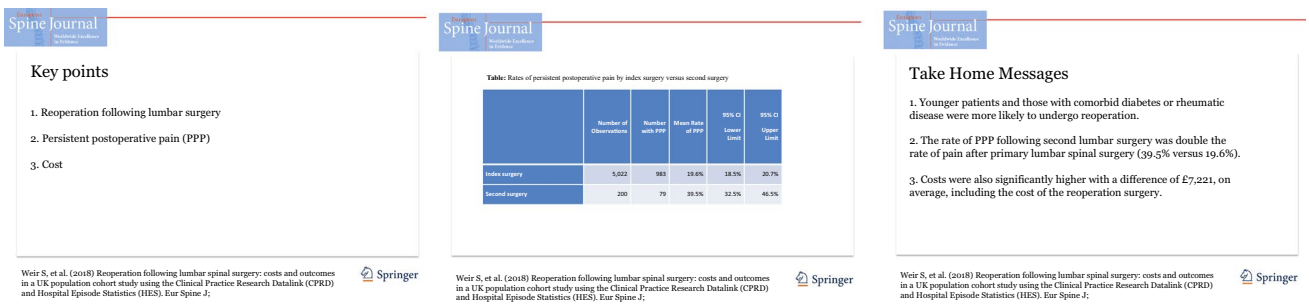
Purpose To assess the likelihood of persistent postoperative pain (PPP) following reoperation after lumbar surgery and to estimate associated healthcare costs.

Methods This is a retrospective cohort study using two linked UK databases: Hospital Episode Statistics and UK Clinical Practice Research Datalink. Costs and outcomes associated with reoperation were evaluated over a 2-year postoperative period using multivariate logistic regression for cases who underwent reoperation and controls who did not, based on demographics, index surgery type, smoking status, and pre-index comorbidities using propensity score matching.

Results Risk factors associated with reoperation included younger age and the presence of diabetes with complications or rheumatic disease. The rate of PPP after reoperation was much higher than after index surgery, with 79 of 200 (39.5%; 95% CI 32.5%, 46.5%) participants experiencing ongoing pain compared with 983 of 5022 (19.5%; 95% CI 18.5%, 20.7%) after index surgery. Mean costs in the 2 years following reoperation were £1889 higher (95% CI £2, £3809) than for patients with PPP who did not undergo repeat surgery over an equivalent follow-up period. With the cost of reoperation itself included, the mean cost difference for patients who underwent reoperation compared with matched controls rose to £7221 (95% CI £5273, £9206).

Conclusions High rates of PPP and associated healthcare costs suggest that returning to the operating room is a complex and challenging decision. Spinal surgeons should review whether the potential benefits of additional surgery are justified when other approaches to managing and relieving chronic pain have demonstrated superior outcomes.

Graphical abstract These slides can be retrieved under Electronic Supplementary Material.



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Extended author information available on the last page of the article

Keywords Lumbar surgery · Reoperation · Persistent postoperative pain · Cost

Introduction

Rates of lumbar surgery in the UK have risen significantly in the past two decades. Persistent postoperative pain (PPP) occurs when chronic back and/or leg pain continues following spinal surgery. We previously reported that one-in-five UK patients suffer with PPP following index lumbar spine surgery [1]. Further surgery may be offered as a treatment option to address ongoing pain.

This study uses a nationally representative UK dataset to evaluate a cohort of patients with PPP symptoms after lumbar surgery who underwent reoperation. Patients were followed for at least 2 years postoperatively. We aimed to identify whether patients who undergo reoperation are more or less likely to experience PPP than index lumbar surgery patients.

Methods

Setting and data sources

This is a retrospective cohort study using two linked UK databases: Hospital Episode Statistics (HES) and UK Clinical Practice Research Datalink (CPRD). Together, these datasets provide detailed clinical records covering primary care events, inpatient hospital admissions, outpatient clinic visits, accident and emergency attendances, and drugs prescribed in primary care. Approval was granted by the Independent Scientific Advisory Committee for Medicines and Healthcare products Regulatory Agency (MHRA) on December 17, 2014 (ISAC Protocol 14-180R). We provide additional information on methodology in a report on PPP following index lumbar surgery [1].

Study participants

The dataset included patients aged 18 and older having one or more lumbar procedures identified from a CPRD-HES linked dataset between April 2007 and March 2012. Data were available through March 2014, allowing for a minimum of 2 years of follow-up. Index operative procedures included any single procedure or combination of discectomy/microdiscectomy, excision of lumbar intervertebral disc, laminectomy, foraminotomy, lumbar decompression (or fenestration) or lumbar fusion, including all anterior, posterior and combined approaches. To ensure that our reoperation sample had at least 2 years of postoperative follow-up data, only patients who underwent a second surgery before March 2012 were included as cases in the analyses of PPP and costs following reoperation. Cases were matched 1-to-1 with a control group drawn from among lumbar surgery patients with PPP after their index surgery who did not have additional lumbar surgery during the follow-up period.

Risk factors for reoperation on the lumbar spine

Risk factors included the type of index surgery (decompression/discectomy, instrumented fusion, and other fusion), sex (male vs. female), age group at index surgery (< 65 versus 65+), smoking status (current smoker vs. non-smoker in the year prior to the index surgery) and selected Charlson comorbidities (evaluated in the baseline period 1 year before the index surgery).

Persistent postoperative pain (PPP)

Each individual was categorized as a 'success' (i.e. no evidence of PPP) or 'failure' (i.e. evidence of PPP). We allowed for a period of 6 months recovery time after the index surgery. Evidence of ongoing pain beyond 6 months postoperatively was inferred from one or more of the following: (1) any type of lumbar surgery in the period 6–24 months following the index procedure; (2) any surgical intervention for lumbar pain (e.g. neuromodulation, implantation of drug infusion delivery system) at any time after the index surgery; (3) at least one pain-related GP visit or specialist pain clinic visit in each of two consecutive quarters occurring 6–24 months postindex surgery.

Any surgical procedures in the first 6-month postoperative period were assumed to be related to the management of postoperative complications associated with the index procedure. A patient having additional lumbar surgery beyond the 6-month postoperative period was classified as having PPP. Our primary aim was to assess whether or not pain resolved following reoperation. We applied identical criteria to the second surgery to determine whether patients continued to experience PPP or not (Fig. 1).

Healthcare utilization and costs

A standard cost-of-illness approach was taken to estimate direct medical costs from the perspective of the UK National Health Service (NHS). We classified all healthcare encounters into major categories of healthcare resource utilization and assigned standard published unit costs. We estimated total cost per patient over 24 months following the second surgery for cases and controls. To account for inflation and variations in

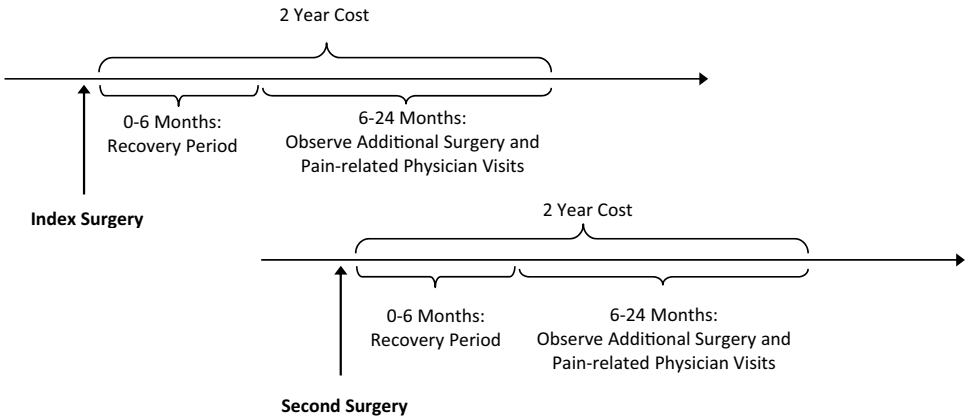

Fig. 1 Study timeline

pricing over time, 2013 unit costs were applied to all years. Costing methods were described in more detail previously [1].

Statistical analyses

To assess risk factors for spinal reoperation, we used multivariate logistic regression to model the probability (odds) of receiving reoperation as a function of the initial surgery type (decompression or discectomy vs. fusion), age at first lumbar surgery, sex, smoking status, and Charlson comorbidities evaluated at baseline in the year prior to index surgery.

Rates of PPP were computed as a percentage of all patients who underwent the initial or further lumbar surgery within the time frame.

Costs in the 2 years following additional surgery were compared to costs for a control group drawn from among lumbar surgery patients with PPP after their index surgery who did not have additional surgery. Controls were assigned a follow-up start date aligned with the date of second surgery for their matched case. We used 1:1 propensity score matching (without replacement) based on patient's age at surgery, sex, year of surgery, type of the initial surgery (fusion vs. decompression/discectomy), and the presence of each of seventeen comorbidities that comprise the Charlson Comorbidity Index using the greedy matching algorithm [2].

Costs attributable to reoperation were estimated as the difference in total costs for cases versus controls. Statistical significance of the difference in average costs between patients in each group were evaluated using bootstrapped 95% confidence intervals.

All data manipulation and analyses were conducted using SAS software, Version 9.4 for Windows [SAS Institute, Cary NC].

Results

Study population

A total of 5022 patients in the linked CPRD-HES data met the study inclusion criteria of having had lumbar surgery during the study intake period, with a minimum of 12 months data prior to their initial lumbar surgery and 24 months postoperative data from the later of index surgery or revision surgery, if applicable (Fig. 2).

Table 1 provides descriptive information on those who underwent reoperation in the period 6–24 months following the index surgery (cases; $n = 200$), compared with matched patients with evidence of PPP following index surgery who did not undergo additional lumbar surgery (controls; $n = 200$). There was no evidence of differences in key characteristics between cases and matched controls.

Type of revision surgery

Table 2 presents first and second surgery type for those who had both surgeries ($n = 200$). Most patients requiring reoperation initially had decompression/discectomy ($n = 179$; 90%). By contrast, only three-quarters ($n = 150$; 75%) of second surgeries were decompressive procedures. Among this cohort of patients whose second surgery occurred 6–24 months following their initial surgery, the mean elapsed time between the procedures was more than 13 months (standard deviation 5 months) (Table 3).

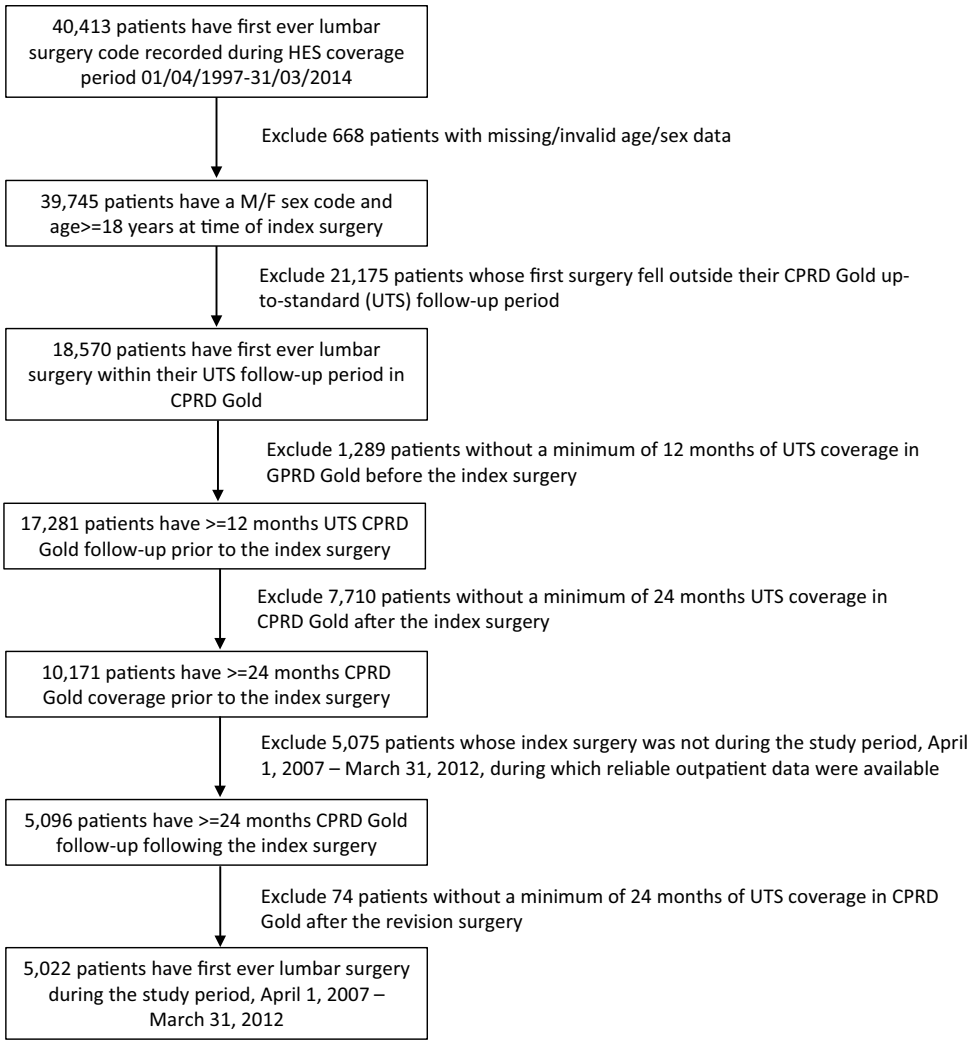

Fig. 2 Study population

Likelihood of revision surgery

Odds of undergoing reoperation were not predicted by type of index surgery, patient sex, or smoking status (Table 4). However, the odds of reoperation were substantially lower among older patients (over 65 years) compared to younger patients (OR 0.63, 95% CI 0.44, 0.89). Most comorbid health conditions were not associated with reoperation. Exceptions were patients with rheumatic disease, who had double the odds of reoperation, and those with diabetes, who had more than four times the odds of undergoing reoperation.

PPP following revision surgery

Nearly one-in-five lumbar surgery patients experienced PPP following the initial surgery (Table 5). Among 983 patients with PPP who met our study criteria for this analysis, 200 (20.3%) underwent reoperation within 6–24 months following their first operation. Two-in-five reoperation patients continued to meet criteria for PPP during the second surgery follow-up period.

Costs attributable to revision surgery

The main component driving costs following second surgery was the hospitalization for the surgery itself, which contributed £5332 to the total cost differential of £7221 (CI £5273, £9206; Table 6). Second surgery, at £5332 on average, was also significantly more expensive than the mean cost of the index surgery for the 200 cases, at £4394. On average, reoperation cost an additional £938 (CI £648, £1228) compared to the initial surgery for the same patients.

Discussion

Our analysis of reoperation included all patients aged 18 and above in the UK CPRD-HES linked dataset who underwent lumbar surgery from 2007 through to 2012. We compared

Table 1 Characteristics of lumbar surgery patients with PPP having reoperation (cases) or not (matched controls) compared with all lumbar surgery patients who did not have reoperation

	PPP with second surgery (cases)	PPP without second surgery (controls)	All lumbar surgery patients without second surgery
	$n=200$	$n=200$	$n=4822$
Age at index surgery (years), mean (sd)	52.2 (14.7)	53.8 (15.1)	55.1 (16.1)*
Male, %	45.0	43.3	49.3
Smoking status (current smoker in 12 months pre-index surgery date), %	22.5	20.0	18.5
Charlson Comorbidity Index (CCI), mean (sd)	0.5 (0.9)	0.5 (0.9)	0.6 (1.1)
Charlson Comorbidity Index conditions, %			
Myocardial infarction	1.0	2.0	2.5
Congestive heart failure	0.5	0	2.0
Peripheral vascular disease	1.5	1.0	2.0
Cerebrovascular disease	2.0	3.0	1.7
Dementia	0	1.0	0.2
Chronic pulmonary disease	15.0	14.5	12.6
Connective tissue-rheumatic disease	5.0	3.5	3.1
Peptic ulcer disease	0.5	2.0	1.7
Mild liver disease	0	1.0	0.6
Diabetes without complications	7.5	8.5	7.6
Diabetes with complications	2.0	0.5	0.6*
Paraplegia and hemiplegia	4.0	2.0	3.0
Renal disease	0	0.5	1.3
Cancer	2.5	4.5	4.2
Moderate or severe liver disease	0	0	0.02
Metastatic carcinoma	0	0	0.6
AIDS/HIV	0	0	0

*Significant at the alpha = 0.05 level. Fisher's exact tests were used for categorical variables and Wilcoxon tests for continuous variables

Table 2 Number (%) patients by first and second surgery, $n=200$

Index surgery	Second surgery			
	Decompression/discectomy *n* (%)	Instrumented fusion *n* (%)	Other fusion§ *n* (%)	All second surgery *n* (%)
Decompression/discectomy	143 (71.5)	13 (6.5)	23 (11.5)	179 (89.5)
Instrumented fusion	4 (2.0)	1 (0.5)	6 (3.0)	11 (5.5)
Other fusion	3 (1.5)	2 (1.0)	5 (2.5)	10 (5.0)
All index surgery	150 (75.0)	16 (8.0)	34 (17.0)	200 (100)

Table 3 Time to second surgery in days, $n=200$

Index surgery type	Number of patients	Mean	SD	Median	IQR
Decompression/discectomy	179	413.0	146.3	393.0	221
Instrumented fusion	11	358.9	160.6	359.0	235
other fusion	10	451.1	133.1	465.5	235
All index surgery	200	411.9	146.6	393.0	227

index lumbar surgery with reoperation in terms of rates of PPP, assessed risk factors for reoperation, and estimated healthcare costs associated with reoperation for PPP versus more conservative management. We sought to understand whether rates of pain after reoperation are comparable to those after index spinal surgery. This is an important clinical question to help physicians and patients evaluate the risk-benefits of undergoing further surgery when other approaches to managing and relieving chronic pain have

Table 4 Multivariate logistic regression of the likelihood of additional surgery, all lumbar surgery patients ($n = 5022$)

Parameter	Odds ratio	95% CI lower limit	95% CI upper limit
Index surgery type (vs. decompression/discectomy)			
Instrumented fusion	0.759	0.406	1.416
Other Fusion	0.605	0.316	1.156
Sex (vs. male)			
Female	1.188	0.891	1.584
Age group (vs. < 65 years)			
Age >=65 years at index surgery	0.629*	0.443	0.893
Smoking status			
Current smoker (vs. not current smoker)	1.187	0.839	1.678
Comorbid conditions			
Myocardial infarction	0.488	0.116	2.050
Congestive heart failure	0.690	0.093	5.140
Peripheral vascular disease	1.012	0.306	3.344
Cerebrovascular disease	1.258	0.446	3.549
Chronic pulmonary disease	1.196	0.799	1.790
Rheumatic disease	2.166*	1.098	4.275
Peptic ulcer disease	0.339	0.047	2.463
Diabetes without complications	0.889	0.479	1.652
Diabetes with complications	4.704*	1.406	15.742
Paraplegia and hemiplegia	1.255	0.604	2.607
Cancer/metastatic carcinoma	0.689	0.278	1.705

*Statistically significant at $\alpha < 0.05$ level

Table 5 Rates of PPP by index surgery versus second surgery

	Number of observations	Number with PPP	Mean rate of PPP (%)	95% CI lower limit (%)	95% CI upper limit (%)
Index surgery	5022	983	19.6	18.5	20.7
Second surgery	200	79	39.5	32.5	46.5

Table 6 Healthcare costs (2013 British Pounds) of second surgery

	Patients with PPP but no second surgery (Controls, $n = 200$)	Patients with PPP who had second surgery (Cases, $n = 200$)	Cost difference [Lower 95% CI, Upper 95% CI][a]
Total cost, including second surgery	£9452	£16,673	£7221 [£5273, £9206]
Total cost, not including second surgery	£9452	£11,341	£1889 [£2, £3809]
Inpatient	£3119	£3725	£606 [−£426, £1601]
Outpatient procedures	£312	£265	−£47 [−£177, £85]
Outpatient attendances	£975	£1184	£209 [−£9, £412]
Accident & emergency	£59	£74	£15 [−£12, £42]
Primary care	£4089	£4561	£472 [−£75, £1041]
Pain medication	£896	£1531	£635 [£40, £1472]

[a]Bootstrapped 95% confidence intervals

demonstrated equal or superior outcomes [3]. This is the first study to compare index surgery and reoperation in terms of persistent pain outcomes. Most studies examining the risks of lumbar spine surgery reoperation are based on single-institution case series or small clinical trials [4–6]. Few population-based studies have been published. A US study found that the risk of spinal reoperation increased with age, recent hospitalization, and diagnosis of herniated disc. Data were limited to those eligible for Medicare health insurance (those aged 65 and greater) and comorbidities were not considered [7]. Another study using all hospital claims records for Ontario, Canada, examined similar factors for reoperation and found that the probability of second surgery was greater in patients younger than 65 years. Other factors, including the type of the initial surgery, index diagnosis, sex and score on the combined Charlson Comorbidity Index, were not found to predict risk of reoperation [8].

Our findings are broadly in line with the published literature. However, we identified particular comorbid conditions associated with reoperation: diabetes and rheumatic disease were independent predictors associated with reoperation. These findings are concerning given that diabetic microangiopathy is associated with poor wound healing and risk of surgical site infection due to decreased local tissue perfusion and local tissue ischaemia [9–13]. Similar risks have been noted following orthopaedic surgery among patients suffering from systemic immune disease, such as rheumatoid arthritis, owing to the use of immune modulating drugs [13–15].

Recent literature on the association between smoking and reoperation on the lumbar spine, and poor outcomes of lumbar surgery, is somewhat mixed. With a few notable exceptions [16, 17], most studies of tobacco use suggest that it is a risk factor for poor postoperative outcome [18–21]. However, smoking status in the year prior to the index surgery was not a significant predictor of reoperation in our study.

Reoperation may be technically more complex and challenging than the initial spinal surgery. The literature suggests variable success in lumbar reoperation to address chronic pain, although many of these studies have methodological weaknesses. Previous studies investigating PPP following reoperation are largely single-institution case series conducted in the 1960s. Surgical practice and healthcare management of these patients has changed considerably. The follow-up periods used to assess PPP ranged from 1 to 29 years after surgery, suggesting inconsistent definitions of PPP which might have included new lumbar conditions. Not surprisingly, reported rates of failure of reoperation surgery varied enormously, from 13 to 78% [5, 22–24]. None of these studies attempted to compare the initial surgery with reoperation on outcomes of persistent pain.

Using a population-based approach, we found that more than 39% of patients experienced PPP following lumbar reoperation, double the rate of PPP following index surgery. Nearly 40% did not benefit from revision surgery and may have fared better with more conservative therapies. A randomized controlled trial of lumbar fusion versus cognitive intervention and exercises for ongoing pain after disc herniation surgery found no benefit of lumbar fusion compared to conservative care [25]. Another trial reported better outcomes for spinal cord stimulation (SCS) versus reoperation for patients with persistent pain after the initial lumbar surgery [26]. We compared the healthcare costs of reoperation against matched controls who also had PPP after index surgery but without reoperation. The controls thus represent a counterfactual treatment pathway of patients with PPP, and were similar in other characteristics, but treated conservatively.

The largest component of costs attributable to reoperation was the surgery itself. Given that nearly 40% of reoperation patients did not obtain resolution of PPP with reoperation, the higher costs of this treatment pathway are a cause for concern.

Study limitations

There are some limitations to using population-based healthcare records data to study risk factors and outcomes of lumbar surgery. In particular, as there are no specific diagnosis codes for PPP, our estimates were based upon hospital records of reoperation surgery, other interventions and attendance at pain clinics. These data do not contain information on pain scores or results from postoperative imaging. It is possible that some patients were misclassified as having PPP after either their initial or second surgery. Similarly, some of the clinical factors that may be associated with reoperation surgery are not recorded in routine databases.

Our consideration of costs is limited to those borne by the UK NHS and does not include out-of-pocket expenditures by patients and their families, indirect costs associated with work limitations, or intangible costs, including pain and suffering.

An additional limitation is the small number of second surgery cases identified during the study period ($n = 200$). However, the size of the cohort was sufficient for descriptive analyses of PPP and costs and is nationally representative.

Conclusion

This study assessed the clinical outcomes and 2-year costs of lumbar reoperation. Younger patients and those with comorbid diabetes or rheumatic disease were more likely to undergo reoperation. The rate of PPP following second lumbar surgery was double the rate of pain after primary lumbar spinal surgery (39.5% vs. 19.6%). Costs were also

significantly higher with a difference of £7221, on average, including the cost of the reoperation surgery. Spinal surgeons should question this modality of treatment for these patients and consider whether additional spinal surgery is really worth the risk of ongoing pain.

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Author's contribution DC conceived the study. SW acquired the data. TCK, MS, and SW developed the analysis plan. TCK and MS analysed the data. SW and DC drafted the manuscript. JB, DC, SE, TCK, AM, MS, RST, TT and SW revised the manuscript. All authors contributed intellectually to the interpretation of the data, participated in manuscript development and approved the final version. SW is the guarantor.

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Data sharing No additional data are available.

Compliance with ethical standards

Competing interests PHMR, LLC, received consulting fees from Medtronic. SW, MS and TCK received consulting fees from PHMR, LLC. RST, AM, JB, DC and SE received consulting fees from Medtronic as advisors to the project. TT has no competing interests associated with this work.

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