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Functional outcome after posterolateral spinal fusion using pedicle screws: comparison between primary and salvage procedure

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Abstract Lumbar spinal fusion is a commonly performed surgical procedure, yet both the indications for its performance and its results remain controversial. It is generally believed that apart from situations where obvious measurable instability exists, a repeat surgical procedure such as spinal fusion does not improve the functional outcome in more than an average of 50% of cases. The aim of this study was to analyse functional outcome after posterolateral lumbar or lumbosacral spinal fusion, comparing primary and salvage procedures. It was designed as a prospective case/referent study with a 2-year follow-up. A total of 39 patients underwent a short posterior fusion with Cotrel-Dubousset (CD) pedicle screw fixation after earlier surgery of the lumbar spine. Two patients were erroneously omitted from the study at the index, so 37 patients were included in the salvage group. In the same period, 69 patients underwent lumbar fusion with pedicle screw fixation (CD) as primary surgery (referent group). Functional outcome was assessed by means of the Dallas Pain Questionnaire preoperatively and 1 and 2 years postoperatively. Fusion rates were determined by ordinary X-ray evaluation by two inde-

pendent observers. Patients who had undergone previous spinal surgery had a significant improvement in functional outcome in terms of daily activity, work and leisure-time activities and anxiety/depression. With regard to social functioning, a significantly inferior outcome was found after the salvage procedure. The return-to-work rates at 2 years after surgery were 50% in the salvage group and 53% in the referent group. There was a significant correlation between radiological evaluation of the fusion mass and the functional outcome. The fusion rate was 76% in the salvage group and 72% in the referent group. This study demonstrates that a posterolateral spinal fusion can be effectively used as a salvage procedure. The functional and radiological outcome of the patients with revision surgery did not differ from those of the group of patients who underwent primary surgery. There was, however a clear indication of inferior social functioning after revision surgery.

Key words Lumbar fusion · Pedicle screw · Reoperation · Functional outcome · Dallas Pain Questionnaire · Revision surgery

Introduction

Lumbar spinal fusion is a commonly performed surgical procedure, yet both the indications for surgery and its results remain controversial. It is generally believed that apart from situations where obvious measurable instability exists, a repeat surgical procedure such as spinal fusion does not improve functional outcome in more than an average of 50% of cases (range 25%–80%) [11, 12, 17, 20]. It appears that the reason for failure is most often neither technical nor physiological, but rather is attributable to a need for improved indication. Slosar et al. [16] have examined the results of combined anterior and posterolateral lumbar fusion in 92 patients who had had previous surgery. They found no difference between primary and revisionary results. The authors concluded that they viewed this type of surgery as a 'salvage procedure'. No prospective study has been published analysing functional outcomes after posterolateral lumbar spinal fusion as a revision procedure.

The aim of the study was to analyse the functional outcome, fusion rates, and reoperation rates after posterolateral lumbar spinal fusion as a salvage procedure subsequent to earlier surgery of the lumbar spine as compared with primary lumbar spinal fusion.

Materials and methods

Patients

From 1990 to 1993, a total of 39 patients underwent a short posterior lumbar or lumbosacral fusion with Cotrel-Dubousset (CD) pedicle screw fixation, subsequent to earlier surgery of the lumbar spine (salvage group). Two patients were erroneously not included in the study at the index and therefore had incomplete data entry prior to surgery. This study therefore comprises 37 salvage procedure patients, 22 men and 15 women, with a mean age of 45 years ($SD \pm 9.2$, range 20–66 years). Nine patients had previously undergone laminectomy due to spinal stenosis and fracture sequelae, 21 patients discectomy with a small laminotomy due to herniated discs, and 9 patients spinal fusion (anterior interbody fusion or/and facet joint fusion with titanium screws) [2] due to spondylolisthesis. The preoperative diagnoses for the salvage procedure were 13 degenerated discs, 7 spinal stenoses, 13 isthmic spondylolistheses (4 of the patients were previous treated for herniated discs, although they had a spondylolisthesis slip of 15%–25%), and in 4 cases spinal fracture sequelae in the form of spinal stenosis and disc degeneration. Seventeen patients had one-level fusion, 18 had two-level fusion and 2 patients had three-level fusion. Seventy-four percent had had severe back pain for more than 2 years.

Within the same period, 69 patients (27 men and 42 women, mean age 44 years, $SD \pm 11.5$, range 17–69) underwent lumbar fusion with CD pedicle screw fixation as primary surgery (referent group). The preoperative diagnoses were so-called degenerative instabilities secondary to degenerative changes of the discs (11 patients), spinal stenoses that were not relieved by nonoperative treatment (23 patients), and isthmic spondylolistheses (35 patients). Thirty-three underwent one-level fusion and 36 had two-level fusion. Seventy-seven percent had suffered from severe back pain for more than 2 years.

All the patients (salvage and referent group) had been on a waiting list for this operation for at least 1.5 years, and in that period they had been in touch with physiotherapists, had practised back exercises, etc.

The indication for fusion in patients with degenerated discs and spinal stenosis was back and leg pain. Seventy-one percent in the salvage group and 53% in the referent group had reflex asymmetry, a sensory loss, or a positive straight leg test (SLR) at less than 60°, and many had a combination.

Three senior surgeons performed the operations and were equally distributed between and within the salvage and referent groups (46%/38%, 13%/22%, 41%/40%).

Evaluation of the functional outcome

This is a prospective case/referent study, with a 2-year follow-up of the functional outcome. The functional treatment result was assessed by means of the Dallas Pain Questionnaire (DPQ) [14] before surgery, at 1-year follow-up and again after 2 years. The DPQ is a 16-item visual analog scale based questionnaire developed to assess the functional impact of chronic spinal pain under four categories: daily activity (7 questions), work-leisure time activities (3 questions), anxiety-depression (3 questions), and social functioning (3 questions). The validity of the DPQ as an instrument for clinical assessment in a group of patients with low back pain has recently been established in comparison with six alternative psychometric tests [18].

The questionnaire was filled in by the patients independent of the surgeons on the day before the operation and at 1 and 2 years postoperatively and scored by an independent observer.

Except for the functional outcome scores all data were prospectively collected by the surgeons by filling in registration sheets pre- and postoperatively, at discharge, and at the 1- and 2-year follow-up in the outpatient clinic. The data were continuously stored in our spinal surgery database.

This defined a study population of initially 37 patients in the salvage group and 69 patients in the referent group, and 34 in the salvage group and 58 in the referent group at the 2-year follow-up. Participation was 92% in the salvage group and 84% in the referent group at the 2-year follow-up. If one of the DPQ questions were not answered the score from that category was omitted in that patient. All the remaining data are intact.

The patients' work status and employability was recorded at the index and at the 2-year follow-up.

Radiological assessment

All the fusions were evaluated by the same two independent observers at one year postoperatively by means of anterior/posterior and lateral X-rays. Each level and each side was judged separately and continuous intertransverse bony bridges on just one of the two sides indicated the presence of fusion at that level. "Fusion" indicates this quality of fusion at all levels, "doubtful fusion" indicates suboptimal quality at one or more levels, including fusion mass hidden behind the instrumentation, and "non-union" indicates a definite lack of fusion at one or more of the levels. Only when the two observers were in agreement was the case classified as "fused". The X-rays were evaluated once by each observer. Radiological follow-up was 100% in the salvage group and 95% in the referent group.

Statistics

The Mann-Whitney rank sum test and Wilcoxon matched-pairs ranks sum test were applied for statistical analysis. The variables

Table 1 DPQ score before and 1 and 2 years after surgery in the salvage and referent groups^a

	Daily activity			Work/leisure			Anxiety			Social function		
	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>
<i>Before</i>												
Salvage group	65	32; 88	37	65	20; 100	37	40	10; 95	37	45	0; 100	36
Referent group	56	12; 100	69	70	5; 100	68	45	0; 95	67	40	0; 100	68
<i>One year after</i>												
Salvage group	41	3; 96	33	45	0; 100	32	25	0; 95	32	30	0; 90	33
Referent group	35	0; 82	65	40	0; 90	62	25	0; 85	61	20	0; 75	63
<i>Two years after</i>												
Salvage group	51	0; 93	34	55	0; 100	35	35	0; 100	35	38	0; 90	34
Referent group	42	0; 93	57	40	0; 100	57	25	0; 85	58	15	0; 100	58
<i>P</i> < 0.03												

^aHigh scores are related to poor condition. The Mann-Whitney rank sum test and the 5% significance level were used.

Table 2 Relative improvement in DPQ score from before surgery to the 1- and 2-year follow-up in the salvage and referent groups^a

	Daily activity			Work/leisure			Anxiety			Social function		
	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>
<i>Before vs 1-year follow-up</i>												
Salvage group	23	-27; 68	33	18	-30; 95	32	15	-65; 75	32	15	-35; 60	32
Referent group	18	-27; 67	65	20	-55; 75	61	13	-55; 85	60	10	-45; 70	62
<i>Before vs 2-year follow-up</i>												
Salvage group	14	-18; 68	34	15	-25; 95	35	13	-45; 80	35	8	-60; 55	34
Referent group	18	-63; 62	57	20	-50; 85	56	10	-60; 95	57	10	-30; 70	57
<i>P</i> < 0.05												

^aHigh scores are related to significant improvement. The Mann-Whitney rank sum test and the 5% significance level were used.

applied in the statistical analyses were four DPQ categories, age, sex, diagnosis and fusion rates. These data are all presented in Tables 1–3. Where no *p*-value is given, its value was nonsignificant.

K-statistics were used to evaluate the agreement between the radiological observers.

The 5% two-tailed limits of statistical significance were used.

The stratified DPQ values and working status are poorly descriptive data.

Results

Functional outcome

The functional treatment results are summarized in Tables 1–3. The patients who had had previous spinal surgery showed a significant improvement in the DPQ score from preoperatively to the 2-year follow-up with respect to daily activities ($P < 0.005$), work and leisure-time activities ($P < 0.002$) and anxiety/depression ($P < 0.03$) (Table 1). When looking at the preoperative DPQ score and at the 1-year follow-up, no significant difference between the salvage group and the group of patients with primary surgery was found in any of the four categories (Table 1).

The 2-year follow-up showed a significantly poorer DPQ score in the ‘social functioning’ category ($P < 0.03$) for patients with previous surgery.

Table 2 compares the changes in DPQ scores from preoperatively to 1 and 2 years for the salvage and referent group. There were no significant differences between the two groups in the categories daily activity, work and leisure activity or anxiety/depression. Concerning social functioning, a significantly poorer outcome was found in the salvage group ($P < 0.05$).

The differences between the DPQ score before and 2 years after surgery were graded as improved (a score of 10 or higher), unchanged (–9 to 9) or worse (–9 or lower). The rationale of this stratification was to obtain a more descriptive presentation of the data (Fig. 1) and, hopefully, to eliminate the score differences based on random variation. Figure 1 shows that in the salvage group, 63% of the patients experienced improvement in physical function and 53% had improvement in psychosocial functioning. In the referent group, 66% had improvement in physical function and 62% had improvement in psychosocial functioning. Thirty-two percent in the salvage group reported a deterioration in social functioning.

Table 3 Relative improvement in DPQ score from before surgery to the 2-year follow-up in relation to sex, diagnosis and radiology^a

	Daily activity			Work/leisure			Anxiety			Social function		
	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>	Median	Range	<i>n</i>
<i>Sex</i>												
Salvage group												
Men	15	-18; 68	20	15	-5; 95	21	10	-15; 80	21	5	-35; 55	20
Women	11	-16; 52	14	1	-25; 55	14	15	-45; 40	14	10	-60; 25	14
Referent group												
Men	23	-63; 42	22	10	-20; 55	22	10	-30; 80	21	10	-10; 65	22
Women	17	-34; 62	35	20	-50; 85	34	20	-60; 95	36	13	-30; 70	35
<i>Diagnosis (salvage group)</i>												
Disc degeneration & spinal stenosis (mean age 45, range 20–60)	20	-16; 68	19	15	-15; 95	19	15	-45; 80	19	10	-35; 55	19
	$P < 0.02$											
Isthmic spondylolisthesis (mean age 42, range 15–59)	-3	-18; 30	12	5	-25; 40	12	5	-35; 45	12	5	-60; 50	12
Fracture sequelae (mean age 46, range 40–52)	6	3; 6	3	15	-20; 15	3	0	-15; 35	3	-20	-20; 3	3
<i>Radiology (salvage and referent groups)</i>												
Fusion	18	-16; 68	64	20	-20; 95	63	15	-45; 95	65	10	-60; 140	64
Doubtful/non-fusion	3	-34; 56	25	-5	-50; 50	26	0	-60; 45	25	0	-30; 40	25
	$P < 0.02$			$P < 0.004$			$P < 0.002$					

^aThe table shows the DPQ score before surgery minus the score at the 2 year follow-up. High scores are related to great improvement. The Mann-Whitney rank sum test and the 5% significance level were used.

In the category 'daily activity' the salvage patients with isthmic spondylolisthesis had poorer functional outcome score at the 2-year follow-up than did salvage patients with disc degeneration and spinal stenosis ($P < 0.02$) (Table 3).

With regard to distribution of sex and age, as well as preoperative DPQ scoring, there was no significant difference between the salvage group and reference group.

Work status and employability

Working status preoperatively and at 2 years postoperatively is presented in Fig. 2. The government has made it possible to retire at the age of 60 years in the hope of creating more jobs for young people; normal retirement is at 67 years of age. Within the age group of 60–67 years, we were therefore unfortunately not able to separate patients who received a pension as a result of physical incapacity from patients who were receiving a retirement pension. However, only one patient in the salvage group and five patients in the referent group were in the age group of 60–67 years and on a pension. Among patients under the age of 60 years, 28% in the salvage group and 17% in the referent group received a disability pension. The salvage group's return-to-work rate was similar to that of the referent group. Only 18% of the patients in the salvage group received a pension prior to surgery but at the 2-year follow-up 45% had gone on a pension.

Fig. 1 Comparison between DPQ scores before and 2 years after surgery in the salvage and the referent groups. The results were graded as improved (a score of 10 or higher), unchanged (-9 to 9) or worse (-9 or lower)

Fig. 2 Working status preoperatively and 2 years postoperatively. Separating the patients who received a pension due to invalidity from those receiving a retirement pension was not possible

The decrease in patients sick-listed and the increase in patients working, studying or receiving a pension in both the salvage and referent group were highly significant ($P < 0.002$).

Radiological assessment

Using the above indications for the quality of bony healing and only confirming fusion if the two observers were in agreement – i.e. any doubt ruled out a case as ‘fused’ – 76% in the salvage group and 72% in the referent group had radiological fusion. The overall interobserver agreement was 83% ($n = 86$) ($K = 0.52$). The salvage group had a 2% higher interobserver agreement than the referent group. There was a significant correlation between spinal fusion and functional outcome in three of the four functional categories measured by the DPQ (Table 3).

Complications

In the salvage group, five patients had their implants removed at a mean of 15 months (range 10–19 months) after spinal fusion owing to pain and discomfort (three cases), and back and leg pain (two cases). Two of the three patients with pain and discomfort had complete spinal fusion as analysed intraoperatively and by X-rays. All three patients had well-placed screws without breaking or loosening of the screws. Both the patients with back and leg pain had solid bony fusion. One of the patients with back and leg pain exhibited a neurological deficit with loss of sensitivity perianally and on both feet. She also had a positive SLR at 20°. None of the screws

were broken or misplaced, but the proximal screws had loosened. She underwent a 360° spinal fusion 4 years later. In the outpatient clinic three of the five patients had experienced pain relief following removal of the implants.

In the referent group the implants were removed in seven cases at a mean of 13.4 months (range 8–19 months) after spinal fusion. One patient had a misplaced screw and four patients had broken screws. The implants were removed in two cases owing to pain and discomfort. Three patients underwent re-fusion without implants and the rest had a solid fusion. Six out of seven reported a satisfactory result after removal of the implants. None of the patients showed any abnormal neurological signs.

No significant difference in the DPQ score was observed at any time between patients with and those without complications.

Discussion

It has been stated that repeat surgery on the lumbar spine is difficult and not particularly rewarding [13, 15]. In a study of 103 patients, Waddell et al. reported the success rate of a second operation to be 50%, while 20% of patients considered themselves worse off afterwards [20]. Furthermore, the number of surgical successes diminishes proportionally to the number of procedures performed [4, 20]. Fritsch et al. found the same tendency but also stated that the best revision technique was spinal fusion [5].

In the present study, all data were collected in a prospective manner. We found that patients with previous spinal surgery had an overall significant improvement in three of the four functional DPQ categories. The 2-year follow-up showed no difference between the group of pa-

tients with previous surgery and the reference group with respect to daily and work/leisure activities and anxiety/depression, whereas there was a significantly inferior outcome with regard to social functioning in the group of patients with previous surgery. The 'social functioning' category comprises three questions concerning the patient's relation to other people, need for social support, and self-criticism. These results indicate a need for social support in relation to surgical revision. Twenty-one percent of the patients in the salvage group reported deterioration in the category 'anxiety/depression'. Unfortunately, we were not able to predict the need for psychosocial support from the preoperative DPQ score. The relation between chronic pain symptoms and psychosocial status has been discussed and shown to be important [3, 10, 20]. Using psychological tests, Waddell et al. found that 65% of patients with multiple back operations showed evidence of anxiety, depression, hypochondriasis and conversion reactions [20]. In prospective studies, depression measured with the Beck Depression Inventory was shown to be an important predictor of chronicity in patients with lumbar disc herniation [7, 9]. The quality of life experienced enjoyed to the illness may never again be attained even with a rehabilitation programme. One way to improve the treatment results in revisionary surgery could be to establish a network which can attend to psychosocial problems before and after surgery. It is therefore important that a careful assessment of psychosocial factors be included in the preoperative work-up of a candidate for fusion. Becoming aware of this symptom complex in the selection of patients for revisionary surgery is essential. The cost-effectiveness of such a psychosocial network could be high.

In analysing and recording our patients' pain, function and disability, both before surgery and at follow-up, we have since 1987 routinely made use of the Dallas Pain Questionnaire. As shown in a previous study, we found a significant correlation between spinal fusion measured by X-ray and DPQ scores [2]. Our impression is that this tool works well in clinical practice and it has been shown to be a valid instrument for clinical assessment of low back pain [18]. With hindsight, further analysis of psychosocial function by use of, for example, the Beck Depression Inventory [9] could have been valuable, since some differences in anxiety/depression were found between the salvage and the referent group. However, the result showing a poorer social outcome for the salvage group agrees with our experience from the outpatients' clinic.

We believe that a 92% response rate at 2-year follow-up in the salvage group is acceptable and realistic. The response rate in the referent group is 8% lower (84%). The 8% lower response rate could potentially reduce the internal validity by distorting the effect measure by a selection

bias. However, the referent group had a functional outcome result at the index and at follow-up which agreed with those in another study [19] that used the same outcome assessment and had a response rates of 98% ($n = 64$) at 2 years. The actual likelihoods that the response rates in the present study exert a bias effect is therefore judged to be small.

An ongoing debate concerns the validity of radiographical evaluation of the fusion mass. We believe that an attempt to evaluate the solidity of the fusion is important. Although it is subject to a degree of unreliability, the purpose of the operation is to achieve solid arthrodesis. In the present study the overall complete fusion rate was 76%.

The majority of published studies agree that patients who have received or applied for a disability pension for their back complaints have poor surgical results or at least continue to report pain and inability to return to work [1, 6, 8–10]. To our knowledge none of the patients in the salvage group had applied for workers' compensation or personal injury insurance prior to surgery. One patient had applied for workers' compensation at the 1-year follow-up. At the 2-year follow-up, 51% of the patients in the salvage group and 52% in the referent group were capable of working (unemployed and employed). A successful spinal fusion which returns the patient to full working capacity does not necessarily make the patient employed. The percentages of unemployed were comparable in the two groups (5.3%/5.8%) at the 2-year follow-up.

One major problem with this and previous published studies is that it deals with revision surgery of different aetiologies. However, the flow of patients for revision surgery is limited which makes it difficult to control for diagnosis/indications, age and gender. Furthermore there are constant changes in the indication, approach and choice of implants in revision surgery.

Conclusion

This study demonstrates that posterolateral spinal fusion can be effectively used as a salvage procedure. The functional outcomes improved significantly and were similar to those in the group of patients who underwent primary surgery, but social functional outcome was inferior. We generally observed no significant differences between the salvage and referent groups regarding occupational status or fusion rates.

The results of this study indicate that candidates for revision surgery should be evaluated individually and all medical and psychosocial factors considered.

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