Lumbar instrumented posterolateral fusion in spondylolisthetic and failed back patients: a long-term follow-up study spanning 11–13 years

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Abstract

Introduction and materials We examined lumbar transpedicular instrumented posterolateral fusion patients operated on between 1992 and 1997 presenting: degenerative spondylolisthesis with spinal stenosis; adult isthmic spondylolisthesis; failed back syndrome after one to five discectomies; and failed back syndrome after one to three laminectomy operations (Groups 1–4, respectively).

Methods They were examined by an independent orthopedic surgeon, completed the Oswestry Disability Index (ODI) and visual analog scale (VAS) questionnaires and their outcome was evaluated.

Results The overall patient satisfaction at follow-up (mean 11.7 years) was 82.1 %. The reoperation rate was 15.1 % (7.5 % due to adjacent segment disease).

Conclusion Group 1 showed the greatest improvements in ODI and VAS values, Group 2 the lowest and Group 3 the highest preoperative values, and Group 4 the second highest improvements. Patient satisfaction scores were 90.3, 69.7, 63.6 and 80.0 %, respectively, and unplanned reoperation rates were 6.5, 9.1, 31.8 and 20.0 %. Thus, long-term outcomes of lumbar instrumented posterolateral fusion (rarely previously studied) were satisfactory for >80 % of patients, but varied among groups.

Keywords Instrumented lumbar posterolateral fusion · Long-term results · Degenerative and isthmic spondylolisthesis · Failed back syndrome · Adjacent segment disease

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Introduction

During the last three decades, lumbar transpedicular fusion has become the standard surgical procedure for patients with lower back pain who suffer from painful motion segments [1–3]. However, the usefulness of the procedure remains uncertain. It is known that solid fusion can influence the biomechanics of the spine and thus may cause degeneration, leading within 10 years of the operation to adjacent segment alterations and symptoms in up to 40 % of patients [3–8]. Degenerative changes in discs, facet joints and ligaments can cause disc prolapses, stenosis and degenerative spondylolisthesis. According to Martin et al. [9], fused degenerative spondylolisthetic patients needed fewer reoperations than patients who received decompression alone (17.1 vs. 28.0 %). Risk factors for adjacent segment disease (ASD) can be divided into factors related to either the patients or the surgeons. Smoking, obesity and genetic factors favor early degeneration. Surgeon-related

factors include the length of fusion, flatback syndrome, sagittal imbalance and perforation of the facet joint during the procedure [9–14]. Higher educational level, optimistic expectations and diagnosis of herniated disc improve clinical outcome according to Zoriani [10]. Posterolateral fusion is considered better for the biomechanics of the spine because it is less rigid than an anterior fusion [3]. Zagra [15] has reported after 5 years over 80 % good results with Grob's pediculobody screw fixation and posterolateral fusion in inveterate cases of grade 2–3 spondylolisthesis.

Only a few studies have evaluated instrumented posterolateral fusion operations after a follow-up time of more than 10 years [16, 17]. In a randomized controlled trial focusing on instrumented and noninstrumented fusions, Andersen et al. [18] found that 71 % of patients in both groups were still satisfied after 11–13 years. Similarly, a randomized study conducted by

Ekman et al. [19] indicated that 76 % of fusion patients with adult isthmic spondylolisthesis were still satisfied 9 years after the operation. Ekman also stated that fusion seemed to accelerate degenerative changes in adjacent segments, albeit generally without clinical significance, compared with the control group when followed up after 12.5 years [20].

The aim of the study was to assess the long-term clinical outcome, late complications, reoperations and postoperative patient satisfaction in patients with different indications for posterolateral fusion.

Materials and methods

The patients examined in this study underwent lumbar instrumented fusion operations between the years 1992 and

Table 1 The characteristics of the patients

	Group 1, <i>N</i> = 31 Degenerative spondylolisthesis	Group 2, <i>N</i> = 33 Adult isthmic spondylolisthesis	Group 3, <i>N</i> = 22 Postdiscectomy syndrome	Group 4, <i>N</i> = 20 Postlaminectomy syndrome	All <i>N</i> = 106
Female/male	28/3	16/17	12/10	11/9	67/39 (63.2/36.8 %)
Mean age at operation (years, range)	56.3 (39–77)	44.3 (30–62)	47.6 (36–67)	55.4 (41–76)	50.6 (30–77)
Mean follow-up (years, range)	12.9 (10.3–15.5)	11.5 (9.8–14.3)	10.8 (8.3–14.0)	11.1 (8.5–14.3)	11.7 (8.3–15.5)
Mean body mass index (range)	27.8 (20.6–37.9)	26.9 (21.1–38.3)	27.7 (19.8–37.1)	28.2 (22.0–37.0)	27.6 (19.8–38.3)
Ability to work					
Before fusion	5	10		2	17 (16.0 %)
At follow-up	1	13	3	1	18 (17.0 %)
Fused levels					
1 level	17	7	6	4	34 (32.1 %)
2 levels	14	25	14	15	68 (64.2 %)
3 levels		1	2	1	4 (3.8 %)
Floating fusion	22	8	6	8	44 (41.5 %)
Lumbosacral fusion	9	25	16	12	62 (58.5 %)
Instrumentation					
Dick's device	5	5	4	6	20 (18.9 %)
F.V.M. Malaga	2	1	1		4 (3.8 %)
CCD	2		1	1	4 (3.8 %)
USS	22	27	16	13	78 (73.6 %)
Decompression					
Not done			10	5	15 (14.2 %)
Laminotomy	1		3	2	6 (5.7 %)
Laminectomy	30	33	9	13	85 (80.2 %)
Comorbidity (prevalence)					
Preoperative diseases ^a	20 (64.5 %)	15 (45.4 %)	11 (50.0 %)	15 (75.0 %)	61 (57.5 %)
Follow-up diseases ^b	29 (93.5 %)	25 (75.8 %)	17 (77.3 %)	17 (85.0 %)	86 (83.0 %)

^a 1. Hypertension 42.5 %, 2. asthma 16.0 %, 3. coronary disease 11.3 %, 4. diabetes 9.4 %, 5. hypothyreosis 7.5 %, 6. arthritis 4.7 %, 7. malignancy 2.8 %

^b 1. Hypertension 45.3 %, 2. arthritis 25.5 %, 3. coronary disease 17.0 %, 4. asthma 15.1 %, 5. diabetes 14.2 %, 6. hypothyreosis 14.2 %, 7. malignancy 9.4 %

1997. The patients ($n = 106$) were divided into four groups (see Table 1). Before the fusion operation, all of the patients had radicular and/or local low back pain. The same orthopedic surgeon made the decision to operate in most cases and performed over 90 % of the operations. The decision was based on symptoms, clinical status findings and appropriate findings in radiological examinations (native X-ray, myelography, CT or MRI). Conservative therapy before orthopedic consultation and operation decision consisted of treatment with analgesics and in most cases physiotherapy had been attempted. The waiting times for consultations and operations were longer for the patients in this study than is currently the case in our institution. The characteristics of the patients and their symptoms are presented in Tables 1 and 2.

The follow-up study was carried out during the years 2005–2008. Cases were identified from the surgical records of the orthopedic department and basic clinical data collected were from the case histories of 152 patients. A total of 106 (79.1 %) out of the 134 living patients participated in the study. The demographic data of the follow-up patients are presented in Table 1.

The study was approved by the ethics committee of Kuopio University Hospital. Statistical analyses were performed using the SPSS17 software package. The Wilcoxon nonparametric test and one-way ANOVA were used to detect differences between the study groups.

Outcome measures

The patients filled in the Oswestry Disability Index (ODI) (0–100) and visual analog scale (VAS) (0–100 mm) questionnaires pre- and postoperatively [21]. An independent orthopedic surgeon carried out clinical examinations and evaluated the long-term result on a four-point scale (excellent, good, fair or poor). The patients used the same scale in their evaluations and were also asked whether they would be willing to undergo the same surgical procedure again.

Operative technique

In the Kuopio University Hospital, the first instrumented fusion operations were carried out at the beginning of the 1990s. Since then, 25–30 operations have been performed annually. In the first few operations, the transpedicular implant used was Dick's fixation device (AO), which was routinely removed 1 year after the operation [4]. A few patients were operated on using F.V.M. Malaga vertebral fixator (Industrias Quirúrgicas de Levante, S.A.) and CCD instrumentation (Sofamor). USS (steel) devices (Synthes) have been used since 1994.

The length of the fusion was based on the clinical status findings and radiological results. Indication for fusion in addition to decompression was to prevent or treat instability of a spondylolisthetic or a painful segment.

Table 2 Duration of symptoms, prevalence of radicular pain and the use of analgesics in study groups

	Group 1, $N = 31$ Degenerative spondylolisthesis	Group 2, $N = 33$ Adult isthmic spondylolisthesis	Group 3, $N = 22$ Postdiscectomy syndrome	Group 4, $N = 20$ Postlaminectomy syndrome	All $N = 106$
Symptoms before fusion					
<1 year	3	9	4	5	21 (19.8 %)
1–2 years	13	18	11	9	51 (48.1 %)
>2 years	15	6	7	6	34 (32.1 %)
Radiculating pain					
Before fusion					
One leg	12	21	11	12	56 (52.8 %)
Both legs	19	12	9	8	48 (45.3 %)
None			2		2 (1.9 %)
At follow-up					
One leg	7	10	14	9	40 (37.7 %)
Both legs	1	5	3	3	12 (11.3 %)
None	23 (74.2 %)	18 (54.5 %)	5 (22.7 %)	8 (40.0 %)	54 (50.9 %)
Daily use of analgesics due to back disease					
Preoperatively	29 (93.5 %)	29 (87.9 %)	17 (77.3 %)	14 (70.0 %)	89 (84.0 %)
At follow-up	11 (35.5 %)	14 (42.4 %)	11 (50.0 %)	10 (50.0 %)	46 (43.4 %)

The principal intention was to carry out as short a fusion as possible, while including all of the likely symptomatic segments. Until June 1994, miniheparin antithrombotic therapy was routinely used, but this was discontinued following one postoperative hematoma case. The infection prophylaxis included cefuroxime for 2 days at a dose of 1.5 g three times a day. The average operation time was 220 min (range 118–380 min). Following the midline incision, transversal processes and the lateral cortex of facet joints were decorticated. Next, nerve root decompression (laminectomy or laminotomy) was undertaken. Pedicle screws were installed with c-arm checking in the anterior–posterior direction, longitudinally to the screw as well as in the lateral direction. Posterolateral bone grafts were taken subcutaneously from the same midline incision from outside of the posterior iliac crest. The wound was sutured with drains. The drains and urinal catheter were removed on the second postoperative day and the patients were mobilized with an extension brace. Sitting was not recommended for 3 months following the operation. Standing X-rays were taken in the outpatient clinic after 2 and 4 months and 1 and 2 years after the operation.

Study groups

The patients were divided into four groups. Group 1 consisted of 47 patients who had degenerative spondylolisthesis with stenosis. In these patients, decompression of the stenotic levels was carried out in addition to the fusion. One patient experienced deep thrombosis in the leg veins following the operation and this was treated with anticoagulant drugs for 3 months. Of the 41 patients still living, 31 (75.6 %) participated in the study.

Group 2 included 43 adult isthmic spondylolisthetic patients with foraminal stenosis. The operation involved fusion and decompression of the nerve roots by removal of the lytic lamina. Five patients had two adjacent lytic arches. One operation was complicated by a postoperative hematoma, which was evacuated without further problems. Of the 41 patients still living, 33 (80.5 %) agreed to participate in the study.

Group 3 included 29 patients for whom the indication for fusion was failed back syndrome following a disc hernia operation. The number of earlier operations varied from one to five open or microscopic discectomies. In addition to the fusion, decompression of the nerve root was carried out when required. One superficial wound infection was treated with antibiotics. Of the 25 patients still living, 22 (88.0 %) participated in the study.

Group 4 consisted of 33 postlaminectomy syndrome patients who had previously undergone one to three decompression laminectomy operations. They had developed new symptoms leading to instability and/or restenosis. In these

patients, fusion was performed as well as decompression when necessary. One patient experienced a nerve injury and urine retention that did not heal. Twenty patients out of the 27 still living (74.1 %) participated in this study.

Nonparticipating patients

In Group 1, one elderly woman suffering from coronary heart disease had succumbed 3 weeks after the operation and five patients had died from other causes. Two patients had relocated to another hospital area. Three patients refused to participate in the study and five patients did not take part because of their other diseases or disabilities. According to the medical records, three of the ten nonparticipating patients had further operations. Of these, one patient had fusion of the adjacent segment, one patient's implant was removed because of malposition of the screws and one patient had adjacent segment decompression.

In Group 2, two patients had died of other causes. Two of the eight nonparticipating patients belonging to this group were largely confined to wheelchairs. Of these, one was suffering from cervical area demyelinating disease and the other from multiple system atrophy. One patient's leg had been amputated at the thigh level due to arteriosclerosis. Five patients did not participate for other reasons in the study. Of these eight patients, three had undergone reoperation during the follow-up time. Re-fusion was performed on two patients due to nonunions, one of whom later also had fusion and decompression of the adjacent segment level. Re-decompression of the fusion area was performed on the third patient.

In Group 3, four patients died from other causes. One of the three nonparticipating patients reported that she had undergone re-spondylodesis, adjacent segment fusion and subsequent implant removal in another hospital. One unplanned implant removal was undertaken due to chronic pain with poor results. One patient refused to take part in the study.

In Group 4, one elderly man died due to cerebral infarct 3 weeks after the fusion operation and five patients had died from other causes. One of the seven nonparticipating patients underwent a further thoracic region meningioma surgical procedure. Three patients refused to participate due to other illnesses and four for other reasons.

Results

The characteristics of the patients are presented in Table 1. Two-thirds of patients were female. The mean age was higher in Groups 1 and 4. The mean body mass index (BMI) did not differ between the groups.

Before the fusion operation, 84.0 % of the patients were unable to work, and at the time of the follow-up, 83.0 % were not in active employment. Preoperatively, 17.9 % had been retired from work due to back problems; at the time of follow-up, this had increased to 50.0 % (Table 1).

A number of patients had developed other illnesses during the follow-up time (Table 1). The prevalence of comorbidity among the patients (83 %) had almost tripled compared with the situation before fusion. For example,

one in four of the patients followed up suffered from osteoarthritis of the hip, knee or ankle joint. Endocrine disorders such as diabetes and hypothyreosis clearly increased. Ten patients were treated for cancer (breast, renal or prostatic). These illnesses were not related to ODI or VAS results. The prevalence of hypertension was the same preoperatively and at follow-up.

The ODI and VAS questionnaire data are presented in Table 3. On average, the mean ODI improved by 16.1 units

Table 3 The Oswestry Disability Index (ODI) and visual analog scale (VAS) results preoperatively and at the end of the follow-up (mean with SD and range)

	Group 1 Degenerative spondylolisthesis	Group 2 Adult isthmic spondylolisthesis	Group 3 Postdiscectomy syndrome	Group 4 Postlaminectomy syndrome	All
ODI					
Preoperative	47.0 (14.0) (14–76)	41.0 (14.8) (8–68)	49.8 (13.1) (26–72)	49.5 (10.8) (32–68)	46.2 (13.8) (8–76)
Follow-up	26.4 (19.4) (0–78)	29.7 (19.9) (0–72)	37.2 (15.6) (2–68)	28.7 (20.4) (0–78)	30.1 (19.2) (0–78)
Change	20.6 (43.8 %)	11.3 (27.6 %)	12.6 (25.3 %)	20.8 (42.0 %)	16.1 (34.8 %)
	$P < 0.001$	$P < 0.003$	$P < 0.012$	$P < 0.002$	$P < 0.001$
VAS					
Preoperative	6.3 (2.9) (0.5–10)	7.1 (2.0) (3.0–9.5)	7.6 (1.5) (4.0–10)	7.0 (2.2) (2.0–10)	7.0 (2.2) (0.5–10)
Follow-up	2.2 (2.4) (0.0–7.0)	4.2 (3.1) (0.0–10)	5.6 (2.4) (0.5–10)	3.5 (3.0) (0.0–10)	3.8 (3.0) (0.0–10)
Change	4.1 (65.1 %)	2.9 (40.8 %)	2.0 (26.3 %)	3.5 (50.0 %)	3.2 (45.7 %)
	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.004$	$P < 0.001$

Fig. 1 The mean values of the Oswestry Disability Index (ODI, units) before fusion (dark and light columns together), at the time of follow-up (dark columns) and their mean changes (light columns)

Group 1 = Degenerative spondylolisthesis, N = 31 Mean changes of ODI, $P < 0.001$ Wilcoxon test

Group 2 = Adult lytic spondylolisthesis, N = 33 Mean changes of ODI, $P < 0.003$ Wilcoxon test

Group 3 = Postdiscectomy syndrome, N = 22 Mean changes of ODI, $P < 0.012$ Wilcoxon test

Group 4 = Postlaminectomy syndrome, N = 20 Mean changes of ODI, $P < 0.002$ Wilcoxon test

All = All patients, N = 106 Mean changes of ODI, $P < 0.001$ Wilcoxon test

Fig. 2 The mean values of the visual analog scale (VAS, millimeters) before fusion (*dark and light columns together*), at the time of follow-up (*dark columns*) and their mean changes (*light columns*)

Group 1 = Degenerative spondylolisthesis, N = 31 Mean changes of VAS, $P < 0.001$ Wilcoxon test
 Group 2 = Adult lytic spondylolisthesis, N = 33 Mean changes of ODI, $P < 0.001$ Wilcoxon test
 Group 3 = Postdiscectomy syndrome, N = 22 Mean changes of ODI, $P < 0.001$ Wilcoxon test
 Group 4 = Postlaminectomy syndrome, N = 20 Mean changes of ODI, $P < 0.004$ Wilcoxon test
 All = All patients, N = 106 Mean changes of ODI, $P < 0.001$ Wilcoxon test

Table 4 The long-term results according to the patient and the independently reviewing orthopedic surgeon on a four-point scale (excellent, good, fair and poor)

Estimator	Group 1, N = 31 Degenerative spondylolisthesis	Group 2, N = 33 Adult isthmic spondylolisthesis	Group 3, N = 22 Postdiscectomy syndrome	Group 4, N = 20 Postlaminectomy syndrome	All N = 106
Surgeon					
Excellent	15	12	5	8	40 (37.7 %)
Good	13	14	14	8	49 (46.2 %)
Fair	2	6	3	2	13 (12.3 %)
Poor	1	1		2	4 (3.8 %)
Patient					
Excellent	14	13	4	6	37 (34.9 %)
Good	15	13	10	12	50 (47.2 %)
Fair	2	5	8	2	17 (16.0 %)
Poor		2			2 (1.9 %)
Surgeon and patient					
Same	24	23	14	14	75 (70.8 %)
Surgeon one point better	3	5	7	3	18 (17.0 %)
Patient one point better	4	5	1	3	13 (12.3 %)

($p < 0.001$) and VAS was 32 mm better ($p < 0.001$) at follow-up (Figs. 1, 2). The greatest improvement was found in Group 1; ODI was 20.3 units lower ($p < 0.001$) and VAS was

41 mm better ($p < 0.001$) at follow-up. The mean levels of ODI and VAS were higher in Group 3 than in the other groups, both at the time of fusion and at follow-up.

The results of the operation were evaluated by an independent orthopedic surgeon and by the patients themselves on a four-point scale (excellent, good, fair and poor) (Table 4). In 81 cases (76.4 %), both the surgeon and the patient shared the same opinion, viewing the result as either good or excellent. In five cases (4.7 %), the operation result was regarded as poor by either the doctor or the patient. In 28 cases (90.3 %) in Group 1, the patients and doctor both regarded the result of the operation as good or excellent and in one case, poor. In Group 2, in 23 cases (69.7 %) the patients and the doctor classified the result as either good or excellent, and in two cases (6.1 %) as poor. In Group 3, in 14 cases (63.6 %) the operation result was regarded as either good or excellent, whereas no poor evaluations emerged in this postdiscectomy group. In Group 4, in 16 cases (80.0 %) the patients and the doctor agreed on either a good or excellent outcome, and in two cases (10.0 %) they shared the opinion that the result was poor. The accuracy of the patient's and surgeon's evaluations is presented in Table 4.

Among the patients, 96.2 % would have agreed to undergo the same fusion operation again.

Two postlaminectomy syndrome patients in Group 4 and one patient in both spondylolisthetic Groups 1 and 2 would not have agreed to the same fusion operation again. Only one of the patients with a poor result had follow-up ODI and VAS results that were worse than their preoperative ones. The patient in Group 1 who would have been unwilling to undergo the procedure again regarded her operation result as good.

Two infection complications related to reoperations occurred during the follow-up time. In Group 1, there was one deep infection with meningitis caused by *Pasteurella multocida*, which was treated with a revision operation and antibiotics. Another infection related to the epidural stimulator occurred in Group 4 and an operation to remove the stimulator was needed. One patient in Group 4 suffered

spondylodiscitis several years after the primary operation in the fused segment and this was treated with antibiotics. No thromboembolic complications were observed during the follow-up time. Complications related to instrumentation were mainly screw breakages, as seen in follow-up X-rays (Table 5).

The number of planned and unplanned reoperations is presented in Table 6. Unplanned operations were mostly performed on postdiscectomy patients in Group 3.

Discussion

The positive effect of the instrumented posterolateral fusion was still seen nearly 12 years after the fusion procedure. The patients' overall satisfaction was over 80 % as reported independently by the doctor and the patients themselves. Improvements in the patients' ODI and VAS results support this perception. Only 3.8 % of patients would refuse to have the fusion operation if they were offered the option again. In RCT studies, patient satisfaction was about 70 % when followed up after about 10 years [18, 19]. Half of the patients followed up had no radicular pain and their daily use of analgesics had reduced to half the original amount.

A total of 28 (20.9 %) of the 134 patients still living did not participate in the study. Many of these patients had suffered additional illnesses or acute trauma. A few patients had changed their residence to another part of Finland. The participation rate achieved in this study (79.1 %) is relatively good for such a long-term follow-up study. In addition, we were able to access data from the patients' case histories and were thus aware if they had undergone reoperations. However we do not know whether the nonparticipating patients were as satisfied with the fusion as the studied patients.

The reoperation rate for the patients lost to follow-up (28.6 %) was almost twice as high as the rate for the

Table 5 Complications during the time of follow-up of the patients

Complication	Group 1, <i>N</i> = 31 Degenerative spondylolisthesis	Group 2, <i>N</i> = 33 Adult isthmic spondylolisthesis	Group 3, <i>N</i> = 22 Postdiscectomy syndrome	Group 4, <i>N</i> = 20 Postlaminectomy syndrome	All <i>N</i> = 106
Peroneal weakness			1	1	2 (1.9 %)
Urinary dysfunction				1	1 (0.9 %)
Deep infection	1		1	1	3 (2.8 %)
Implant complications					
Breakage of screw	3	4	2	2	11 (10.4 %)
Implant failure or resorption		2			2 (1.9 %)
Adjacent segment disease (operated)	2	1	3	2	8 (7.5 %)
Donor site pain				1	1 (0.9 %)
All	6	7	7	8	28

Table 6 Reoperations conducted in the study groups

Operation	Group 1, <i>N</i> = 31 Degenerative spondylolisthesis	Group 2, <i>N</i> = 33 Adult isthmic spondylolisthesis	Group 3, <i>N</i> = 22 Postdiscectomy syndrome	Group 4, <i>N</i> = 20 Postlaminectomy syndrome	All <i>N</i> = 106
Planned reoperations					
Implant removal	5	5	4	6	20
Unplanned operations					
Implant removal		2	1	1	4
Implant removal and decompression		1	1		2
Decompression	1		1	2	4
Fusion			1		1
Fusion and decompression	1		1		2
Epidural stimulator					
Application			3	1	4
Removal			2	1	3
Revision due to infection	1				1
Unplanned reoperations together	3	3	10	5	21
Patients with unplanned reoperation	2 (6.5 %)	3 (9.1 %)	7 (31.8 %)	4 (25.0 %)	16 (15.1 %)

patients followed up (15.1 %). The overall reoperation rate for the 134 surviving patients was 17.9 %, which is comparable to or even lower than values in the literature that contain follow-up data after 10 years (9, 22). In all, 31 unplanned reoperations were necessary for 24 patients. Most of these operations took place in the postdiscectomy group ($n = 9$, 36.0 %). An operation for ASD was necessary in 12 patients out of the 134 surviving patients (9.0 %), less than the rate reported by other studies [9, 12, 13, 22]. In the failed back groups, reoperations were performed in 13 out of 52 surviving patients (25.0 %) and in the spondylolisthetic groups in 11 out of 82 surviving patients (13.4 %). The need for reoperations in the postdiscectomy group was two or three times greater than in the other groups in this study, corresponding with previous studies [22–24].

Although degenerative diseases such as osteoarthritis of the hip, knee and ankle increased fivefold with respect to the preoperative situation, this had no significant effect on patients' satisfaction.

Based on the ODI results, the spondylolisthetic patients in Group 1 and the postlaminectomy syndrome patients in Group 4 seemed to have gained greater benefits than the adult isthmic spondylolisthetic patients in Group 2 and the postdiscectomy patients in Group 3. This may be attributable to the easier decompression of central stenotic levels rather than to lateral or foraminal stenotic changes. In addition, the positive change in VAS was higher in Groups 1 and 4. Postdiscectomy patients also exhibited the smallest percentage change in both ODI and VAS, a finding in parallel with the level of patient satisfaction.

The postdiscectomy patients (Group 3) were the most likely to participate in this study (88.0 %). In this group,

the orthopedic surgeon evaluated the results of the fusion as one point better than the patients themselves in seven cases (31.8 %) and in fact only one patient's estimate was better than that of the surgeon (4.5 %) [22–24].

The overall complication rate in this study was low. No perioperative dural tears, deep primary infections or pulmonary embolisms occurred. Complications included one postoperative hematoma, one leg vein thrombosis, one permanent urine dysfunction syndrome and two peroneal weaknesses after the primary operation. The complication rate is also low in the literature and thus posterolateral fusion can be regarded as a safe procedure [2, 15]. Screw breakage observed in postoperative X-rays is the most usual complication occurring during follow-up, often without the need for revision. In spite of the few primary complications seen in this study, as fusion operations do carry risks, the patients' responses to conservative treatment should be observed for a sufficient time before evaluating the need for operation. The risk of complications is higher for reoperations [25]. Degenerative changes may continue unabated, affecting adjacent segment alterations and leading to ASD in the long run. The overall reoperation rate due to ASD in the nonparticipating and studied patients was 9 %. Re-fusions due to pseudarthrosis were performed in a total of three patients (2.2 %). No pseudarthrosis was found in the followed up group. The patient must be made aware of these risks and the potential risks of reoperations due to later adjacent segment problems [9, 14, 22, 24].

The study has some limitations. This is a retrospective nonrandomized trial, so the results are descriptive and could be distorted to some extent by a good relationship between the patients and the doctor. Although we studied

the histories of nonparticipating patients, we have not interviewed them on their satisfaction.

The strengths of this study include a high participation rate of about 80 %, rising to 88 % in one group (the failed back Group 3 with postdiscectomy syndrome). The inclusion of reliable data from the case histories of nonparticipating patients strengthens the conclusions. The study is one of very few which examines outcomes after 10 years or more, providing a valuable overall impression of operated adjacent segment diseases in this population.

Further randomized long-term control studies are needed not only to establish the optimal indications for instrumented posterolateral fusion surgery, but also to clarify the real benefits of the operations. Alterations in the adjacent segments leading to ASD are common in the years after fusion and, therefore in agreement with Sears et al. [22], we recommend that end points for ASD are both radiological and clinical symptoms requiring surgical intervention. This is important, since in many cases, the radiologic findings do not coincide with the symptoms.

Among the four study groups, degenerative spondylolisthetic patients enjoyed the best improvements in both ODI and VAS values, reported the greatest patient satisfaction and had the lowest unplanned reoperation rate. Postlaminectomy patients showed the second best improvements and satisfaction in the follow-up. Adult isthmic spondylolisthesis and especially postdiscectomy patients showed poorer improvements and lower than 70 % satisfaction with higher unplanned reoperation rates.

We conclude that lumbar instrumented posterolateral fusion gives satisfactory long-term results in more than 80 % of patients suffering from axial lumbar back pain. However, there are differences in outcome among patient groups with different indications for operation.

Conflict of interest None.

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