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A long-term (4- to 12-year) follow-up study of surgical treatment of lumbar spinal stenosis

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Abstract Limited data are available about the long-term outcome of surgical treatment for lumbar spinal stenosis, and there is a wide variation in reported success rates. There is also a controversy regarding differences in long-term outcome between patients undergoing decompressive surgery alone and those undergoing both decompression and fusion. The aim of this study was to evaluate the long-term clinical outcome and possible complications of decompressive surgery, with special reference to possible differences between patients undergoing fusion, with or without instrumentation, and those undergoing decompression alone. All 124 patients undergoing first-time surgery for lumbar spinal stenosis between 1982 and 1991 at our department were included, and their medical records were reviewed retrospectively. Ninety-six of the patients were available for follow-up and were re-examined by an independent investigator and assessed with a questionnaire after a mean follow-up period of 7.1 (range 4.0–12.2) years. Sixty-five percent of all the patients at the follow-up were subjectively satisfied. Eighty-eight percent of the patients reported constant or daily leg pain preoperatively compared to 43% at follow-up. Constant or daily low back pain was reported by 83% of the patients preoperatively compared to 45% at follow-up. Improvement in walking capacity was found in most patients, and only 4% of the patients who had a preoperatively documented maximum walking distance reported a decreased walking capacity. Twenty-four (25%) of all patients used analgesics daily at the time of follow-up, 34 patients (35%) occasionally and 38 patients (40%) never. The patients with fusions, instrumented or non-instrumented, did not differ significantly from the unfused patients regarding any of the above-mentioned parameters. The results of the study showed that most patients demonstrated a considerable improvement in walking capacity at follow-up. This improvement was significant ($P < 0.001$) and of clinical importance. A significant improvement regarding both low back pain and leg pain was found postoperatively compared to preoperatively ($P < 0.001$). There were no statistical differences, judged by all the evaluated parameters, regarding the clinical outcome between patients who were fused and those who were not. Neither were any significant differences found between instrumented fusions compared to uninstrumented fusions. In accordance with most other long-term follow-up studies, about two-thirds (65%) of the patients claimed a satisfactory result at follow-up.

Key words Spinal disease · Spinal stenosis · Surgery · Follow-up studies · Treatment outcome

Introduction

Lumbar spinal stenosis is a common cause of low back pain, radiating pain in the lower extremities, decreased walking capacity and disability [16, 28, 35, 36]. Conservative therapies may be helpful, but do not in most cases result in a long-term improvement [16, 37]. The most widely used surgical techniques are all based on the principles of decompression alone or decompression and fusion, with or without instrumentation [24]. These operations are performed with an increasing frequency, leading to increasing societal costs [4, 23], but the documentation regarding their long-term efficacy is sparse and debatable [34]. During the last decades, a number of studies describing the short-term outcome of surgical treatment of lumbar spinal stenosis have been published. Success rates of 26–100% have been reported for different surgical interventions [34]. However, few data have, until recently, been available about the long-term results of surgery for lumbar spinal stenosis. Although long-term outcome has been evaluated in recent studies [1, 3, 6, 8, 9, 10, 11, 13, 14, 17, 19, 22, 27, 28, 30, 33], there is still a wide variation in reported success rates and a continuing controversy regarding differences in long-term clinical outcome between patients undergoing decompression alone and those undergoing both decompression and fusion [2, 7, 20, 31, 34]. There is also an ongoing debate about whether fusions should be instrumented or not [5, 20]. The aim of this study was to evaluate retrospectively the long-term clinical outcome and possible complications of decompressive surgery of spinal stenosis, with special reference to possible differences between patients undergoing fusion, with or without instrumentation, or decompression alone.

Material and methods

All patients who underwent first-time decompressive surgery for central and/or lateral spinal stenosis at our department between January 1 1982 and December 31 1991 were included in the study. These entry criteria were met by 124 patients. At the time of follow-up, 6 patients were deceased and 22 patients were lost to follow-up for other reasons. Ninety-six, i.e. 81% of the patients who were alive, were re-examined by an independent investigator and assessed with a questionnaire. The mean follow-up period was 7.1 (range 4.0–12.2) years and the mean age at follow-up was 64.4 (range 29–87) years.

Chart review

The records of all included patients were reviewed. Data were collected regarding preoperative low back pain (LBP), radiating leg pain, sensor or motor disturbances, walking capacity, duration of symptoms, work status and previous history of lumbar spine surgery. The radiographic diagnosis and the type or types of radiographic examinations undergone were recorded, as well as the type of surgical procedure performed and possible postoperative complications and reoperations.

Baseline variables

Fifteen of the 124 included patients had undergone previous lumbar spine surgery, 13 of them for a disc herniation and 2 for spondylolisthesis.

The records of the 96 patients who attended the follow-up showed that 89 patients (93%) had suffered preoperative LBP, 50 patients (52%) unilateral radiating leg pain and 41 patients (43%) bilateral radiating leg pain. Seventeen patients (18%) were reported to have had preoperative sensor or motor deficits in both legs, 47 (49%) sensor or motor deficits in one leg and 32 (33%) had presented no preoperative sensor or motor deficits. The 17 patients with preoperative sensor or motor deficits in one or both legs included 5 patients (5%) without any radiating leg pain. Information about preoperative walking capacity was found in the records of 55 of the 96 patients. Thirty-four (62%) of these patients were reported to have had a preoperative walking capacity of less than 200 m, 14 patients (25%) between 200 and 500 m and 3 patients (5%) between 500 m and 1 km. One patient (2%) had been able to walk between 1 and 5 km and 3 patients (5%) more than 5 km (Fig. 1).

Information about preoperative duration of symptoms was found in the records of 94 patients. Fifty-nine (63%) of these patients were reported to have had symptoms for more than 3 years, 9 patients (10%) between 2 and 3 years and 15 patients (16%) between 1 and 2 years. In 11 patients (12%) the duration of their symptoms had been less than 1 year.

Preoperative radiographic evaluation with plain radiographs, myelography and computed tomography (CT) had demonstrated that one level was compressed in 50 patients (52%), two levels in 34 patients (35%), three levels in 11 patients (11%) and four levels in 1 patient (1%). Ninety-four (98%) of the 96 patients had been preoperatively evaluated with a CT scan, 36 patients (38%) with myelography and 19 patients (20%) with MRI. In 27 patients the radiographic evaluation had demonstrated an accompanying spondylolisthesis.

In 54 patients (56%), a single-level decompression had been performed. Thirty-two patients (33%) had undergone a two-level decompression and ten patients (10%) a three-level decompression. In 62 patients (65%) decompression had been performed at the L4-L5 level, in 48 patients (50%) at the L5-S1 level, in 32 patients (33%) at the L3-L4 level and in 6 patients (6%) at the L2-L3 level. Regarding the type of decompression performed; 41 patients (43%) had undergone a central decompression and a bilateral decompression of the root canals, 20 patients (21%) had been decompressed centrally, including a unilateral root canal decompression, and 17 patients (18%) had received an isolated central decompression. In 14 patients (15%) a unilateral root canal and in

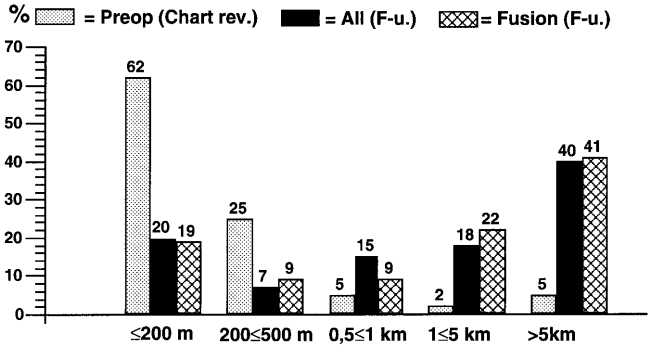

Fig. 1 Walking capacity for the subgroup of 55 patients whose medical records contained information about preoperative walking capacity (*F-u* follow-up)

4 patients (4%) a bilateral root canal decompression had been performed, without any central decompression.

The policy of the department, at the time these patients were operated, was to add a concomitant posterior fusion in patients with a preoperatively known significant spondylolistheses or in patients where the spinal surgeon believed the decompression induced a possible iatrogenic instability. Whether the fusions were instrumented or not was a decision that was up to the spinal surgeon in charge of the operation. Eight different spinal surgeons were involved in the surgical procedures. Fifty-nine patients (61%) had received a posterior fusion in the same surgical session as the decompression. Forty-two out of these 59 fusions were instrumented, mostly with the Steffee variable screw placement system (VSP) [4].

No statistically significant differences regarding the baseline variables were found between the groups with different surgical treatment.

Follow-up

The clinical examination, by an independent observer, included motor and sensory testing of the lower extremities, quadriceps and achilles tendon reflexes and a straight leg raising test. The questionnaire included items on preoperative and current work status, low back pain and radiating leg pain, but also present pain level, disturbed sensibility, disturbed motor function, use of analgesics, walking capacity, ability to perform daily activities and overall patient satisfaction. For evaluation of present pain levels regarding low back pain and leg pain, a standing 100-mm visual analog scale (VAS) was used. Forty-nine of the 96 patients attending the follow-up were women and 22 patients were smokers.

Statistical analysis

Fisher's non-parametric permutation test was used to compare the different treatment groups. The Sign test was used to compare the preoperative with the postoperative values. *P*-values of less than 0.05 were considered significant.

Results

At follow-up, 62 patients of 96 (65%) were subjectively satisfied, 24 patients (25%) dissatisfied and 10 patients (10%) uncertain about whether they were satisfied or not. Of the 59 patients with a fusion, 39 patients (66%) were satisfied, 12 patients (20%) dissatisfied and 8 patients (14%) uncertain. Twenty-three (62%) of the 37 patients with an instrumented fusion were satisfied, 12 patients (32%) dissatisfied and 2 patients (5%) uncertain. The patients with fusions, instrumented or non-instrumented, did not differ significantly from the decompressed and unfused patients regarding patient satisfaction. Neither were there any statistically significant differences between patients with a single-level decompression and those with a two- or three-level decompression.

Seventeen of all 96 patients (18%) were working full time and 10 patients (10%) part time. Forty-seven patients (49%) were retired because of their age, 10 patients (10%) had taken early retirement and 12 patients (12%) were on a disability pension (Fig. 2). Sixty of the 96 patients (62%) claimed that their work/leisure-related physical load at time of follow-up was similar to that experienced before the first appearance of spinal stenosis symptoms. Thirty-four patients (35%) claimed a lower work/leisure load and 2 patients (2%) reported an increased work/leisure load. Comparing the different surgical procedures, the results reported by the patients with fusions, instrumented or uninstrumented, and patients without fusions, regarding both their work status and work/leisure load were not significantly different.

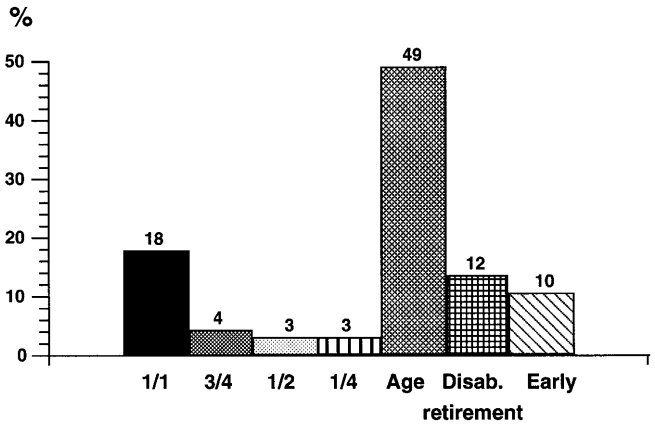

Fig. 2 Working status at follow-up

One of the 124 included patients, who had a two-level decompression and a concomitant instrumented posterior fusion, developed a postoperative haematoma and a cauda equina syndrome. She was re-operated the day after the first operation with an evacuation of the haematoma and an extended laminectomy. However, she had a remaining paresis of the bladder and the lower extremities at dismissal to her community hospital. She did not attend for the follow-up. One patient, who had a two-level decompression without a fusion, developed symptoms regarded as signs of instability during the first postoperative years, and he had an instrumented two-level fusion after 4 years. At the follow-up, he was satisfied with the outcome of surgery and reported a walking capacity of more than 5 km.

One patient, with a three-level decompression (L3-L4, L4-L5 and L5-S1) without a fusion, and with remaining symptoms of spinal stenosis postoperatively, was re-operated after 18 months with an extended laminectomy of the two lower levels without a concomitant fusion. At the follow-up, he was dissatisfied with the outcome and reported a walking capacity between 0.5 and 1 km. Another patient, with a two-level decompression without a fusion (L4-L5 and L5-S1) was re-operated after 7 months, with a new two-level decompression (L1-L2 and L2-L3). However, her symptoms were not improved and she was referred for a "second-opinion" at the Department of Neurosurgery at our hospital. She did not attend for the follow-up.

Dural tears were noted in the surgery records of two of the included patients. One of these two patients did not attend for the follow-up, the other patient claimed satisfactory outcome and a walking capacity exceeding 5 km.

Four patients had wound infections (two instrumented fusions, one uninstrumented fusion and one decompression without fusion). Both patients with wound infection and instrumented fusions had their instruments removed due to the infection. One of the patients with wound infection and an instrumented fusion also had an excision of a fistula in her gluteal region excised at the time of instrument removal. In a total of ten patients, 24% of the patients with instrumented fusions, the instrument had been removed before the follow-up.

Subjective LBP and leg pain, evaluated with a standing VAS, graded 0–100, was 35.8 (SD ± 32.0) and 33.9 (SD ± 34.4) respectively for all operated patients at follow-up. The patients with a fusion reported 39.4 (SD ± 34.0) for LBP and 32.6 (SD ± 35.5) for leg pain. Comparing instrumented an uninstrumented fusions, patients with uninstrumented fusions reported 33.6 (SD ± 35.5) for LBP and 35.9 (SD ± 38.4) for leg pain, and those with instrumented fusions 41.8 (SD ± 33.5) for LBP and 31.2 (SD ± 34.6) for leg pain.

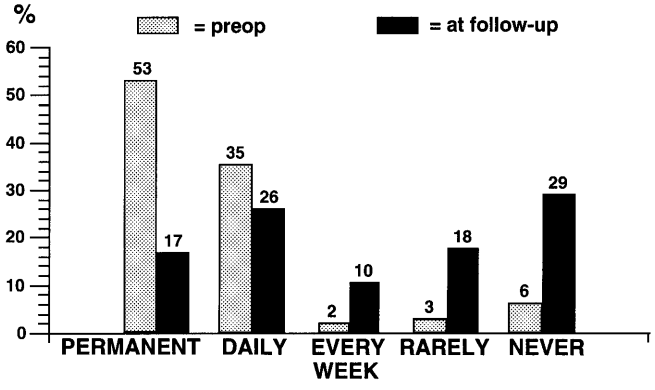

Fig. 3 Percentage of patients with leg pain

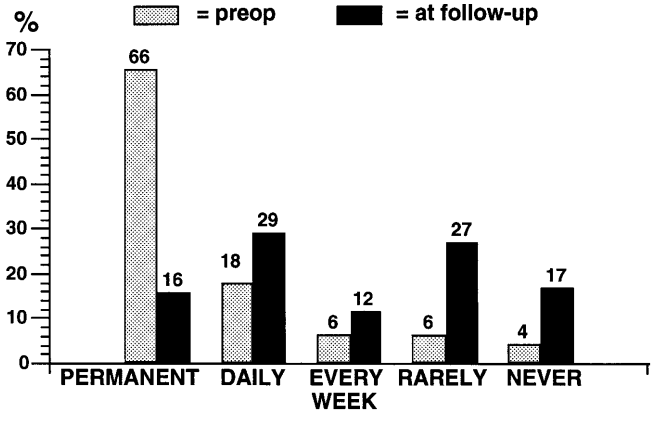

Fig. 4 Percentage of patients with low back pain

Eighty-five of 96 patients (88%) described constant or daily leg pain preoperatively compared to 41 patients (43%) at follow-up. The improvement regarding leg pain was statistically significant ($P < 0.0001$) (Fig. 3). Constant or daily LBP was reported by 80 patients (83%) preoperatively compared to 43 patients (45%) at follow-up. This improvement was also statistically significant ($P < 0.0001$) (Fig. 4). The patients with a fusion, instrumented or non-instrumented, did not differ significantly from the unfused patients regarding these pain parameters.

At follow-up, 24 (25%) of all patients used analgesics daily, 34 patients (35%) occasionally and 38 patients (40%) never. Eighteen (30%) of the patients with a fusion used daily analgesics, compared to six patients (16%) who were decompressed without a fusion. Fifteen (36%) of the patients with instrumented fusions used analgesics daily compared to 3 (18%) of those with uninstrumented fusions. However, there were no statistically significant differences between the different groups.

At follow-up, 42 patients of 96 (44%) reported a walking capacity of more than 5 km, and an additional 19 patients (20%) stated that they were able to walk between 1 and 5 km. Seventeen patients (18%) reported a walking capacity of less than 200 m at follow-up. The walking capacity of the group with uninstrumented or instrumented fusions did not significantly differ from that of the group who underwent decompression without a fusion (Table 1, Table 2).

As was mentioned earlier, information about preoperative walking capacity was found in the medical records of 55 patients. The follow-up data for this subgroup (Fig. 1) showed a significant improvement in walking capacity ($P < 0.001$). Thirty-eight of the 55 patients reported an increased walking capacity at the follow-up compared to their preoperative capacity from the chart review. Twenty-

Table 1 Walking capacity at follow-up: comparison of fused and non-fused patient groups

	All	Fusion	Non-fusion
≤ 200 m	17/96 (18%)	10/59 (17%)	7/37 (19%)
200–500 m	5/96 (5%)	4/59 (7%)	1/37 (3%)
500 m–1 km	13/96 (14%)	6/59 (10%)	7/37 (19%)
1–5 km	19/96 (20%)	12/59 (20%)	7/37 (19%)
≥ 5 km	42/96 (44%)	27/59 (46%)	15/37 (40%)

Table 2 Walking capacity at follow-up: comparison of fused patients with and without instrumentation

	Fusion with instrumentation	Fusion without instrumentation
≤ 200 m	8/42 (19%)	2/17 (12%)
200–500 m	4/42 (10%)	0/17 (0%)
500 m–1 km	4/42 (10%)	2/17 (12%)
1–5 km	9/42 (21%)	3/17 (18%)
≥ 5 km	17/42 (40%)	10/17 (59%)

four of 34 patients with a preoperative walking capacity of less than 200 m improved their walking capacity; 12 of them could walk for 5 km or more at the follow-up, two of them between 1 and 5 km, seven of them between 500 m and 1 km and three of them between 200 and 500 m. All 14 patients with a preoperative walking capacity of between 200 and 500 m could walk longer at the follow-up, and 7 of those 14 patients could walk 5 km or more. Only 2 of the 55 patients claimed a decreased walking capacity at the follow-up compared to their preoperative medical records. One of these patients had a preoperative walking capacity of between 0.5 and 1 km, but reported postoperatively a maximum walking distance of less than 200 m. The other one had a preoperative walking capacity of between 1 and 5 km and a postoperative walking capacity of between 200 and 500 m. Interestingly, both these patients stated that they were satisfied with the operation.

At follow-up, remaining sensory deficit in one or both legs was reported by 51 patients (53%) in the questionnaire and was found at the clinical examination in 53 patients (55%) (Table 3, Table 4). Remaining motor deficit in one or both legs was reported by 32 patients (33%) in the questionnaire at the follow-up. Remaining motor deficit or reflex abnormality was found at the follow-up clinical examination in 50 patients (52%), and in 32 of those patients the motor deficit or reflex abnormality originated only from the operated level (Table 5, Table 6).

Table 3 Sensory deficit at follow-up (clinical examination): comparison of fused and non-fused patient groups

	All	Fusion	Non-fusion
No.	43/96 (45%)	28/59 (48%)	15/37 (41%)
Op. level	42/96 (44%)	25/59 (42%)	17/37 (46%)
Other level	5/96 (5%)	1/59 (2%)	4/37 (11%)
Op. + other level	6/96 (6%)	5/59 (8%)	1/37 (3%)

Table 4 Sensory deficit at follow-up (clinical examination): comparison of fused patients with and without instrumentation

	Fusion with instrumentation	Fusion without instrumentation
No.	21/42 (50%)	7/17 (42%)
Op. level	17/42 (40%)	8/17 (47%)
Other level	0/42 (0%)	1/17 (6%)
Op + other level	4/42 (10%)	1/17 (6%)

Table 5 Motor deficit or reflex abnormality at follow-up (clinical examination): comparison of fused and non-fused patient groups

	All	Fusion	Non-fusion
No.	46/96 (48%)	32/59 (54%)	14/37 (38%)
Op. level:	32/96 (33%)	17/59 (29%)	15/37 (41%)
Other level:	11/96 (12%)	7/59 (12%)	4/37 (11%)
Op + other level	7/96 (7%)	3/59 (5%)	4/37 (11%)

Table 6 Motor deficit or reflex abnormality at follow-up (clinical examination): comparsion of fused patients with and without instrumentation

	Fusion with instrumentation	Fusion without instrumentation
No.	21/42 (50%)	11/17 (65%)
Op. level	12/42 (29%)	5/17 (29%)
Other level	5/42 (12%)	1/17 (6%)
Op + other level	4/42 (10%)	0/17 (0%)

Table 7 Negative straight leg raising test at follow-up

All	72/96 (75%)
Fusions	45/59 (76%)
Non-fusions	27/37 (73%)
Fusions with instrumentation	31/42 (74%)
Fusions without instrumentation	14/17 (82%)

Seventy-two patients (75%) had a negative straight leg raising (SLR) test in both legs at follow-up. Table 7 presents a comparison between the different surgical procedures regarding the SLR tests. Regarding both motor and sensory deficits and SLR tests, there were no significant differences between decompression with a fusion compared to decompression without a fusion or between instrumented and uninstrumented fusions.

At the follow-up, 3 of the 96 patients (3%) were noted to have an impairment of their sphincter function at the clinical examination. These three patients included one patient with a decompression of L4-L5 without a fusion, one patient with a decompression of L5-S1 without a fusion and one patient with a two-level decompression of L4-S1 and an uninstrumented fusion.

Discussion

The percentage of patients with satisfactory results in the present study, 65% of all patients, is in accordance with the results of the few previous long-term follow-up studies of surgery for lumbar spinal stenosis [1, 6, 8, 9, 19, 21, 27, 33], including one meta-analysis of the literature [34]. Regarding the natural course of lumbar spinal stenosis, Johnsson and co-authors compared the clinical course of 19 untreated patients with spinal stenosis with that of 44 patients treated surgically. At the follow-up, after 31 and 53 months respectively, one-third of the treated and one-half of the untreated patients still had neurogenic claudication. Sixty percent of the patients treated surgically, compared to 33% of the untreated patients, reported that they “felt better” at the follow-up [15]. In a later study, the same authors followed 32 untreated patients with lumbar spinal stenosis for a mean period of 49 months. They stated that symptoms were unchanged in 70% of the cases, improved in 15% and had worsened in 15% [16].

Airaksinen and co-workers followed 438 surgically treated patients with a mean follow-up period of 4.3 years, and noted, using the Oswestry Low Back Pain Questionnaire and the Oswestry Disability Score, excellent to good results in 62% of the patients [1]. No fusions were included in this group of patients, which is the largest published patient population, even though the whole facet was removed in some patients – a procedure that is generally regarded as a criterion for a concomitant fusion by most spinal surgeons [12, 26]. Herno and co-authors, from the same spinal centre in Finland, evaluated 102 patients [9]. These patients, with a mean follow-up time of 12.4 years, were all also treated with decompressions without fusions and assessed with The Oswestry Low Back Pain Questionnaire and Disability Score. They reported 68% excellent to good results.

Fox and co-workers evaluated 124 patients, 92 decompressions without fusions, 17 instrumented fusions and 15 uninstrumented fusions, with a questionnaire, retrospectively, after a mean follow-up period of 5.8 years [6]. Patients reporting "good or fair outcome" were regarded as satisfied. Twenty-one percent in their study reported a "poor outcome" and were dissatisfied – a figure that can be compared to our figure of 25% dissatisfied patients. However, they reported that 91% percent of those who underwent concomitant fusions had good or fair outcomes compared to 75% of those who had decompression alone. A similar increase in the percentage of satisfied patients after fusions could not be found in our study. The follow-up procedure, the percentage of patients who were fused and the outcome criteria were, however, not fully comparable, and therefore a comparison between these two studies is hardly possible.

Recently, Javid and Hadar [14] published results of a study of 86 patients evaluated with a questionnaire after an average of 5.1 years following decompression for lumbar spinal stenosis, including four instrumented and two uninstrumented fusions. They reported a 71% positive response to the question of whether, in retrospect, they would still have chosen surgery. The group of patients with a fusion was too small to be separately evaluated.

Jönsson and co-workers recently published a prospective study of 105 consecutive patients undergoing decompression, with a facet joint preserving technique, for central lumbar spinal stenosis [17]. They examined, in particular, the clinical features related to radiographic findings and, in a 5-year follow-up, the value of preoperative parameters in predicting surgical outcome. Five years after the surgical procedure, they reported that 48% of their total study population claimed an excellent result and about 65% a fair to excellent result. Also from the 5-year follow-up, they reported an improved walking capacity in 53% of the patients, unchanged in 33% and deteriorated in 14%. These figures are less favourable than our results. However, they did not include any patients with fusions, and thus their patients clearly differed from ours.

Katz and co-authors [19] performed a retrospective review and prospective follow-up, a similar study design as in our study, of 88 patients who had a decompressive laminectomy with or without fusion. They were followed for an average of 8.1 years. Seventy-five percent of the patients were reported as "somewhat or very satisfied" with the results of surgery. The group of patients with a concomitant arthrodesis (n = 8) was small. All fusions were uninstrumented. At the follow-up, they reported that 53% of the patients were unable to walk two blocks. Regarding this parameter, the patients in our study seemed to perform better, with 64% of all patients claiming a better walking capacity than 1 km, and as many as 78% of the patients more than 500 m. The smaller percentage of patients with a fusion in the study by Katz et al. can hardly explain this difference, since our subgroup of patients without a fusion claimed a walking capacity very similar to the patients with a fusion. However, the mean age at the time of surgery for the patients in the study by Katz and co-workers was 69.3 years, compared to 64.4 years at the time of follow-up in our study. Thus, the fact that our patients were, on average, about 10 years younger at the time of surgery could, at least partially, explain the better results regarding walking capacity in our study.

Considerable improvement in walking distance at follow-up was found in most of our patients. Only two patients claimed a decreased walking capacity compared to preoperatively. The improvement in walking capacity was significant ($P < 0.001$).

Over 80% of the patients reported constant or daily LBP and/or leg pain preoperatively compared to under 50% at follow-up. There were no significant differences for any of the studied parameters between patients who were fused and those who were not. Neither were there any significant differences between patients with instrumented fusions compared to those with uninstrumented fusions, but this lack of statistical difference could be influenced by the comparatively small number of patients with uninstrumented fusions. However, one disadvantage to be recognised with the instrumented fusions is the number of patients needing a second surgical procedure to remove the instrument. The instrument had been removed at follow-up in 24% of patients with instrumented fusions in this study. The strength of our study, compared to most other long-term follow-up studies, is that we evaluated the patients clinically at the follow-up, and did not just rely on answers to a mailed questionnaire. Another strength is that the subgroups of uninstrumented and instrumented fusions were proportionately large in comparison with the other follow-up studies. However, the limitation of the study is the retrospective design and the relatively small number of patients with an uninstrumented fusion who were included. Thus, there is a need for prospective studies on the long-term effects of lumbar spinal stenosis surgery.

Conclusions

From this 4- to 12-year follow-up study of surgical treatment of lumbar spinal stenosis, we conclude that:

1. About two-thirds of the patients with a preoperatively reported walking capacity showed a considerable improvement in walking distance at the follow-up. The improvement in walking capacity was still significant, compared to preoperative distances, at our follow-up after an average of 7.1 years.

2. A significant improvement in both LBP and leg pain was found at the follow-up compared to the reported preoperative LBP and leg pain.

3. In accordance with other long-term follow-up studies, about two-thirds of the patients claimed that they were satisfied with the operation.

4. This study did not demonstrate any statistically significant differences in the clinical outcome between patients who were fused and those who were not. Neither were any significant differences between instrumented compared to uninstrumented fusions found. However, one-fourth of the patients with instrumented fusions had had the instrument removed in a second surgical procedure by the time of the follow-up.

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