Clinical Outcomes of Revision Lumbar Spinal Surgery: 124 Patients with a Minimum of Two Years of Follow-up

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Background: Pertinent literature on revision lumbar spinal surgery has revealed a wide variation in success rates, ranging from 12% to 82%. In addition, a solid consensus has not yet been reached on its positive factors. We retrospectively reviewed 124 consecutive patients who underwent revision lumbar spinal surgery and investigated the factors that affected the outcomes of their surgery.

Methods: Revision lumbar spinal surgery was performed in 124 patients from January 1992 to December 1996, with an average follow-up of 37.6 months (range, 24-89 months). The various factors analyzed included age, gender, previous diagnosis, number of previous operations, period of pain-free interval, neurologic deficit, operative procedure, and fusion status. This analysis revealed the effect of each factor on the overall results. Radiographs were obtained, and patients were assessed during the final follow-up or by questionnaire.

Results: The success rate of revision lumbar spine surgery in this study was 83.9%. Successful outcomes were significantly associated with the spinal procedure with fusion and with union of the spinal fusion. Patients with defined mechanical instability had better results than did those with stenosis only. In addition, the complication rate for repeated lumbar spinal surgery was 9.6% and major complications attributed to poor results.

Conclusion: This study reveals a high success rate of revision spinal surgery. We recommend performing spinal fusion, and achievement of solid fusion in repeated low back surgery is invaluable for patients with spinal instability. Targeting the specific pathology of failed back surgery syndrome is crucial in attaining satisfactory results with revision lumbar spinal surgery.
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Key words: **failed back surgery syndrome, spinal fusion, revision surgery.**

Failed back surgery syndrome causes distress for both patients and the spinal surgeons. Not only is the syndrome difficult to diagnose and treat appropriately, but surgery also yields unpredictable results.

Most failures of primary lumbar spinal surgery occur within the first 5 years after the operation.[1] Common causes of failure are infection, misdiagnosis, inadequate treatment, and psychological prob-

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lems.[2] Success rates of revision lumbar spinal surgery in the relevant literature range from 12% to 82%.[3-13] The success rate of revision lumbar spinal surgery decreases with an increase of the follow-up period and the number of spinal procedures. Fritsch et al. reported the short-term success rate of revision lumbar spine surgery as 80%, which decreased to only 20% with long-term follow-up.[7] In addition, the results of patients who undergoing a second surgery were disappointing compared with those who only underwent primary surgery.[8,12,14] Factors correlated to successful results are inconsistent, and reaching a consensus on factors which may predict the outcome of repeated lumbar spinal surgery is extremely difficult. The favorable factors vary according to differing patient populations, operation indications, follow-up procedures, and criteria for success.[11]

This study included different causes for failed back surgery syndrome leading to revision lumbar spinal surgery. This study assessed the results of revision low back surgery and analyzed the factors correlated to successful outcomes.

METHODS

A consecutive series of 148 patients who underwent revision lumbar spine surgery was retrospectively studied. All patients had recurrent low back pain and radiculopathy after the first spinal surgery, and were unresponsive to conservative treatments. The senior author (W.J.C.) performed all of the operations between 1992 and 1996. Surgical intervention was performed for definite lesions, such as recurrent disc herniation, adjacent stenosis or instability, pseudarthrosis and flat back syndrome. All patients were studied with preoperative plain films, computed tomography, myelography, or magnetic resonance imaging. Twenty patients, whose follow-up period was less than 2 years or with whom contact was lost, were excluded. The remaining 124 patients received adequate clinical and radiographic follow-up for a minimum of 24 months (range, 24-89 months; mean 37.6 months).

This group consisted of 45 men and 79 women. Their average age at the time of revision spinal surgery was 55.4 years (range, 25 to 73 years). The average number of previous operations was 1.17 (range, 1-4). One hundred and six patients had previously undergone surgery once, 15 twice, 2 three times, and 1 four times. In a review of patients' initial presentations, 39 patients had herniated intervertebral disc (HIVD), 37 had spinal stenosis, 33 had spondylolisthesis, 9 had segmental instability, and 6 had degenerative scoliosis. All patients suffered from leg pain. Ninety-four patients experienced spinal stenosis with claudication, 89 suffered mechanical instability with back pain, and 15 experienced neurological deficit with motor weakness. The average pain-free interval after the previous operation was 39.6 months (range, 0 to 348 months). Pre-operative radiographs, such as anteroposterior, lateral, and flexion-extension stress views, were taken to evaluate the alignment and stability of the lumbosacral spine. Computed tomography, myelography, or magnetic resonance imaging was arranged to assess the spinal lesion. Causes of failed back surgery syndrome were recurrent disc herniation in 28 patients, spinal stenosis in 21, post-laminectomy instability in 30, adjacent instability in 24, pseudarthrosis in 17, and flat back syndrome in 4. The current operations consisted of 11 discectomies, 18 simple laminectomies, 11 spinal fusions with instrumentation, 13 decompressions with fusion, and 71 decompressions with fusion and instrumentation.

The postoperative evaluation consisted of a physical examination, a review of chart records, radiography, and a questionnaire. The questionnaire included pain assessment using a visual analog scale, frequency of medication, and the status of working and daily activity. The operative results were classified as "excellent" (if the patient felt no pain, required no medication, and returned to his or her previous work); "good" (if the patient felt pain was much improved, returned to work, and required little medication); "fair" (if patient's pain improved moderately, he or she took frequent medication, and changed to lighter work); "no improvement"; or "worse" being the poorest result. "Excellent" or "good" results were considered successful with the others being considered failures. Radiography was reviewed to clarify the status of spinal fusion. The fusion mass was graded as follows: grade 1, bilateral fusion with trabeculated transverse processes and facet fusion; grade 2, unilateral fusion with difficulty visualizing the other side; grade 3, suspected lucency or defect in the fusion mass; and grade 4, resorption of the graft with instrumentation failure. Union of the fusion mass was defined by grades 1 and 2; poor quality of the fusion mass was defined as grade 3; and grade 4 consisted of nonunions.

Statistical analyses with log-rank test (univariately) or Cox's proportional hazard model (multivariately) were performed to investigate which factors were associated with certain outcomes. The criterion for statistical significance was $p<0.05$.

RESULTS

Forty-one patients were classified into the "excellent" group, with no pain, requiring no medication, and returning to their former work. Sixty-three patients were much improved in pain, took medication rarely, and returned to their former work. Nineteen patients had moderately improved pain, relied on frequent medication, and changed to lighter work; 3 of these 19 patients sustained postoperative motor weakness. One patient was classified as a poor result owing to cauda equina syndrome after the operation, with persistent motor weakness and urine retention; this patient required rehabilitation.

The success rate of revision spine surgery was 83.9% (104 patients with "excellent" or "good" results). According to the different causes of failed back surgery syndrome, the success rate for the treatment of pseudarthrosis was highest and for spinal stenosis the lowest (Table 1). There were no mean-

Table 1. Success Rate of the Index Procedure for Different Causes of Failed Back Surgery Syndrome

	Patients (N=124)	No. of Success (%)
Recurrent disc	28	22 (78.6%)
Spinal stenosis	21	15 (71.1%)
Post-laminectomy instability with stenosis	30	28 (93.3%)
Adjacent instability with stenosis	24	20 (83.3%)
Pseudoarthrosis	17	16 (94.5%)
Flat back syndrome	4	3 (75.0%)

Table 2. Factors Associated with Successful Outcome of Revision Lumbar Spinal Surgery (by Univariate Survival Analysis)

	N	Failure (%)	Success rate (%)				p
			2-year	3-year	4-year	5-year	
Total	124	20 (16.1)	97.6	87.1	70.3	66.1	--
Age (year)							0.8558
≤55	50	8 (16.0)	98.0	85.8	70.0	70.0	
>55	74	12 (16.2)	97.3	88.2	70.7	62.8	
Gender							0.0475*
Male	45	10 (22.2)	95.6	78.3	57.8	57.8	
Female	79	10 (12.7)	98.7	92.3	77.5	71.5	
Number of previous operations							0.5832
1	106	17 (16.0)	98.1	87.2	67.5	63.0	
2-4	18	3 (16.7)	94.4	86.7	86.7	86.7	
Pain-free interval (months)							0.3925
≤6	41	10 (24.4)	97.6	87.7	74.5	74.5	
>6	83	10 (12.0)	97.6	81.2	64.4	56.4	
Neurological deficit							0.4170
Yes	15	5 (33.3)	86.7	86.7	67.4	50.6	
No	109	15 (13.8)	99.1	86.6	71.0	71.0	
Fusion							0.0008*
Yes	95	11 (11.6)	99.0	91.0	79.3	74.6	
No	29	9 (36.0)	93.1	70.3	38.5	38.5	
For those who had fusion (N=95)							
Graft fusion							0.0013*
Yes	91	8 (8.8)	100	92.4	85.2	79.9	
No	4	3 (75.0)	75.0	75.0	25.0	25.0	

* $p<0.05$

ingful differences in success rates among the different causes of failed back surgery syndrome. However, mechanical instability and defined mechanical compression by a disc obviously produced more-favorable outcomes than did spinal stenosis. Table 2 lists the various factors that contributed to successful outcomes as analyzed with the log-rank test. The overall success rate of revision lumbar spinal surgery decreased from 97.6% in a 2-year follow-up to 66.1% in a 5-year follow-up. We classified patients into 2 groups depending on whether they were younger or older than 55 years of age. There was no significant difference between 2 groups. Ten of 45 male patients were failure compared to 10 of 75 female patients which significantly differed. The 5-year success rate was higher in the female group. Although the 5-year success rate was greater in the group receiving 2-4 previous operations, the failure rate between 2 groups was not significant. There was no meaningful association with the failure rate for weighing whether the pain-free interval was longer than 6 months or not. The failure rate of patients with neurological deficit was higher than that of patients without neurological deficit, but the different was not significant. In addition, the 5-year success rate was better in patients without neurological deficit. Patients were also classified into fusion or non-fusion groups to evaluate the effects on outcomes. The fusion procedure was significantly associated with successful outcomes; the 5-year success rate was 74.6% in the fusion group compared to 38.5% in the non-fusion group. Radiography was performed at the last follow-up and examined by an independent blinded observer. The overall union rate of posterolateral fusions was 95.0%. There was an 8.8% failure rate in the union group in comparison with 75.0% in the nonunion group, which significantly differed. A high 5-year success rate in the graft union group was achieved.

In this study, we performed 17 spinal fusion procedures among the 28 patients with recurrent disc herniation. Eighty-eight percent (15/17) of patientswith recurrent disc recovered successfully after fusion, but this did not significantly differ from patients without fusion ($p = 1.00$). In addition, the success rate of patients with stenosis after spinal fusion was 78% (14/18) in comparison with 33% (1/3) for the non-fusion group; this also did not significantly differ ($p = 0.184$).

Cox's proportional hazard model with forward selection revealed that fusion was the only important factor in determining outcome. Female gender was not a predictive factor. Patients without the fusion procedure were 4.24 times more likely to have unfavorable outcomes than were those with the fusion procedure (Table 3).

Table 3. Factors Associated with Successful Outcome of Revision Lumbar Spinal Surgery
(by Cox's Proportional Hazard Model)

Variable entered	Failure hazard ratio	95% CI	*p*
Fusion			0.003*
Yes	1.00	Reference	
No	4.24	1.68-10.72	

* $p < 0.05$.

Cauda equina syndrome was the most complicated problem encountered after revision lumbar spinal surgery. One patient suffered from progressive weakness of the lower limbs after surgery caused by acute hematoma compression. An emergent operation for evacuation of the hematoma was performed. However, the patient's motor power of the lower limbs recovered poorly, and rehabilitation was arranged due to urine retention and motor weakness. Poor results were accompanied by the complication of cauda equina syndrome. Other early complications included dura tear in one patient, wound infection in one and neurological deficit in 3. Four patients suffering from adjacent instability, one from pseudarthrosis, and one from kyphoscoliosis were noted during the follow-up period. The complication rate for revision lower back surgery was 9.6%.

DISCUSSION

Successful outcomes of revision lumbar spinal surgery reported in the previous literature ranged between 12% and 82%.[3-13] Successful results vary due to differences in populations, pathology, and selection criteria of patients. The operative criteria used by the surgeons also affect the results. Finnegan et al.[6] stated that the usual operative criteria for primary spine operations are not applicable when a patient sustains failed back surgery syndrome. The surgeon's experience is the most important, and he or she must judge the treatment and consider objective criteria for the operation before surgery. Our high success rate indicates the importance of a precise diagnosis and appropriate treatment conducted by a single, experienced surgeon.

Stewart et al. stated that differences in patient populations, operative criteria, follow-up procedures, and criteria of success explained why researchers could not agree on which factors favor successful outcomes among the findings.[11] Independent factors such as gender and age of a patient population affect the outcomes, yet Fritsch et al.[7] revealed no differences in outcomes based on age or gender. In contrast, both North et al. and Stewart et al. demonstrated that younger patients and female patients recovered more successfully from repeated surgery.[11,15] Biondi et al. also supported the claim that female patients experienced a greater number of successful outcomes.[4] This study supports the notion that female gender is significantly related to successful outcomes, as higher 5-year success rates were maintained in female patients. However, age was not a significant factor. Activity level may have affected the results between men and women, as most of the women in this study were not working before their operation.

Previous multiple spine operations make surgery more difficult and worsen the outcomes. Waddell et al. verified that the success rate in revision spinal surgery decreased in relation to the number of reinterventions.[12] Fritsch et al. reported 47% poor results in patients with multiple revisions.[7] Kim et al. stated a 55% success rate for re-revision surgery compared to a 66% success rate for revision surgery, but this difference in success rates was not significant.[8] Quimjian et al. indicated that the improvement score decreased in patients with 2 or more operations, but with no statistical significance.[16] In this study, there was no significant difference between patients with one previous operation and those with more than one.

The period of the pain-free interval after the operation can assist in the differential diagnosis between disc herniation and fibrosis. Finnegan et al.[6] stated that a pain-free interval of less than 12 months was associated with extensive fibrosis. A symptom-free period of 12 months or longer indicated a lesion other than fibrosis. The absence of any pain-free interval usually means that the previous operative procedure did not properly target the lesion. In addition, successful outcomes may be related to the period of pain-free intervals. Biondi et al. and Waddell et al. both supported the premise that a pain-free interval greater than 6 months was correlated with a successful outcome.[4,12] In this study, the failure rate was higher in patients with pain-free intervals of less than six months; however, this prediction of successful outcome was not significant.

Although some authors have claimed that a neurological deficit affected the operation, this deficit did not always indicate an unsatisfactory outcome.[10,11,16] In contrast, positive outcomes were successfully predicted for patients without neurological deficit in the current study. The postoperative activity level of patients with neurological deficit may have been affected, and the outcome was worse.

Most reports in the literature on revision lumbar spine surgery are for a single disease, such as disc herniation or repair of pseudarthrosis.[5-7,14,15,17] Kim et al. revealed that the results for recurrent disc herniation were better than those for spinal stenosis, but the reason was unclear.[9] Cauchoix et al. and Lehmann et al. believed that the results for lysis of scar tissue were worse than those for true disc protrusion.[1,10] Finnegan et al. reported good results after revision surgery for the causes of mechanical compression by a disc and dynamic instability.[6] This study collected different causes of failure to evaluate the outcomes of revision spinal surgery. Mechanical instability, pseudarthrosis and recurrent disc herniation had higher success rates than did stenotic spinal lesion (Table 1).

Whether the spinal fusion procedure performed during revision surgery is valuable remains contentious, especially with reoperation for recurrent disc herniation. A biomechanical study revealed that both the amount of tissue removal and the type of annulus incision changed the stability of the disc.[18,19] Brinckmann et al. indicated that a loss of disc tissue in vitro decreased the disc height, increased the radial bulge, and decreased the intradisc pressure. The reduced disc height led to a larger compressive load on the posterior elements, and the increased bulge may have compromised the nerve tissue.[18] Ahlgren et al. revealed that box incisions through the annulus led to noticeably weaker healing in the early healing phase than for slit incisions, and resulted in a larger amount of motion.[19] Cinnoti et al. showed that spinal fusion was not necessary in reoperation for contralateral recurrent lumbar disc herniation.[13] However, Fritsch et al. supported the claim that patients with recurrent disc without fusion experienced poorer results than did those with spinal fusion. Initial laminectomy accompanied by discectomy resulted in a high rate of revision due to greater instability, which induced permanent irritation and contributed to the formation of epidural fibrosis.[7] Schlegel et al. suggested that fusion of the decompressed adjacent segment reduced post-surgical back pain.[20] In this study, we performed 17 spinal fusion procedures among 28 patients with recurrent disc herniation, but without instability of the spine. Fifteen of 17 patients recovered successfully, but there was no significant difference from results for patients without fusion. In addition, spinal fusion performed in patients with stenosis did not contribute to a significantly greater chance of a successful outcome. Another 78 patients with definite instability or instability created during the operation were given a spinal fusion. Cumulatively, 84 of 95 patients with spinal fusion achieved a successful outcome. This result significantly differed from those without fusion among patients with failed back surgery syndrome from different causes. Patients without the fusion procedure were 4.24 times more likely to have unfavorable outcomes than were those with the fusion procedure, as calculated with Cox's proportional hazard model. In addition, the effect of the fusion procedure maintained the successful results in long-term follow-up (Fig. 1). The beneficial effects of fusion may be achieved by limiting abnormal motion and stress that have been shown to occur at segments adjacent to a prior lumbar fusion.[21]

Established fusion with good quality of fusion mass was positively correlated with better results, and could reduce radiculopathy by creating local traction on the tethered nerve root in the direction of the segmental motion.[7,15] A high fusion rate depended on decorticating the lateral cortex of the superior facet and the dorsal side of the transverse process, eradicating the soft tissue between the transverse processes, preventing soft tissue interposition in

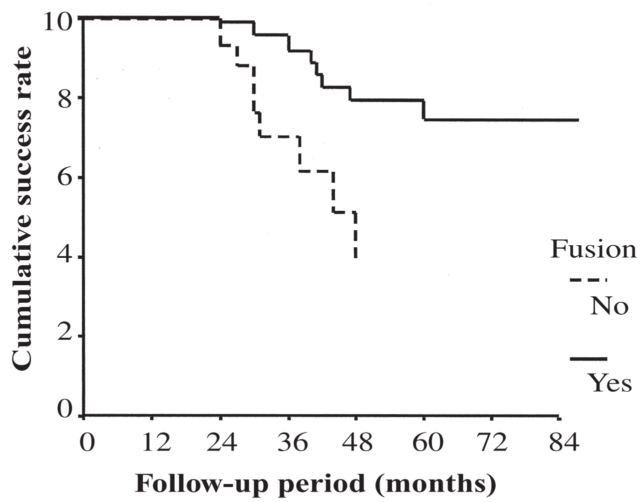

Fig. 1 Effect of the fusion procedure in long-term follow-up.

between the bone graft, and producing a good-quality bone graft.

Operations on patient with poor psychological profiles may be more likely to fail.[2,12] Psychological profiles are problematic in practice but may help explain some of the remaining variation.

Acute major complications such as cauda equina syndrome are an unpredictable tragedy. A careful and skilled technique is required to handle this challenging task, with an additional treatment program needed to aid the recovery of these patients. In this study, the success rate decreased from 97.6% in the 2-year follow-up to 66.1% in the 5-year follow-up. The decline in the success rate may be due to late complications consisting of adjacent instability, pseudoarthrosis, and flat back syndrome. These complications reduce the rate of successful recovery, and further operations should be considered for treating the next failed back surgery syndrome.

In conclusion, a high success rate for revision lumbar spinal surgery was achieved in this study. Significant positive predictive factors for revision spinal surgery consist of the spinal fusion procedure and union of the fusion graft. Revision spinal surgery is an arduous task that requires an experienced surgeon for decision making. We recommend spinal fusion for repeated low back surgery in patients with spinal instability; solid fusion is invaluable for a successful outcome. Understanding the pathological basis and targeting the specific pathology of failed back surgery syndrome are crucial in attaining satisfactory results with revision surgery.

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腰椎再次手術追蹤二年以上之臨床結果

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背 景： 文獻報告腰椎再次手術之成功率由12%至82%不等。探討造成手術成功之因素並沒有一致共識，本篇追蹤124位病患接受腰椎再次手術之臨床結果及探討那些因素和預後有關。

方 法： 從1992年至1996年，共124位病患接受腰椎再次手術及追蹤24至89個月，平均37.6個月。我們從病患接受門診追蹤檢查，問卷調查及X光片影像判讀，了解病患術後狀況。分析不同因素和臨床結果之關係，如：年齡、性別、術前診斷、主術前手術次數、疼痛解除期、神經功能缺損、手術方式及腰椎融合情形。

結 果： 腰椎再次手術之成功率達83.9%。施行腰椎融合術及成功之腰椎融合與成功之結果有統計數據上的相關。腰椎不穩定之病患接受腰椎再次手術比腰椎狹窄之病患有較好之結果。腰椎再次手術之併發症達9.6%，嚴重之併發症會影響術後結果。

結 論： 對於要達到成功的腰椎再次手術，必須了解及解決腰椎手術失敗的原因，才能達到滿意的結果。若腰椎不穩定，建議同時施行脊椎融合手術及達到成功的腰椎融合。
(長庚醫誌 2002;25:175-82)

關鍵字： 脊椎手術失敗症候群，脊椎融合術，再次手術。

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