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*Original Article*

# Adult degenerative scoliosis: comparison of clinical outcome, reoperation rates and survivorship after three different surgical treatments

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**Abstract:** *Purpose:* To compare surgical outcomes, reoperation rates and survivorship of three procedures used to treat adult degenerative scoliosis (ADS). *Methods:* A retrospective cohort analysis of 113 consecutive patients (mean age 70.6 years) with 5-year mean follow-up (minimum 2 years), treated for lumbar degenerative scoliosis by laminectomy alone (LA), short fusion (SF), or long fusion (LF). Clinical outcomes were assessed using validated measures including Oswestry Disability Index (ODI) and physical-component summary score of the Medical Outcomes Study 36-Item Short-Form Health survey (SF-36). Additional outcome measures included perioperative complications and reoperations. The incidence of reoperation was assessed by Kaplan-Meier survival analysis. *Results:* The LF group had a greater increase in SF-36 physical-component summary scores at last follow-up after surgery than the LA and SF groups ($P<0.05$). With respect to reduction in ODI scores, the change in the LF group at last follow-up after surgery was significantly greater than in the LA and SF groups ($P<0.05$). The LF group had higher blood loss and longer operation duration than LA and SF groups ($P<0.05$). Kaplan-Meier analysis revealed the lowest incidence of reoperation for the LF group and highest incidence for the SF group ($P<0.05$). *Conclusions:* The use of LF for ADS yielded better clinical results in comparison with LA and SF. Moreover, LF led to longer survival and should be carefully considered by surgeons as a feasible option.

**Keywords:** Adult degenerative scoliosis, outcome, surgery, survival analysis

## Introduction

Adult degenerative scoliosis (ADS), a major cause of low back pain and leg discomfort in the elderly, results from a combination of osteoporosis and disc disease with asymmetric degeneration and subsequent rotatory subluxation of multiple lumbar functional spinal units [1-5].

The etiology of symptoms in ADS patients comprises lumbar stenosis and spinal imbalance. The lumbar stenosis symptom consists of neurological claudication and leg pain. Neurological claudication can be relieved by forward posture, such as bicycling, whereas vascular claudication is relieved by standing still. Ploumis *et al*. [6] pointed out the necessity to distinguish neurological from vascular claudication. The radicular pain is mainly caused by the nerve root compression caused by central lumbar spinal stenosis or foraminal stenosis [7]. The spinal imbalance symptom in ADS consists of mechanical axial pain and the incapacity to stand upright, mainly caused by severe deformity and weak back muscles. The sagittal imbalance, resulting from the loss of lumbar lordosis, can also generate back pain because of fatigued back muscles. Moreover, back pain on the concave side might be caused by degenerative changes of disc and joint arthritis [4].

Conservative treatment is not always satisfactory in adult degenerative scoliotic patients [8, 9], and surgical management is becoming more frequent and aggressive. Surgical treatment varies from laminectomy alone (LA), through short fusion (SF), to attempts at full correction of the deformity by using long fusion (LF). The optimum choice of surgical treatment for the condition remains controversial [10]. Patients with ADS are typically elderly, with possible

increased comorbidities and perioperative complications, making surgical decision making more challenging.

Numerous studies have researched the surgical outcome after lumbar spinal fusion for ADS but have reported contradictory results [11-14]. Moreover, there are no available data in the literature regarding reoperation with special emphasis on comparison of three different surgical treatment methods.

We conducted the present study to evaluate surgical outcomes and survival (event defined as reoperation) in a large consecutive series of ADS patients being treated by LA, SF, or LF, with the aim of helping surgeons to find the best method (among three) that provides the longest survival and other preferred outcomes such as fewer complications and improved quality of life.

## Materials and methods

The study was approved by the Ethics Committee of the Hebei Provincial Hospital of Traditional Chinese Medicine in China, and patient consent was not required because of the retrospective nature of the study. Patient's information was anonymized and re-identified prior to analysis. The methods were carried out in accordance with the approved guidelines.

We retrospectively reviewed 113 patients who had undergone surgical treatment for ADS at a single institution from January 1, 2005 to December 31, 2012. Inclusion criteria for patients were: (1) at least 50 years of age; (2) presence of ADS, defined as a coronal Cobb angle >10°, with no known history of adolescent scoliosis; (3) no previous surgery of the lumbar spine; (4) surgery in the lumbar or lumbosacral region of the spine; (5) minimum 2-year follow-up. The study population consisted of 48 men and 65 women. The average age at the time of surgery was 70.6 years (ranged 50-84 years) and the average follow-up period was 60.3 months (ranged 24-120 months).

### *Surgical technique*

All operations were performed by a single surgeon (Y.S.). The decision of whether to perform simple decompression or fusion reflected his routine decision-making process used in daily clinical practice, and typically considered factors such as patient's age, general health status, leg pain, back pain, activity level, radiological findings, and willingness to undergo additional fusion. Laminectomy was performed by removal of the inferior half of the superior lamina, superior one-third of the inferior lamina, and all intervening ligaments from medial facet to medial facet. Next, the lateral recesses and foraminae were decompressed by removal of the ligamentum flavum, medial and deep facet capsules, and osteophytes. In short fusion constructs, a 360° fusion was usually performed, limited to 1-2 segments without curve correction. In the long fusion constructs, a 360° fusion at the lower levels and posterior fusion in the upper levels were performed with attempted curve correction.

### *Clinical outcomes*

Demographic information such as sex and age, preoperative comorbidities, and perioperative complications were recorded. Clinical outcomes were measured by the Oswestry Disability Index (ODI) [15] and physical-component summary score of the Medical Outcomes Study 36-Item Short-Form Health survey (SF-36) [16], collected preoperatively and at the last follow-up.

Reoperation was defined [17] as any additional surgery for either recurrent stenosis of the index level or adjacent segment disease. Reasons for reoperation were recorded. Complications were defined as any event for which the patient required specific treatment during hospitalization.

### *Radiological outcomes*

Imaging studies were conducted with plain radiography (neutral, flexion, and extension views), computed tomography, and magnetic resonance imaging. Coronal plane deformity was measured according to the Cobb method (using the maximally angled end vertebrae of the coronal curve). The presence of impingement of the lumbar spinal nerve root, foraminal size, and affected intervertebral levels were evaluated in each patient. Postoperatively, patients were followed up with anteroposterior and lateral radiographs.

### *Statistical analysis*

Descriptive data are presented as mean ± standard deviation. The significance of any differences between treatment groups (LA, SF, LF)

**Table 1.** Baseline demographic data for the three surgical treatment groups

| Variables | LA (n=30) | SF (n=48) | LF (n=35) | *P*-value |
|---|---|---|---|---|
| Age (years) | 71.8±5.9 | 71.1±6.1 | 68.6±6.7 | 0.09 |
| Male sex | 13 (43.3%) | 20 (41.7%) | 15 (42.9%) | 0.988 |
| Smoker | 6 (20.0%) | 14 (29.2%) | 6 (17.1%) | 0.394 |
| Comorbidities | | | | |
| Cardiovascular | 18 (60.0%) | 27 (56.3%) | 20 (57.1%) | 0.947 |
| Pulmonary | 3 (10.0%) | 7 (14.6%) | 4 (11.4%) | 0.819 |
| Diabetes | 5 (16.7%) | 8 (16.7%) | 7 (20.0%) | 0.912 |
| Obesity | 1 (3.3%) | 4 (8.3%) | 2 (5.7%) | 0.666 |
| Carcinoma | 0 (0%) | 1 (2.1%) | 1 (2.9%) | 0.668 |
| Follow-up | 54.3±18.5 | 63.0±21.3 | 61.9±22.1 | 0.186 |

LA: Laminectomy alone; SF: Short fusion; LF: Long fusion.

**Table 2.** Surgical data for the three surgical treatment groups

| Variables | LA (n=30) | SF (n=48) | LF (n=35) | *P*-value |
|---|---|---|---|---|
| Blood loss (ml) | 155±56 | 230±62 | 720±280* | 0.000 |
| Duration of operation (min) | 120±33 | 149±40 | 292±56* | 0.000 |
| Length of stay in the hospital (days) | 5.5±2.0$^{\Delta}$ | 10.4±1.8 | 10.8±2.6 | 0.001 |

*Significantly different from LA and SF (P<0.05); $^{\Delta}$Significantly different from SF and LF (P<0.05); LA: Laminectomy alone; SF: Short fusion; LF: Long fusion.

**Table 3.** Clinical and radiological data for the three surgical treatment groups

| Variables | LA (n=30) | SF (n=48) | LF (n=35) | *P*-value |
|---|---|---|---|---|
| Cobb angle (°) | 19.2±7.1 | 23.5±9.0 | 22.7±6.5 | 0.059 |
| Preoperative SF-36 score | 34.4±7.0 | 36.7±6.3 | 36.3±7.5 | 0.353 |
| Preoperative ODI score | 36.5±12.6 | 35.7±14.7 | 33.7±12.4 | 0.635 |
| Preoperative Cobb (°) | 19.2±7.1 | 23.5±9.0 | 22.7±6.5 | 0.059 |
| Postoperative SF-36 score | 44.1±8.7 | 43.1±9.3 | 50.6±8.8* | 0.001 |
| Postoperative ODI score | 22.4±4.8 | 23.6±4.7 | 18.5±3.5* | 0.000 |
| Reoperation | 5 (16.7%) | 16 (33.3%) | 1 (2.9%)$^{\#}$ | 0.002 |

$^{\#}$Significantly different from SF (P<0.05); *Significantly different from LA and SF (P<0.05); LA: Laminectomy alone; SF: Short fusion; LF: Long fusion; ODI: Oswestry disability index; SF-36: 36-Item Short-Form Health survey.

in their comparative variables was analyzed using analysis of variance (with post hoc Fisher's PLSD tests) for continuous data and contingency analyses with Chi-squared or Fisher's exact test for categorical variables. The incidence of reoperation was analyzed using Kaplan-Meier survival analysis. The log-rank test was used to compare survival curves. Significance was assessed using a two-sided α of 0.05. Data analysis was performed using SPSS software version 19.0 (SPSS, Chicago, IL, USA).

## Results

There were no differences in the baseline SF-36, ODI scores, and preoperative comorbidities between the three groups (**Table 1**). Preoperatively, all 113 patients complained of severe back pain with or without neurological symptoms, such as radiculopathy (motor or sensory disturbance) and claudication, and did not respond to standard conservative therapy for at least 6 months.

In total, 22 (19.5%) patients underwent second surgery of their index operation: 5 (16.7%) in the LA group (3 fusions after recurrence of symptoms and 2 fusions to treat adjacent segment diseases); 16 (33.3%) in the SF group (2 revisions because of pseudarthrosis, 2 after recurrence of symptoms, 4 for progressive deformity, and 8 to treat adjacent segment diseases); and 1 (2.9%) in the LF group (revision due to broken bars for non-union). The difference in reoperation rates among the groups was statistically significant (*P*=0.002, **Table 3**).

The mean SF-36 and ODI scores were significantly changed at the last follow-up compared with the baseline values for all groups. At the last follow-up, the mean SF-36 score in the LF group was significantly higher than that in the LA group (*P*=0.005) and SF group (*P*=0.000); the mean ODI score in the LF group was significantly lower than that in the LA group (*P*=0.001) and SF group (*P*=0.000) (**Table 2**).

The LF group had higher blood loss and longer operation time than LA and SF groups (*P*<0.05).

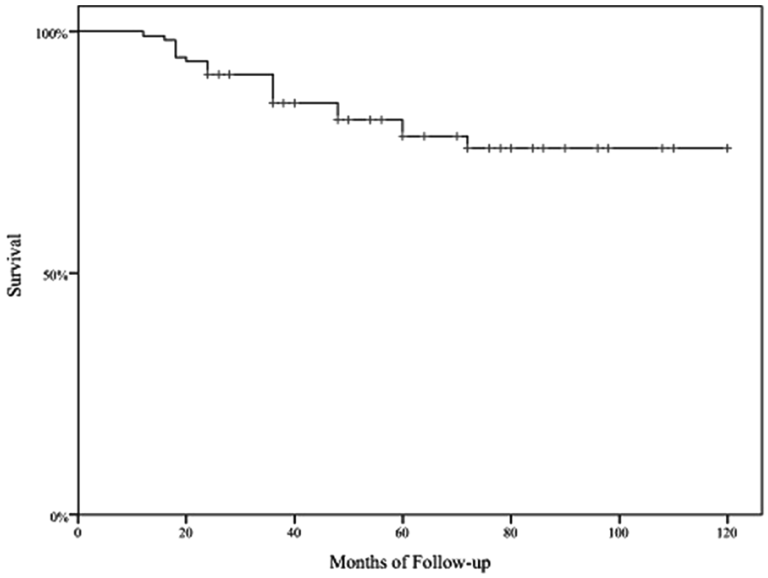


**Figure 1.** Kaplan-Meier analysis of survival from reoperation for all patients undergoing surgical treatment over time.

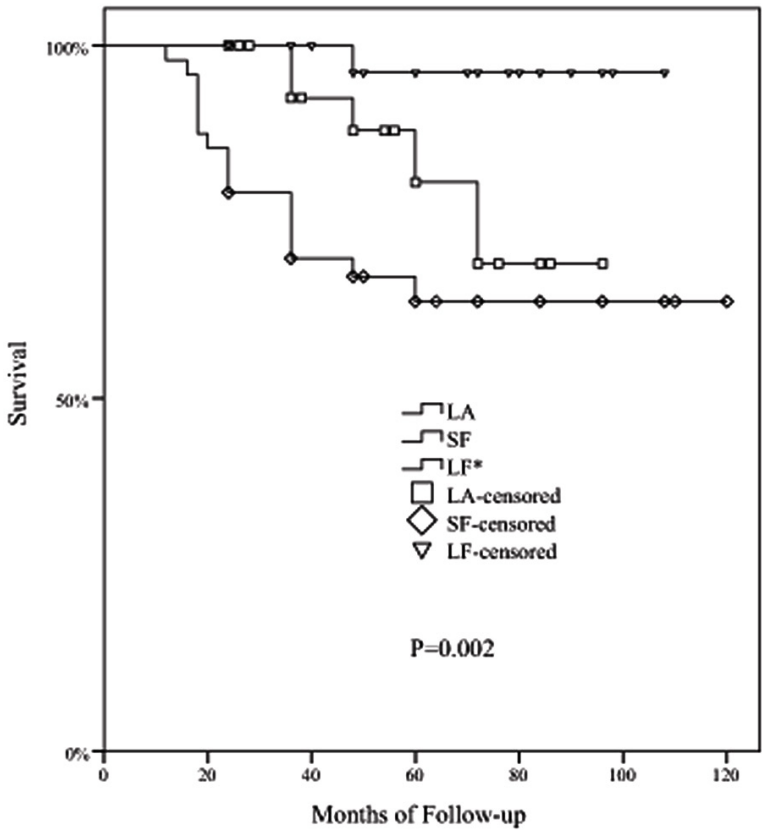


**Figure 2.** Kaplan-Meier analysis of survival from reoperation for each treatment group. LA, Laminectomy alone; SF, Short fusion; LF, Long fusion. *Significantly different from LA and SF (P<0.05).

One patient in the LA group, two in the SF group, and two in the LF group had a wound infection that resolved with irrigation and debridement combined with antibiotics. In the LA group, two patients with epidural hematoma required immediate evacuation, with complete resolution of symptoms. Two patients in the LA group, three in the SF group, and two in the LF group had a perioperative dura tear that resolved with duroplasty combined with conservative treatment postoperatively. Both the SF and LF groups contained one patient with worsening radiculopathy that resolved with conservative treatment. These were not included in the reoperation statistics. The total complication rates were not significantly different among the three groups ($P$=0.468, **Table 3**).

Kaplan-Meier analysis predicted a disease-free survival rate of reoperation in 91.2% of patients at 2 years and 78.4% at 5 years after index surgery for ADS (**Figure 1**). Log-rank analysis revealed the lowest incidence of reoperation for the LF group and the highest incidence for the SF group ($P$<0.05, **Figure 2**).

## Discussion

Patients with ADS, also known as *de novo* scoliosis, are usually elderly patients with accompanying lumbar stenosis [1-5]. The etiology of ADS involves the asymmetric degeneration of lumbar functional spinal units, including intervertebral discs, ligament flavum, and the posterior facet joint. Another theory is that osteoporosis after the menopause leads to degenerative lumbar spinal scoliosis, as it is most prevalent in women older than 50 years [1]. There is a wide range of treatment options for ADS, ranging from con-

servative therapy to full curve correction with LF. The surgical treatment method must be considered for each patient on an individual basis, as patients with ADS usually have a relatively wide age range, varying amounts of comorbidity, and different symptoms. Most commonly, surgical treatment for ADS comprises LA (simple decompression), SF without any attempt at deformity correction, or LF with or without decompression in an attempt to correct the deformity. Although several authors reported that LF with correction surgery generates better outcome and satisfaction [7, 13], varying concomitant medical comorbidities in the elderly population receive more attention nowadays. The ideal surgical treatment of ADS is still under debate in the literature.

The results of this study showed that the LF group had a greater change in SF-36 and ODI scores than the SF and LA groups. It is generally believed that patients treated with LA are those who present with predominantly neurological symptoms but with the load-bearing component of the lumbar spine appearing adequate. However, simple decompression is not always satisfactory and can lead to increased reoperation rates. Instability and recurrence of symptomatic stenosis are the main causes of second surgery after LA for ADS [18-20]. Mardjetko *et al.* [21] also reported that LA for the treatment of stenosis with degenerative spondylolisthesis was associated with a 31% incidence of slip progression. However, the addition of fusion has also raised concerns about the increased risk of surgical complications, especially in elderly patients, and the added fusion may not result in significantly improved clinical outcomes [22-28]. Although SF can protect the decompressed segment from further collapse, it is associated with a high incidence of adjacent segment disease. In a study by Sánchez-Mariscal *et al*. [27], 11.8% of non-planned surgeries were due to adjacent segment disease. By contrast, LF can relieve pain associated with mechanical weight bearing and also prevent progress of deformity. In a study by Kleinstueck *et al.* [11], there was a slight tendency for patients who underwent fusion to report slightly better patient-orientated outcomes, but this was not statistically significant. This contrasts with our findings whereby LF groups appear to benefit more from surgery according to SF-36 and ODI scores.

Excessive blood loss is not uncommon during surgery for ADS. Increased fusion level and longer operation time are associated with more blood loss [23, 24]. In these studies the LF group had higher blood loss and longer duration of the operation, which is consistent with our present findings. However, none of these factors appeared to have any bearing on the overall complication rates, since these were similar in the three treatment groups. Minimally invasive techniques did not show a trend toward significant reduction of perioperative complications.

There is a paucity of studies using Kaplan-Meier survival analysis (event defined as reoperation) in patients with ADS and even fewer examining these in relation to three different treatment modalities. To the best of our knowledge, this study reports for the first time that the LF group had the lowest incidence of reoperation and the SF group the highest incidence. At the last follow-up, 3.3% of the LF group, 16.7% of the LA group, and 33.3% of the SF group had undergone additional surgery for either recurrent stenosis of the index level or adjacent segment disease. Recognition of the reoperation rate after a long follow-up is an important clinical issue in guiding surgeons to make appropriate decisions.

Several limitations need to be considered in our study. First, this was a retrospective cohort study without a priori criteria detailing how patients were selected for the different surgical treatments. Thus, decompression was not always the treatment of choice but of circumstance. Second, the radiological parameters were not well evaluated and compared between the groups. Third, there was a wide range of age distribution and the groups were somewhat different in mean age. However, based on this positive report, a long-term follow-up prospective comparative study is recommended to further evaluate the clinical and radiological outcomes and survival rates of the three procedures used to treat this patient population.

The strengths of the study are the long follow-up (mean, 5 years) and the consecutive nature of this case series at a single institution. To the best of our knowledge, this is the first survival analysis of these three different surgical procedures. These data are potentially useful for sur-

geons when counseling their patients about surgical options.

The goal of ADS surgery is not only to relieve back or leg pain and correct spinal deformity, but also to minimize complications related to surgery. The use of LF for ADS yielded better clinical results than the use of LA and SF. However, LF leads to greater blood loss and longer operation time. Nonetheless, LF delivered the longest survival and should thus be carefully considered by surgeons as a preferred option.

## Disclosure of conflict of interest

None.

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