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Original Article

Effect of spinal fusion on degenerative scoliosis in elderly patients and analysis of influencing factors

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Abstract: Objective: To analyze the factors influencing efficacy of spinal fusion for the improvement of degenerative scoliosis in elderly patients. Methods: Retrospective analysis of clinical data was conducted on 194 elderly patients with degenerative scoliosis treated with minimally invasive lumbar lateral fusion at Affiliated Hospital of Hebei University on February 2018 to February 2021. The patients were divided into a recovered group (n = 138) and an uncured group (n = 56) according to their recovery. The basic information of patients, preoperative complications, preoperative and postoperative imaging results, clinical function scores, postoperative complications, and other relevant information were collected. Logistic regression analysis was used to analyze the factors affecting outcome. Receiver operating characteristic curves were used to determine the predictive value of factors influencing prognosis. Results: Univariate analysis showed that, compared to the uncured group, the recovered group showed younger age, shorter duration of symptoms and length of hospital stay, less history of hypertension or diabetes, and lower Oswestry disability index (ODI), and Japanese Orthopedic Association scores ($P<0.05$). Multivariate retrospective analysis revealed that age, duration of symptoms, length of hospital stay, history of hypertension and pretreatment ODI score were independent risk factors affecting treatment efficacy ($P<0.05$). The area under the curve of the risk model for predicting efficacy was 0.951. Conclusion: Age, duration of symptoms, length of hospital stay, history of hypertension, and pretreatment ODI score are risk factors affecting the treatment outcome of elderly patients with degenerative scoliosis, so these preoperative indications may be indicators to predict efficacy.

Keywords: Spinal fusion, degenerative scoliosis, old age, disease improvement, influencing factors

Introduction

Degenerative scoliosis, a common disease in spinal surgery departments, is one of the critical factors causing lumbar and leg pain, commonly occurring in people over 40 years of age [1]. As a spinal disease, it leads to spinal stenosis because of reduced spinal canal volume, convex nerve root traction and concave lateral nerve root compression after onset, with the main clinical symptoms of pain in lower back and legs, unequal length of both lower extremities, and postural scoliosis [2]. Patients with severe conditions experience loss of stability of multiple facet joints and osteoporosis [3].

With an aging population, the incidence of degenerative scoliosis varies from 1.5% to 29.4%, and is higher than that of idiopathic scoliosis [4]. A survey found that the incidence of spinal deformity in people over 60 was about 68%, while the incidence of spinal deformity was 37% in people aged 50 to 84 years [5]. However, the pathogenesis of degenerative scoliosis has not yet been clarified, and most studies suggest that it is congenital or acquired from bad living habits [6]. It has been documented [7] that 60% to 80% of patients with degenerative scoliosis have symptoms of low back pain, and as many as 90% have central canal stenosis and neurogenic claudication. As such, patients with degenerative scoliosis eventually have to face surgical treatment.

For patients with poor efficacy from conservative treatment, surgery can relieve nerve com-

pression, correct deformity, and reconstruct stability [8]. However, traditional orthopedic surgeries, such as posterior interbody fusion, transforaminal interbody fusion and anterior interbody fusion, generally fix the long and invasive fusion segments and require dissection of the paravertebral muscles, resection of the laminae or facets, and traction of the nerves, which bring many postoperative complications such as ischemic contracture of the paravertebral muscles, denervation, nerve injury, and macrovascular injury [9, 10]. Minimally invasive lateral lumbar interbody fusion (XLIF), a minimally invasive surgical method for the clinical treatment of degenerative scoliosis, has great advantages compared to conventional clinical anterior interbody fusion, transforaminal interbody fusion, or posterior interbody fusion, with less trauma and less intraoperative blood loss [11, 12]. However, there is a lack of studies on risk factors affecting the efficacy of XLIF in the treatment of elderly patients with degenerative scoliosis.

In this study, we retrospectively analyzed the effect of spinal fusion on the improvement of degenerative scoliosis in elderly patients and the factors influencing its efficacy, so as to provide a reference for selection of clinical treatment.

Methods and materials

Baseline data

Data from 194 patients with degenerative scoliosis who received XLIF in Affiliated Hospital of Hebei University from February 2018 to February 2021 were retrospectively analyzed. According to the modified Mac Nab criteria [13], 138 patients with excellent efficacy (pain disappeared, no motor function limitation, returned to normal work and activity) were grouped as the recovery group; 39 patients with good (symptoms significantly improved, occasional pain, able to do light work) and 17 patients with moderate efficacy (some improvement, still pain, unable to work) were considered the uncured group. This study was approved by the Medical Ethics Committee of Affiliated Hospital of Hebei University, ethical batch No.: 2018541.

Inclusion and exclusion criteria

Inclusion criteria: patients were diagnosed with degenerative scoliosis, treated with XLIF and had complete clinical data. The selection principles of spinal fusion segments included: (1) proximal fusion vertebral body fixed in the stable area; (2) allowing restoration of spinal sagittal sequence in the fusion area; (3) no obvious degeneration of adjacent segments of the fusion segment; (4) no obvious rotation of the fixed vertebral body; (5) proximal fusion vertebral stability, and intact posterior column structure.

Exclusion criteria: patients had (1) other types of scoliosis; (2) spinal trauma; (3) spinal infection; (4) previous history of spinal surgery; (5) osteoporosis; (6) tumors and age ≥55.

Clinical data collection

Age, sex, smoking status, body mass index (BMI), medical history and complications of the patients were collected from the electronic medical record system. Preoperative complications mainly included hypertension and diabetes mellitus, and included other medical complications (infection, cardiopulmonary disease, gastrointestinal dysfunction, renal failure). Data were observed and compared between two groups, including red blood cell, hematocrit, partial thromboplastin time, prothrombin time, albumin, Oswestry disability index (ODI), Japanese Orthopaedic Association (JOA) score and visual analog scale (VAS) for pain, Cobb's angle, sagittal vertical axis (SVA), and pelvic projection angle minus lumbar lordosis mismatch value (PI-LL) in scoliosis. In addition, the number of instrumented segments, decompressed segments, estimated blood loss, and operative time were obtained in each group.

Statistical analysis

Data were processed using SPSS 20.0. Normality test was performed first by Shapiro-Wilk method, and measured data in accordance with a normal distribution were expressed as mean ± standard deviation ($x \pm s$). Independent sample t-test and paired t-test were used for inter-group and intra-group comparison, respectively. χ^2 test was used for comparison of counted data. Logistic regression was employed to analyze the prognostic factors affecting treatment outcome of patients, and Receiver operating curve (ROC) was applied to analyze the efficacy of risk factors for predicting patient outcome. $P<0.05$ was considered significant.

Table 1. Baseline data comparison

Variable	Recovered group (n = 138)	Uncured Group (n = 56)	χ^2/t value	*P* value
Age			7.901	0.005
≥65 years	58	36		
<65 years	80	20		
Sex			0.240	0.623
Male	62	23		
Female	76	33		
Duration of symptoms (years)	5.24±2.24	6.19±2.29	2.656	0.009
BMI (kg/m^2)	26.84±4.58	27.16±3.56	0.464	0.642
Levels fused (each)	5.35±1.98	5.32±1.73	0.110	0.911
Decompressed segments (each)	1.36±0.70	1.37±0.70	0.113	0.909
Operative Time (min)	237.96±48.71	227.01±53.18	1.381	0.169
Intraoperative blood loss (mL)	1139.69±728.96	1067.39±565.78	0.697	0.486
Length of stay (days)	12.02±2.06	13.85±2.01	5.655	<0.001
History of hypertension			7.156	0.007
Yes	41	28		
None	97	28		
History of diabetes			5.712	0.016
Yes	33	23		
None	105	33		
Smoking history			0.240	0.623
Yes	62	23		
None	76	33		

Note: body mass index (BMI).

Results

Comparison of baseline data

Comparison of baseline data between the two groups showed that the recovered group had younger age, shorter duration of symptoms, and length of hospital stay, and less history of hypertension or diabetes than the uncured group (P<0.05, **Table 1**). However, there was no statistical difference regarding sex, BMI, smoking history, fusion level, decompression level, operation time, or intraoperative blood loss between the two groups (P>0.05, **Table 1**).

Comparison of pre-treatment Cobb's angle, SVA, and PI-LL

Comparison of Cobb's angle, SVA, and PI-LL before treatment between the two groups revealed no significant differences (P>0.05, **Figure 1**).

Comparison of pre-treatment blood test results

By comparing the blood test results before treatment, we found no significant difference in terms of red blood cells, hematocrit, partial thromboplastin time, prothrombin time, or albumin between the two groups (P>0.05, **Figure 2**).

Comparison of pre-treatment functional score

By comparing the functional scores before treatment, we found that the ODI and JOA scores of the recovered group were lower than those of the uncured group (P<0.05, **Figure 3A-C**). However, there was no significant difference in the VAS scores between the two groups (P>0.05, **Figure 3**).

Analysis of risk factors affecting the efficacy of patients

Through the above analyses, we determined that age, duration of symptoms, length of hospital stay, hypertension, history of diabetes, pretreatment ODI score, and pretreatment JOA score had an impact on patient outcome. To further identify risk factors, data obtained were first assigned with a value (**Table 2**). Subsequently, multivariate analysis revealed that age, duration of symptoms, length of hospital

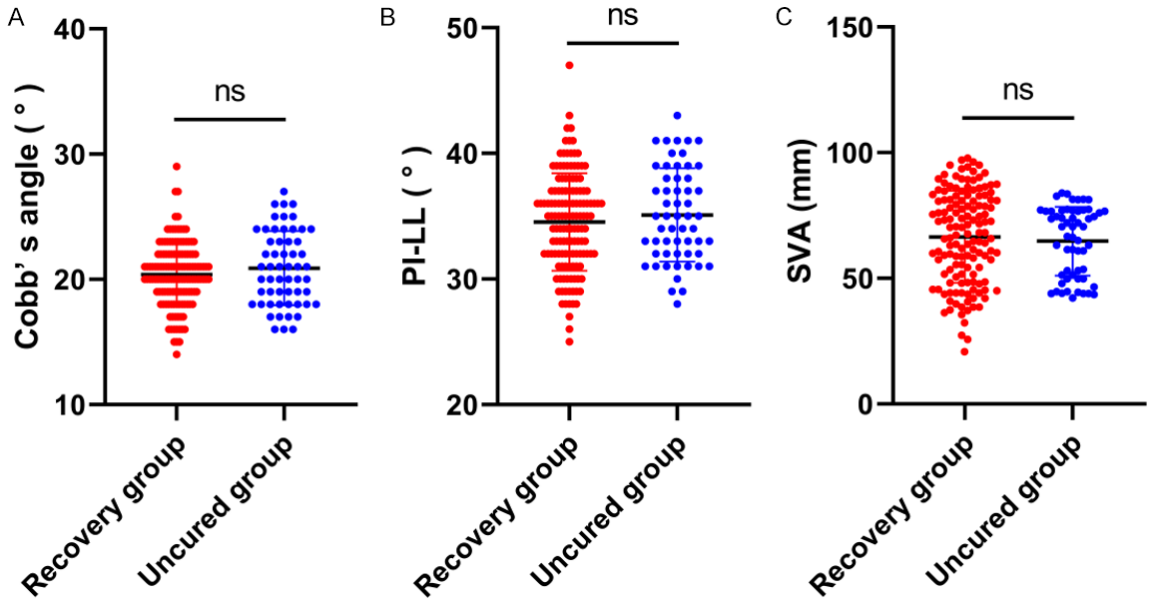

Figure 1. Comparison of Cobb's angle, SVA, and PI-LL before treatment in patients. A. Comparison of Cobb's angle before treatment between the two groups. B. Comparison of SVA before treatment between the two groups. C. Comparison of PI-LL before treatment between the two groups. Note: ns means P>0.05, sagittal vertical axis (SVA), pelvic incidence minus lumbar lordosis mismatch value (PI-LL).

stay, history of hypertension, and pretreatment ODI score were all independent risk factors affecting efficacy (P<0.05, **Table 3**).

Construction of a risk model for predicting efficacy

Based on the risk factors affecting the efficacy obtained by logistic regression. We constructed a model by logistic regression equation to further predict patient response. The equation was 1.280 * age + 0.283 * duration of symptoms + 0.516 * length of hospital stay + 1.462 * hypertension + 0.581 * pretreatment ODI score. The risk score was lower in the recovered group than in the uncured group (P< 0.001, **Figure 4A**), and ROC curve analysis revealed that the area under the curve of the risk score for predicting efficacy was 0.951, indicating that our model was an ideal prediction model (**Figure 4B**).

Discussion

Compared to other surgeries, the approach of XLIF is to go through skin, external oblique muscle, retroperitoneum, and psoas muscle, with clear general anatomy and less risk of damaging important structures [14-17]. Moreover, XLIF enters from the retroperitoneum and needs to separate only part of the psoas muscle. It does not injure the paravertebral muscles, anterior and posterior longitudinal ligaments, facet joints, or laminae, has no effect on spinal stability, and is characterized by low surgical trauma, early ambulation, and early discharge [12, 18]. However, there are no relevant studies focused on the risk factors affecting efficacy after XLIF treatment. In this study, we analyzed such risk factors and found that age, duration of symptoms, length of hospital stay, hypertension, and pretreatment ODI score affected the treatment outcome.

Studies have shown that the majority of degenerative scoliosis involves the thoracolumbar and lumbar spine. The range of involvement is mostly between T11, T12-L5, and S1. The apical cone of scoliosis occurs mostly in the L3, L4 or L2, L3 intervertebral spaces, and the curvature of the spine to one side leads to the imbalance of the spine in the sagittal and coronal plane. With increasing age and the progressive aggravation of degenerative changes in the spine, patients may develop corresponding clinical symptoms including lower back and leg pain, and neurological claudication [19-21]. In the study of Urrutia et al. [22], age was an independent risk factor for degenerative lumbar scoliosis. In our study, age was also found to be

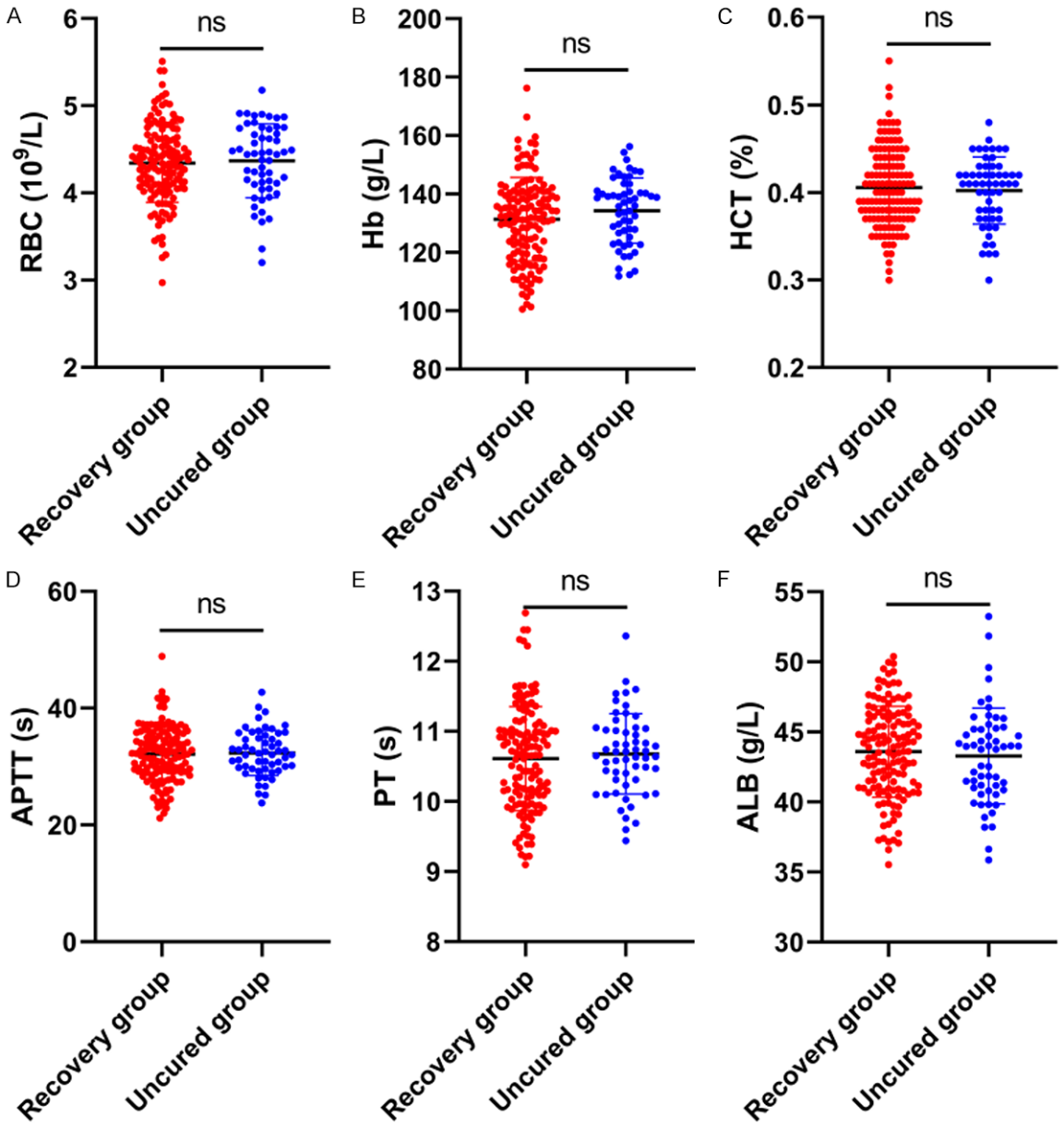

Figure 2. Comparison of patients' pre-treatment blood test results between the two groups. A. Comparison of RBC before treatment. B. Comparison of Hb before treatment. C. Comparison of HCT before treatment. D. Comparison of APTT before treatment. E. Comparison of PT before treatment. F. Comparison of ALB before treatment. Note: ns indicates P>0.05, red blood cells (RBC), hematocrit (Hb), partial thromboplastin time (APTT), prothrombin time (PT), albumin (ALB).

associated with treatment outcome. The clinical efficacy was 3.598-fold higher in patients younger than 65 years compared to those who were 65 years old or older. This suggests that elderly patients should be informed of the expected efficacy of treatment before the procedure, so the surgical plan can be adjusted according to their individual function.

Degenerative scoliosis is a chronic disease that increases in incidence with the rise of age, and approximately 80% of patients with degenerative scoliosis may experience progression, at the rate of 2°-6° per year [23]. In our study, a correlation was found between the duration of symptoms and treatment outcome. This is possibly because the increasing scoliosis of patients results in an increasing duration of illness and difficulty of surgery in clinical practice, thereby inevitably affecting treatment outcome. In a study by Keorochana et al. [24], it was found that onset time greater than 2 years

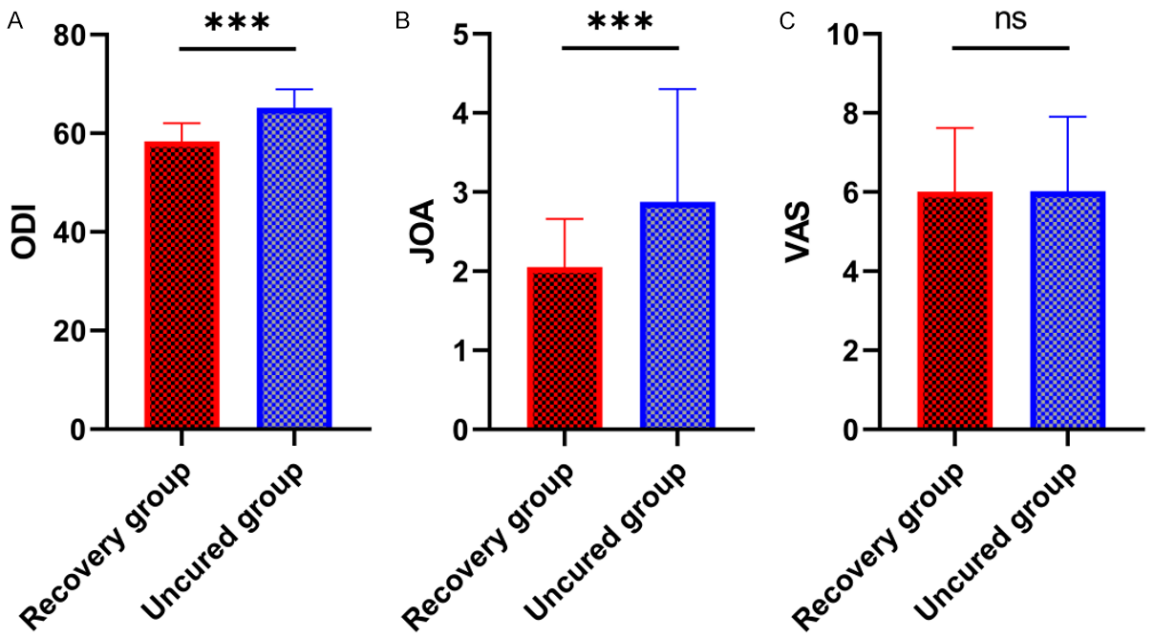

Figure 3. Comparison of functional scores of patients before treatment between the two groups. A. Comparison of ODI score before treatment. B. Comparison of JOA score before treatment. C. Comparison of VAS score before treatment. Note: * means P<0.001, ns means P>0.05, Oswestry disability index (ODI), Japanese Orthopedic Association (JOA) score, and visual analog scale (VAS).

Table 2. Value assignment

Indicator	Assigned Value
Age	≥65 years = 1, <65 years = 0
Symptom duration	Original data analysis was used for continuous variables
Length of stay	Original data analysis was used for continuous variables
Hypertension	Yes = 1, None = 0
Diabetes History	Yes = 1, None = 0
Pretreatment ODI score	Original data analysis was used for continuous variables
JOA score before treatment	Original data analysis was used for continuous variables
Group	Recovered group = 0, Uncured group = 1 OA score

Note: Oswestry disability index (ODI), Japanese Orthopedic Association (JOA).

Table 3. Logistic regression analysis of risk factors affecting the efficacy of patients

Indicator Age	β	Standard Error	χ^2 value	*P* value	OR value	95% CI	
						Lower limit	Upper limit
Symptom duration	1.280	0.590	4.717	0.030	3.598	1.133	11.425
Length of stay	0.283	0.124	5.244	0.022	1.327	1.042	1.691
Hypertension	0.516	0.139	13.747	<0.001	1.675	1.275	2.200
Diabetes History	1.462	0.607	5.807	0.016	4.316	1.314	14.176
Pretreatment ODI score	0.497	0.579	0.737	0.391	1.643	0.529	5.109
JOA score before treatment	0.581	0.106	30.07	<0.001	1.788	1.453	2.201
Indicators	0.510	0.288	3.145	0.076	1.665	0.948	2.926

Note: Oswestry disability index (ODI), Japanese Orthopedic Association (JOA).

was a risk factor affecting unsuccessful outcome after decompression and instrumented arthrodesis for degenerative lumbar spinal stenosis. This suggests that timely treatment

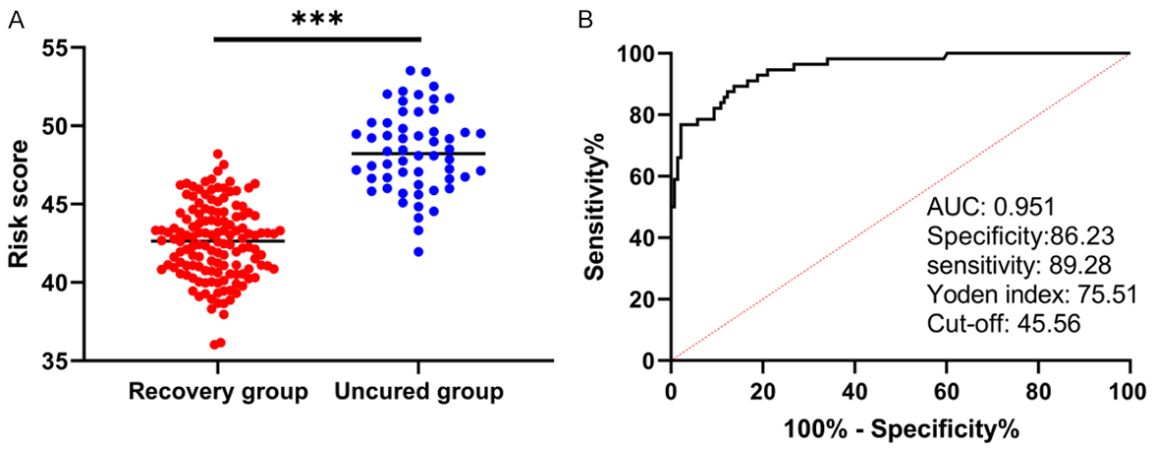

Figure 4. Predictive value of risk model for clinical efficacy. A. Level of risk score in the recovered group and the uncured group. B. ROC curve of risk score in predicting patient response. Note: * indicates P<0.001, receiver operating characteristic (ROC).

may improve therapeutic efficacy and reduce unnecessary risks. In addition, our study found that the length of hospital stay was associated with clinical efficacy, mainly because recovered patients could get discharged from the hospital and return to normal activities timely with pain disappearing gradually after treatment and with no motor function limitation. In the uncured patients, various functions did not meet the discharge requirements, which resulted in an increase in the length of hospital stay.

Studies have found that an increased risk of perioperative complications may affect postoperative clinical outcome [25]. Hypertensive patients are at greater risk for surgery, often having heart, brain, kidney, or other organ damage, which will lead to a greatly increased incidence of intraoperative and postoperative complications [26]. In addition, hypertension is often characterized by large fluctuations in blood pressure, which brings difficulty in controlling blood pressure during surgical anesthesia. If the blood pressure is too high, that increases the risk of bleeding and the difficulty of intraoperative hemostasis, while hypotension can lead to organ hypoperfusion and organ damage [27]. This directly leads to unsatisfactory patient outcome. ODI score is one of the most common scoring systems used for patients with lower back pain. Patients in the recovered group were found to have evidently lower ODI scores before treatment than patients in the uncured group. Higher ODI scores indicate more severe lower back function limitation and severer disease, so targeted adjustment should be made during the treatment of patients with higher ODI scores at admission.

At the end of the study, we developed a risk model to predict treatment outcome, and calculated and compared the risk score of the two groups from the risk model. Patients in the recovered group had a significantly lower risk score than patients in the uncured group. Through ROC curve analysis, the area under the curve of the risk score for predicting efficacy was 0.951. McDaid et al. [28] successfully predicted the risk of venous thrombosis in patients with combined oral contraceptives by establishing a risk model, with an area under the curve of 0.710. With a higher value of area under the curve, our model performed better than theirs.

In this study, we identified the risk factors affecting treatment efficacy in elderly patients with degenerative scoliosis after XLIF through a retrospective study. This study has some limitations. First, as a single center study, it inevitably comes with limited small sample size. Second, sample results collected retrospectively may be biased to a certain extent. Finally, we hope to cooperate in subsequent studies and collect more sample data to refine our study conclusions.

In summary, age, duration of symptoms, length of hospital stay, history of hypertension, and pretreatment ODI score are risk factors affect-

ing the treatment outcome of elderly patients with degenerative scoliosis, and these preoperative indications can be indicators to predict efficacy.

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Disclosure of conflict of interest

None.

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