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Original Article

Clinical efficacy and imaging manifestations of surgical treatment for severe lumbar isthmic spondylolisthesis

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Abstract: Purpose: To evaluate the clinical efficacy and radiological manifestations of the surgeries for severe lumbar isthmic spondylolisthesis. Methods: 21 patients with severe Lumbar Isthmic Spondylolisthesis who underwent surgery treatment were enrolled in the study group. 42 matched patients with mild Lumbar Isthmic Spondylolisthesis were enrolled in the control group. The VAS score, ODI index, lumbar JOA score and the degree of spondylolisthesis, lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT) and pelvic incidence(PI) were used to evaluate the clinical efficacy pre- and postoperatively. All the complications were recorded. Results: The average follow-up time was 26.95 ± 18.58 months in the study group, while it was 30.95 ± 18.86 months in the control group. The VAS score and ODI index were significantly decreased ($P < 0.05$) but Lumbar JOA score increased significantly in both groups at the last follow-up ($P < 0.05$). The average degree of spondylolisthesis and LL also decreased in the last follow-up in both groups ($P < 0.05$). But the SS, PT, PI were not significantly improved in both group ($P > 0.05$). In the study group, 5 cases had transient neurological symptoms in lower extremities, one had minor pulmonary embolism, and two cases had screw breakage and reoperation. Only one case of postoperative neurological symptoms occurred in the control group. The differences between the patients who got the complete reduction and those who didn't showed no difference. But the difference between the patients with/without interbody fusion was found. Conclusions: Surgical treatments for severe Lumbar Isthmic Spondylolisthesis were satisfactory. Slippage should be reduced while complete reduction may not be necessary. The interbody fusion was suggested if possible.

Keywords: Spondylolisthesis, spondylolysis, lumbar, efficacy

Introduction

Spondylolisthesis is the slippage of part or all vertebrae to the lower vertebral body due to the abnormal connection of the adjacent vertebrae caused by congenital dysplasia, strain, trauma and other etiological factors. According to the Meyerding grading, spondylolisthesis degree can be divided into 5 degrees. Degree I: slippage of less than 25%; degree II: slippage of 25-49%; degree III: slippage of 50%-74%, degree IV: slippage of 75%-99%, if the vertebral slip blows to the next level of vertebral, that is degree V [1].

Severe lumbar isthmic spondylolisthesis refers to the spondylolisthesis of degree III or more. Compared to the mild lumbar isthmic spondylolisthesis (degree II or less), severe lumbar isthmic spondylolisthesis is less occurred, presenting severe symptoms, and more difficult to treat. There is strong evidence to support surgical intervention for spondylolisthesis [2-4]. However, it is not clear whether complete reduction is necessary for severe lumbar isthmic spondylolisthesis, and also, in the treatment algorithm, whether to use the interbody is still not yet unified. In this study, we aim to study the clinical efficiency of surgical treatment of severe spondylolisthesis summarized the treatment process of 21 cases with severe lumbar isthmic spondylolisthesis, and evaluate the surgical efficacy and radiological manifestations.

Materials and methods

General information

Patients with surgical treatments of severe Lumbar Isthmic Spondylolisthesis from January

Table 1. Characteristics of patients in study group and control group

Characteristics	Patients Enrolled		*P* Value
	Study Group	Control Group	
Gender			P > 0.05
Male	4	20	
Female	17	22	
Age (yr)	52.48 ± 8.89	53.24 ± 13.16	P > 0.05
Course of the disease (months)	62.14 ± 59.53	37.71 ± 15.36	P < 0.05
Diagnosis			P > 0.05
Isthmic spondylolisthesis	21	42	
Degenerative spondylolisthesis	0	0	
Congenital spondylolisthesis	0	0	
Traumatic spondylolisthesis	0	0	
Meyerding grading of spondylolisthesis			P < 0.05
I	0	14	
II	0	28	
III	20	0	
IV	1	0	
V	0	0	
Average follow-up time (month)	26.95 ± 18.58	30.95 ± 18.86	P > 0.05

2010 to January 2014 in our hospital were analyzed in the study. A total of 21 patients were enrolled in the study group (degree III or more of Lumbar Isthmic Spondylolisthesis according to Meyerding grading) eventually, including 4 males and 17 females, with the mean age of 52.48 ± 8.89 years (range 28 to 67 years). The average follow-up time was 26.95 ± 18.58 months. The course of the disease was 6 months to 20 years, 62.14 ± 59.53 months in average. In all the patients, 20 cases were degree III, 1 case was degree IV. 8 cases' slipping segment was L4 and 13 cases' slipping segment is L5. 6 cases had simple low back pain, low back pain with unilateral leg pain happened in 7 cases, and low back pain combined with bilateral lumbocrural pain happened in 8 cases.

The patients in the control group were selected and matched for sex, age and diagnosis for those patients who suffered from degree I or II of Lumbar Isthmic Spondylolisthesis (Meyerding grading) at 1:2 ratio. The mean follow-up time was 30.95 ± 18.86 months. In the 42 patients, 20 of them were male patients and 22 of them were female. The average age was 53.24 ± 13.16 years old (range from 26 to 76 years). 14 cases were degree I, 28 cases were degree II. 12 cases' slipping segment was L4, 30 cases' slipping segment is L5. 12 cases had simple low back pain, low back pain with unilateral leg pain happened in 11 cases, and low back pain combined with bilateral lumbocrural pain happened in 19 cases. All patients with spondylolisthesis were failed in conservative treatment (**Table 1**).

Treatment methods

All the patients underwent surgeries of posterior lumbar decompression and fixation throw the pedicle with or without interbody fusion.

In the study group, 6 patients underwent the fixation and fusion in L5-S1; 7 patients underwent the fixation in L4-S1 while the fusion in L5-S1; 2 patients underwent the fixation and fusion in L4-L5; 6 patients underwent the fixation in L3-L5 while the fusion was performed in L4-L5. There were two patients who underwent the revision surgery. The first surgery did not perform interbody fusion leading to screw breakage and aggravated slippage. As a result, revision surgery was operated with the intervertebral fusion between sections of the vertebral body.

In the control group, 7 patients had the fixation and the fusion in L4-L5, 10 patients had the fixation in L4-L5 and fusion in L5-S1, 21 patients had the fixation and the fusion in L5-S1, 4 patients had the fusion in L4-S1 and the fusion was performed in L5-S1. No revision surgery occurred in all patients.

Clinical efficacy, imaging manifestations and complications assessment

Clinical efficacy evaluation indexes include pain Visual Analogue Scale (VAS), Oswestry Disability Index (ODI) and lumbar Japanese Orthopedic Association Score (JOA Score). The total score of JOA is 29 points, while the lowest is 0. The lower score indicates more obvious dysfunction. The improvement rate of treat-

Table 2. The clinical effects of surgery on patients in the study group and control group

Evaluation index	Study Group		Control Group	
	Pre-operation	Last follow-up	Pre-operation	Last follow-up
VAS	7.58 ± 0.39	2.67 ± 0.32①	7.35 ± 1.00②	2.45 ± 0.87①,②
ODI	77.95 ± 4.32	19.10 ± 3.91①	75.62 ± 9.33②	19.88 ± 5.90①,②
JOA Score	8.71 ± 1.49	22.48 ± 2.25①	9.76 ± 2.68②	23.05 ± 2.91①,②

①Compared with the preoperative figures in the same group, $P < 0.05$, ②Compared with study group at the same time, $P > 0.05$. VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; JOA Score: Japanese Orthopedic Association Score.

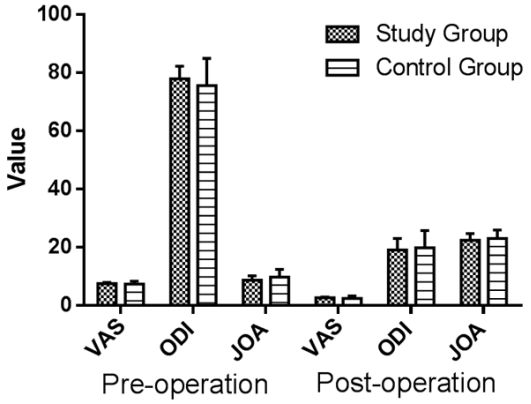

Figure 1. The clinical effects of surgery on patients in the study group and control group. The comparison between the study group and control showed no significant differences in postoperative VAS, ODI and JOA.

ment = [(post-treatment score - pre-treatment score)/(29 - pre-treatment score)] × 100%. If the improvement rate is 100%, we take that as a cure, if the improvement rate is greater than 60%, we take it as remarkably effective, 25-60% as effective and less than 25% as invalid.

Imaging manifestations assessment indicators include the degree of spondylolisthesis before and after surgery, vertebral fusion rate, LL, SS, PT and PI pre- and postoperatively [5]. All patients were taken standing positive and lateral X-ray, Computed Tomography (CT) scan + three-dimensional reconstruction and Magnetic Resonance Imaging (MRI) (including T1 + T2 + STIR sequences) preoperatively, and isthmic spondylolisthesis patients were taken around 45 degrees oblique. CT scan and standing positive and lateral X-rays were taken after the surgery, and MRI scan was selectively taken. According to the lateral X-ray scan, the extent of spondylolisthesis, vertebral fusion rate, LL, SS, PT and PI pre- and postoperatively could be assessed. LL was calculated as the angle between the upper endplate vertical on L1 and S1. The intervertebral fusion rate was evaluated according to the CT at least 6 months postoperatively. SS was calculated as the edge of a straight line intersecting at an acute angle with the horizontal line along the sacrum. PT was calculated as the acute angle between the line of the center of the femoral head to the S1 endplate midpoint and the vertical of it. PI was calculated as the acute angle between the line of the center of the femoral head to the S1 endplate midpoint and the perpendicular bisector of the S1 endplate.

Complications assessment

All patient-related complications were recorded.

The evaluation of the results is charged by specialized doctors not involved in the surgeries.

Statistical methods

All analysis was performed using SPSS 13.0 for Windows (SPSS, Chicago, Ill) as well as Microsoft Excel 2003 (Microsoft, Seattle, Wash). Data is presented as mean ± standard deviation (SD). Paired T-test were used in continuous variable while Mann-Whitney U test was used in the categorical variables, $P < 0.05$ was considered as there were significant differences statistically.

Results

In the study group, the average surgery time was 5.14 ± 1.11 hours; the intraoperative blood loss was 542.86 ± 196.40 ml. The follow-up time was 26.95 ± 18.58 months in average. In the control group, the average surgery time was 4.53 ± 0.79 hours; the intraoperative blood loss was 540 ± 169 ml.

Clinical effects

In the study group, the VAS was 7.58 ± 0.39 preoperatively, 2.67 ± 0.32 in the last follow-up. There were significant differences statistically pre- and postoperatively ($P < 0.05$). ODI

Table 3. The clinical effects of surgery on patients with/without complete reduction in the study group

Evaluation index	Patients with complete reduction in study group (N=6)		Patients without complete reduction in study group (N=15)	
	Pre-operation	Last follow-up	Pre-operation	Last follow-up
VAS	7.78 ± 0.32	2.60 ± 0.50①	7.49 ± 0.39②	2.69 ± 0.23①,②
ODI	79.50 ± 4.64	19.50 ± 3.33①	77.33 ± 4.19②	18.93 ± 4.22①,②
JOA Score	8.67 ± 1.86	22.17 ± 2.93①	8.73 ± 1.39②	22.60 ± 2.03①,②

①Compared with the preoperative figures in the same group, $P < 0.05$, ②Compared with study group at the same time, $P > 0.05$. VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; JOA Score: Japanese Orthopedic Association Score.

was 77.95 ± 4.32 preoperatively, 19.10 ± 3.91 in the last follow-up. There were significant differences statistically pre- and postoperatively (P < 0.05). Lumbar JOA Score: 8.71 ± 1.49 preoperatively, 22.48 ± 2.25 in the last follow-up. There were significant differences statistically pre- and postoperatively (P < 0.05). 2 cases were cured, 17 cases got remarkably improvement, 2 cases got improvement and none was invalid.

In the control group, the VAS was 7.35 ± 1.00 preoperatively, 2.45 ± 0.87 at the last follow-up, the significant difference was discovered (P < 0.05). The ODI was 75.62 ± 9.33 preoperatively and 19.88 ± 5.90 in the last follow-up, there were also significant different differences pre- and postoperatively (P < 0.05). The JOA score was 9.76 ± 2.68 preoperatively and 23.05 ± 2.91 postoperatively, which also showed the statistical significance (P < 0.05). The clinical effects of patients in study group and control group are shown in **Table 2**. The comparison between the study group and control showed no significant differences in postoperative VAS, ODI and JOA (**Figure 1**).

The comparison between the patients who had got the complete reduction and those who didn't were also performed in the study group, the results showed no significant differences between them (P > 0.05), but the differences between the pre- and postoperative figures in patients with or without complete reduction turned out to be significant (**Table 3**).

Imaging manifestations

The degree of spondylolisthesis pre- and postoperatively: According to Meyerding grading, in the study group, the average degree of spondylolisthesis preoperatively was 3.05 ± 0.21 and 1.10 ± 0.83 in the last follow-up. There were significant differences statistically pre- and postoperatively (P < 0.05). The patients in the control group showed an average degree of 1.67 ± 0.48 preoperatively and 0.29 ± 0.46 postoperatively.

In the study group, the postoperative degree of spondylolisthesis improved from III to 0 in 6 cases; In 7 cases, the postoperative degree of spondylolisthesis improved from III to I. In 7 cases, the degree improved from III to II after the surgery. In 1 case, the degree improved from IV to II.

In the study group, the average LL was 53.81 ± 12.88 degree preoperatively, and that was 43.29 ± 17.92 degrees in the last follow-up. There were significant differences statistically pre- and postoperatively (P < 0.05). The average LL of control group was 47.69 ± 8.15 degree preoperatively and which was also significant higher than that of 44.33 ± 6.38 degree postoperatively (P < 0.05).

In the study group, the average SS was 37.48 ± 11.54 degree preoperatively, and that was 36.52 ± 10.43 degree in the last follow-up. There were no significant differences statistically pre- and postoperatively (P > 0.05). In the control group, the preoperative SS was 38.83 ± 6.68 while postoperative SS was 38.02 ± 6.40, no significant difference was found between the data (P > 0.05).

The average PT was 23.67 ± 10.67 degree preoperatively, and that was 24.90 ± 10.33 degree in the last follow-up. There were no significant differences statistically pre- and postoperatively (P > 0.05). In the control group, the PT was 20.64 ± 5.84 preoperatively and 20.88 ± 5.37 postoperatively, which also showed no significant differences (P > 0.05).

The average PI was 55.10 ± 13.60 preoperatively, and that was 56.05 ± 11.44 degree in the last follow-up. There were no significant differences statistically pre- and postoperatively (P > 0.05). In the control group, the average preoperative PI was 50.71 ± 8.85 degree and the postoperative PI was 50.90 ± 8.66 degree,

Table 4. The imaging outcomes of surgery on patients in the study group and control group

Evaluation index	Study Group		Control Group	
	Pre-operation	Last Follow-up	Pre-operation	Last Follow-up
Spondylolisthesis degree	3.05 ± 0.21	1.10 ± 0.83①	1.67 ± 0.48④	0.29 ± 0.46①,④
LL	53.81 ± 12.88	43.29 ± 17.92①	47.69 ± 8.15④	44.33 ± 6.38①,③
SS	37.48 ± 11.54	36.52 ± 10.43②	38.83 ± 6.68③	38.02 ± 6.40②,③
PT	23.67 ± 10.67	24.90 ± 10.33②	20.64 ± 5.84③	20.88 ± 5.37②,④
PI	55.10 ± 13.60	56.05 ± 11.44②	50.71 ± 8.85③	50.90 ± 8.66②,③

①Compared with the preoperative figures in the same group, $P < 0.05$, ②Compared with the preoperative figures in the same group, $P > 0.05$, ③Compared with study group at the same time, $P > 0.05$, ④Compared with study group at the same time, $P < 0.05$. LL: Lumbar Lordosis; SS: Sacral Slope; PT: Pelvic Tilt; PI: Pelvic Incidence.

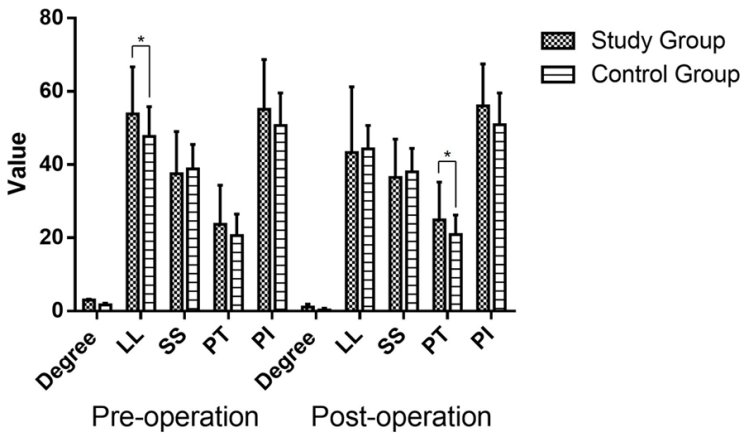

Figure 2. The pre- and postoperative imaging outcomes of surgery on patients in the study group and control group. No significant difference was found in the pre-/postoperative SS, PI and preoperative PT between the study group and control group, but the *P* value of preoperative LL was 0.025, the *P* value of postoperative PT was 0.045, which showed the significant differences. (*indicates significant difference between groups).

no statistical significances was found between them ($P > 0.05$).

Vertebral fusion rate

All patients acquired bony fusion. The imaging outcomes of patients with severe spondylolisthesis are shown in **Table 4**. The pre- and postoperative LL, SS, PT, PI between the study group and the control group was also tested, the result turned out to be of no significances except the pre-/postoperative spondylolisthesis degree, preoperative LL and postoperative PT (**Figure 2**).

Complications

In the study group of 21 cases, transient worsening neurological symptoms of lower extremities was occurred in 5 cases postoperatively. The symptoms were worsening pain, sensory and/or muscular abnormalities. These symptoms got gradually relieved after treatments like detumescence, neurotrophy and a small amount of hormones. Slight pulmonary embolism was occurred in one case that the patient got better after the treatments like hormones, oxygen, antithrombotic treatment and etc.

There are two cases of screw breakage, one of which happened in a 55-year-old male patient with L5 isthmic spondylolisthesis (degree III). His first operation was L5/S1 internal fixation and posterolateral fusion, without intervertebral fusion. Four months postoperatively, bilateral screw fracture occurred in S1, so secondary surgery was operated in 6 months postoperatively. The secondary surgery fixed L4, 5 and S1, while L5/S1 interbody fusion also performed. During three years' follow-up, the patient was in good condition. Another case was a 29-year-old female patient with L5 isthmic spondylolisthesis (degree IV). Her first surgery was the same as the former one. The screw breakage occurred in S1 unilaterally without intervertebral fusion. After that, the patient received the implant removal surgery in other hospital and her symptoms did not improve. Oppositely, the slippage aggravated. As a result, revision surgery was operated in our hospital, plus interbody fusion. During three years' follow-up, the patient was in good condition. Specific information can be seen in appendix. The imaging data of the typical cases are shown in **Figure 3**.

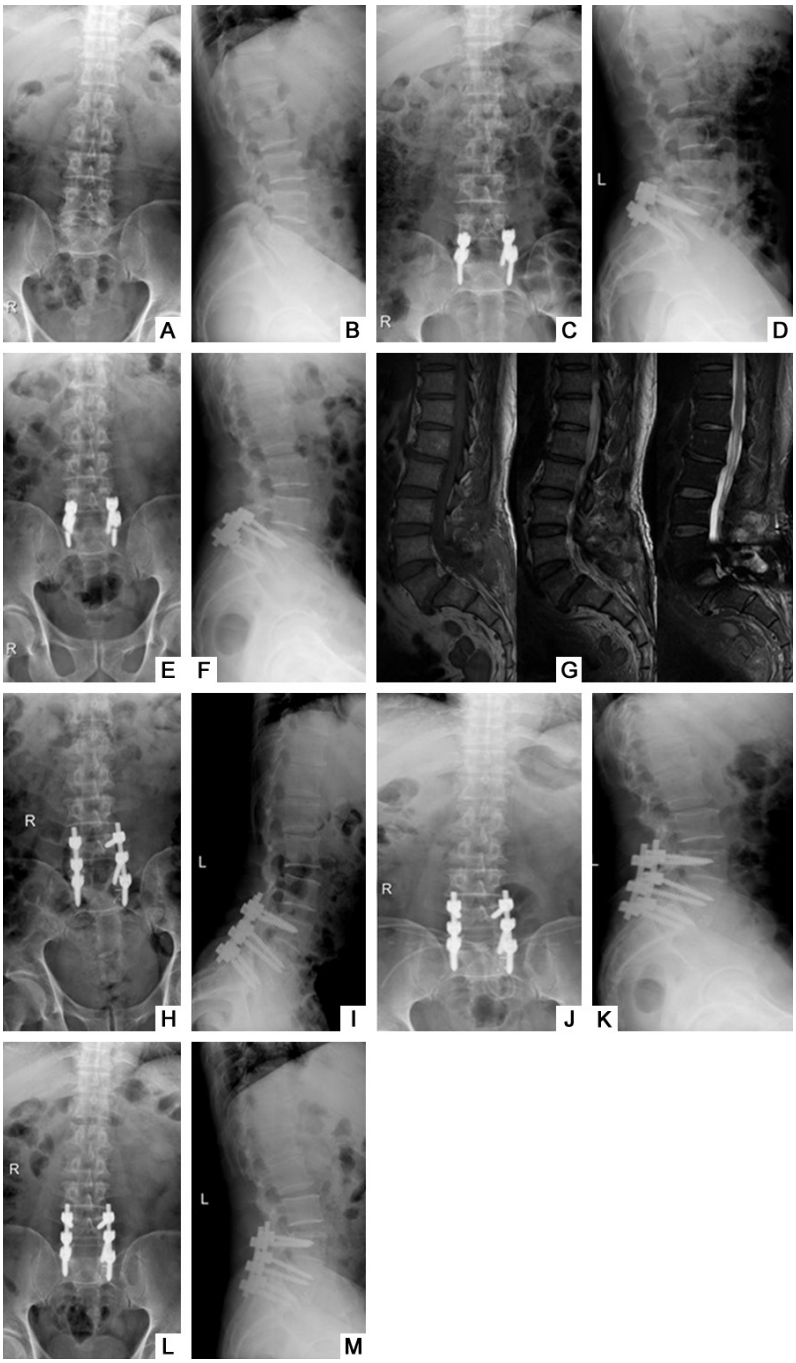

Figure 3. The radiography of the typical case. Male patients, 68, lower back pain for 7 months. Preoperative X-ray showed the L5 isthmic spondylolisthesis (degree V) (A, B); in February 2012, he underwent the surgery of posterior lumbar decompression and fixation and got the pain relief. (C, D). 4 months after surgery (June, 2012), he felt the back pain again. The X-ray showed the screw breakage (E, F); 5 months after surgery, the MR (G) showed a more severe slippage; he underwent the surgery to replace the severed screws with larger screws and to get the bone graft fusion. The symptoms alleviated after surgery, the postoperative X-ray (H, I) showed the reduction is successful. 6 months after the second surgery (January, 2013) (J, K) and 1 year after surgery (July, 2013) (L, M), The X-ray showed the fixation was stable and the patient got the total pain relief.

However, in the control group, only 1 patient suffered from the postoperative neurological symptoms: the patient didn't get the sciatic pain relief and still feel the numbness in the lower limbers 2 weeks after surgery, whereas, the symptoms did not get worse, after one month' conservative treatment, the patient got the symptoms relieved. At the last follow-up (42 months after surgery), there was only sight numbness and the patient had already resumed work and normal life.

The complications between the patients with and without interbody fusion showed a significant difference in the study group while no difference in the control group (**Table 5**). In the study group, 15 out of 21 patients underwent surgery with interbody fusion (1 of them had transient neurological symptoms), among the 6 without interbody fusion, 2 suffered from the screw breakage and underwent the revision surgery, 4 suffered from transient neurological symptoms, 1 had slight pulmonary embolism syndrome. In the control group, only 1 patient out of 9 who didn't get the interbody fusion had the neurological symptoms.

Discussion

Severe lumbar isthmic spondylolisthesis is a disease rarely occurred and difficult to treat. It is a thorny problem for both surgeons and patients. Our study showed the surgical treatment for

Table 5. The chances of complications on patients with/without interbody fusion

Evaluation index	Study Group (N=21)		Control Group (N=42)	
	Patients with interbody fusion (N=15)	Patients without interbody fusion (N=6)	Patients with interbody fusion (N=33)	Patients without interbody fusion (N=9)
Screw breakage	0	2①	0	0②
Postoperative neurological symptoms	1	4①	0	1②
Postoperative pulmonary embolism	0	1②	0	0②
Reoperation	0	2①	0	0②

①Compared with the preoperative figures in the same group, $P < 0.05$, ②Compared with the preoperative figures in the same group, $P > 0.05$.

the severe lumbar isthmic spondylolisthesis in the study group which turned out to be a good clinical results same as the control group.

The classification of spondylolisthesis: Wiltse and Marchetti-Bartolozzi classifications are commonly used in clinical classification of spondylolisthesis [6]. The Wiltse classification divides spondylolisthesis into five categories. Type I, dysplastic; Type II, isthmic; Type III, degenerative; Type IV, iatrogenic; and Type V, pathologic. The Marchetti-Bartolozzi classification system initially divides spondylolisthesis into developmental or acquired. In the acquired subgroup, Marchetti-Bartolozzi classification divided this category into several etiologies: traumatic, degenerative, pathologic, and iatrogenic. In clinic, each type is common in mild spondylolisthesis, while isthmic is the most common in patients with severe spondylolisthesis. In the study group and control in this study, all of them were isthmic spondylolisthesis.

Biomechanical mechanism and anatomical basis of severe lumbar isthmic spondylolisthesis: The majority of severe clinical Lumbar Isthmic Spondylolisthesis occurs in L4~L5 or L5~S1. Under physiological load, the lumbar joints, mutual alignment of upper and lower lamina, disc, ligament and muscle helps maintain the position of lumbar vertebrae. When slippage occurs, the shear stress between vertebrae is increased, which leads to the degeneration of the discs and facet joints, or even ligament strain, etc. [7] Generally speaking, mild slippage usually happens in degenerative spondylolisthesis, severe slippage occurs in the isthmic spondylolisthesis. Although slippage is not always accompanied by arch fracture, the vertebrae is more likely to slip forward as the superior articular process cannot block the lamina of the upper vertebra because of spondylolysis, the severe slippage leads to the severe spondylolisthesis [8]. In this study, the dynamic X-ray of 21 isthmus spondylolisthesis patients all showed the demonstrable vertebral instability, while the flexion radiographs turned out the slippage was significantly increased, which also confirmed the biomechanical mechanisms.

The spinopelvic parameters before and after surgery: Most of the spondylolisthesis of adults are stable spondylolisthesis. In this study, we found there was no significant difference between the pre- and postoperative SS and PI, but a significant PT. This is consistent with previous study [9]. The LL was larger in the patient with severe Lumbar Isthmic Spondylolisthesis, which leads to a stronger shear stress between the articular process, muscle and ligament. The result of a smaller LL after surgery indicated that the sagittal spinopelvic balance was improved, that is of great clinical importance to the pain relief and maintenance of the reduction in spondylolisthesis. In the study group, the results were similar which showed on obvious differences with those in the study group. That showed the effectiveness of surgery was the same in both groups.

The clinical symptoms and signs of severe isthmic spondylolisthesis: The clinical manifestations of severe isthmic spondylolisthesis mainly presented as back pain and/or leg pain, or associated with intermittent claudication. The serious slippage can lead to horsetail nerve damage, causing cauda saddle numbness or bowel and bladder sphincter dysfunction and other symptoms occur. The pathophysiological bases are as follows. Firstly, the damage of spi-

nal sequence owing to severe spondylolisthesis and lumbar spine instability can lead to low back pain. Secondly, slippage of the vertebral body, hypertrophic yellow ligament and hyperplasia of the facet joints lead to stenosis of neural canal, which can compress the nerve roots or cauda equina, causing lower extremities pain, intermittent claudication and cauda equina nerve damage performance. But if the severe traumatic spondylolisthesis occurs, it may result in complete or incomplete paraplegia of both lower extremities because of the huge force. In the study group of 21 patients with isthmic spondylolisthesis, 6 cases presented unilateral back pain, and 15 cases also presented low extremities pain.

The severe lumbar isthmic spondylolisthesis usually needs surgical treatment rather than the conservative treatment [10-15]. Reports indicate the fact that the presence of a progressive neurological deficit, failure of the conservative treatment, radiographic progress of subluxation in spondylolisthesis grade II, or even the unbearable pain affects the life quality. The purpose of surgery is to decompress the nerve and spine, rebuild the stability of spine. The surgery was performed by decompressing the nerve, restoring and fusing the vertebrae. As different types of severe lumbar isthmic spondylolisthesis need different surgical methods. Among the anterior, posterior and combined surgeries, posterior lumbar decompression and fixation with interbody fusion is most commonly used. [16-19] In our study, the results of the surgery for severe lumbar isthmic spondylolisthesis also proved that. The key points of that are as follows:

The reduction of spondylolisthesis: Though it still remains controversial, some people insist the reduction can restore the stability of spine and reduce the shear stress between vertebrae significantly, which may help improve the vertebral fusion and reduce the chance of failure of fixation. The restore of spine volume can improve cauda equina syndrome resulting from spinal stenosis caused by slippage [20]. The people who are against the reduction believe that may stretch the nerve root, worsening the symptoms. The key point of such surgeries are to decompress the nerve and to fix the vertebrae, no reduction is needed [21, 22]. However, according to the mainstream opinions, if there will be no harm to the nerve, the reduction of vertebrae is needed while the complete reduction is not necessary [23, 24]. In our study, the reduction was performed on every one of the 21 patients in the study group, the degree of spondylolisthesis improved from 3.05 ± 0.21 to 1.10 ± 0.83, only 6 of them got the complete reduction, the rest remained the spondylolisthesis of grade 1 or 2, the preoperative and postoperative figures showed the significant change, but the comparison between the group with and without complete reduction showed no significances according to VAS, ODI and JOA. That was a convincing result for the view that reduction is needed while complete reduction is not necessary.

The fusion methods: fusion is also one of the key to ensure the spinal stability and to avoid fixation failure. The interbody fusion is more preferred among all the methods [25]. At the same time, the interbody cage is also used during the fusion. That is because the cage will withstand most of the load to avoid screw breakage or spondylolisthesis aggravating. The implanting of cage may also restore the intervertebral height and expand the intervertebral foramen to decompress the nerve root [14]. In addition to the interbody fusion, intertransverse and interlaminar bone graft can also be used to make the vertebral space as steady as possible. In our research, the 2 patients who had screw breakage and reoperation did not get the interbody fusion. As a result, the failure of the surgery happened. We believe the interbody fusion may be of great importance for the severe lumbar isthmic spondylolisthesis. However, due to the sample size, we found there was no significant difference between the patients with interbody fusion and those who didn't in the complications in this study. A multicenter study with large sample size is imperative in the future.

There are several limitations need to be considered about our results. First of all, as a retrospective study, this research presented only level III evidence. A prospective study is needed to certificate surgical effects of severe lumbar isthmic spondylolisthesis; Furthermore, the less homogeneous data was not as convincing as the homogeneous population. Another limitation was that, the result was concluded in a small sample size, which may lead to the false positives. It still needs to be discussed in a large population in the future.

Conclusions

According to the biomechanical mechanism and anatomical basis, severe slippage occured in the isthmic spondylolisthesis. The sagittal spinopelvic balance was destroyed when such disease occurs, although the surgical treatments for severe lumbar isthmic spondylolisthesis remains controversial, our study found the surgery was satisfactory, and slippage should be reduced while complete reduction may not be necessary, but the interbody fusion was suggested if possible.

Disclosure of conflict of interest

None.

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