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Treatment of Single Level Lumbar Spondylolisthesis with Lumbar Interbody Fusion via Oblique Lateral Approach (OLIF)

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Abstract

Objectives: To investigate the effect of lumbar interbody fusion via the oblique lateral approach (OLIF) in the treatment of single level lumbar spondylolisthesis. **Methods**: Retrospective analysis was made on 32 cases of single level lumbar spondylolisthesis treated by lumbar interbody fusion via the oblique lateral approach from July 2020 to July 2021. 14 males and 18 females; the age was (66.5 ± 11.5) years (55 - 82 years). 1) The operation time, intraoperative blood loss and complications were recorded; 2) the scores of visual analog scale. VAS and Oswestry disability index (ODI) of low back pain and lower limb pain were collected before operation and at the last follow-up; by observing the imaging data, the height of the intervertebral space, the anterior convex angle of the intervertebral space, the anterior convex angle of the lumbar spine, the sagittal diameter of the dural sac and the spondylolisthesis were measured. **Results:** All patients successfully completed the operation, the average operation time was (103.9 ± 21.1) min, the average intraoperative bleeding volume was (72.3 ± 16.4) ml. There was no vascular injury during the operation, no infection occurred in all surgical incisions, and Class I/A healing was achieved. The VAS scores of low back pain and leg pain before operation and at the last follow-up were lower than those before operation, and the difference was statistically significant ($P < 0.05$); the ODI at the last follow-up was lower than that before operation, and the difference was statistically significant ($P < 0.05$). At the last follow-up, the height of intervertebral space, the height of intervertebral foramen and the sagittal diameter of dural sac were greater than those before operation, with statistically significant differences ($P < 0.05$); the spondylolisthesis rate at the last follow-up was lower than that before operation, with a statistically significant difference ($P < 0.05$). Left thigh surface numbness occurred in 2 cases (6.3%) and disappeared after 1 week; Hip flexion weakness occurred in 1 case (0.03%), which recovered af-

ter 12 days; there were no complications such as retroperitoneal hematoma, ureteral injury, retrograde ejaculation, intestinal and lumbar plexus injury. **Conclusion:** The early clinical effect of OLIF in the treatment of single level lumbar spondylolisthesis is significant. This surgical method is minimally invasive, safe and effective, which can significantly reduce the amount of intraoperative bleeding and reduce the risk of postoperative complications. Its main working principle is to make the annulus fibrosus, posterior longitudinal ligament and ligamentum flavum shrink and recover the height of the intervertebral space through decompression, loosening and stretching of the intervertebral space, so as to achieve the reduction of the slipped vertebral body, increase the height of the intervertebral foramen Enlarge the spinal canal volume and eliminate dynamic compression to play an indirect decompression role, improve the symptoms of low back and leg pain, and reconstruct the stability of the spine through interbody fusion.

Keywords

Oblique Lateral Approach, Lumbar Interbody Fusion, Single Segment, Lumbar Spondylolisthesis

1. Background

Lumbar spondylolisthesis is a common clinical disease in spine orthopaedics, and its incidence is about 5.4% [1] [2]. Lumbar pain is the main symptom, which can be accompanied by intermittent claudication and lower limb root pain. When severe lumbar spondylolisthesis occurs and cauda equina nerve is compressed, symptoms such as numbness and discomfort in the sellar region and dysuria may occur, which seriously affect the life and work of patients and significantly reduce their quality of life, causing a certain amount of family and social burden. Conservative treatment is the first choice for lumbar spondylolisthesis, and surgical treatment should be considered for patients with ineffective conservative treatment. Transluminal lumbar interbody fusion (TLIF) via intervertebral foramen is one of the widely used surgical methods at present. The Wiltse approach is entered through the space between the longest muscle and the multifidus muscle. It has little damage to the posterior muscle and ligament peeling, significantly reduces the incidence of low back pain, and conforms to the minimally invasive concept. Although TLIF surgery can achieve good results, it belongs to the operation in the spinal canal, with the risk of nerve root and dura damage. With the development of minimally invasive fusion technology, a new minimally invasive LIF [3]: oblique lateral lumbar interbody fusion (Oblique) was proposed by Silvestre, a French scholar, in 2012.

Lumbar interbody fusion (OLIF) is widely used in clinical treatment of lumbar spondylolisthesis. This operation method uses the retroperitoneum and split psoas major approach to reach the intervertebral space by using the natural

space between psoas major and abdominal aorta. Under direct vision, the intervertebral disc resection and interbody fusion are performed. The height of the intervertebral space is increased by inserting fusion cage through intervertebral loosening, and the area of intervertebral foramen and central tube is increased to achieve indirect decompression, avoiding the damage to the paravertebral muscles caused by posterior lumbar surgery. It also reduces the risk of injury to psoas major muscle and lumbar plexus nerve caused by lateral LIF. However, since this operation is via psoas major muscle approach, there is a risk of injury to psoas major muscle and lumbar plexus nerve. It is reported in the literature that the incidence of injury to lumbar plexus nerve is 0.7% - 23.0% [4]. The most common complications are hip flexion weakness, numbness and discomfort in the anterior medial thigh and inguinal region; occasionally, there were vascular, ureteral, sympathetic nerve injuries, nerve function injuries, and changes in the position of the fusion cage.

To investigate the clinical effect of this surgical method in the treatment of lumbar spondylolisthesis.

2. Data and Methods

2.1. General Information

This study analyzed the clinical data of 32 cases of lumbar interbody fusion via the oblique lateral approach (OLIF) in Tianyou Hospital affiliated to Wuhan University of Science and Technology from July 2020 to July 2021. Inclusion criteria: the bed symptoms were severe low back pain with or without root symptoms of lower limbs or intermittent claudication, and were invalid after strict conservative treatment for 3 months; imaging revealed degenerative or isthmic spondylolisthesis of degree I and II, with no fusion of facet joints; L2-L5 single segment lesions; the symptoms, signs and imaging examinations of all patients were consistent with their responsibility segments. Exclusion criteria: severe osteoporosis ($T < -3.5$); there are huge free intervertebral discs or extreme lateral intervertebral discs at the responsible segment; severe developmental spinal stenosis; spontaneous intervertebral space fusion; previous abdominal surgery; abnormality or abnormality of abdominal blood vessels; preoperative evaluation showed that patients could not tolerate surgery or had surgical contraindications. Among 32 patients, 14 were male and 18 were female; mean age (66.5 ± 11.5 years); 20 cases of degenerative spondylolisthesis (14 cases of grade I, 6 cases of grade II), 12 cases of unilateral or bilateral isthmic spondylolisthesis (8 cases of grade I, 4 cases of grade II); there were 9 cases of pathological segment L3 - L4, 22 cases of L4 - L5, and 1 case of L5 - S1; undergraduate researchIt was approved by the hospital ethics committee.

2.2. Operation Method

All patients received OLIF combined with posterior percutaneous pedicle screw (spinal fusion cage: Dabo Medical pedicle screw: Tianjin Zhengtian Medical In-

strument Co., Ltd.) internal fixation. All patients were operated by the same experienced clinician. After general anesthesia, the patient shall take the right lying position, cushion the armpit and hip with soft pillow, bend the hip and knee, place soft cushion between the legs, fix the chest, thigh and knee joint with wide adhesive tape, position the C-arm fluoroscopy body surface to determine the target segment space, mark the oblique incision about 4cm long parallel to the iliac crest from the midpoint of the responsible segment space to the ventral direction, and disinfect the sterile sheet with active iodine routine in the surgical field of vision. Cut the skin and external oblique fascia, passively separate the external oblique, internal oblique and transverse abdominal muscles, separate the transverse abdominal fascia, push the peritoneum to the ventral side, touch the surface of the quadratus lumbosae muscle with the fingers to the back through the retroperitoneal space, separate the extraperitoneal fat along the surface of the quadratus lumbosae muscle, touch the outer edge of the psoas major muscle, passively separate the fascia of the psoas major muscle, pull forward to protect the ureter, and at the same time touch the level of the intervertebral disc to the front, so as to touch the bulging intervertebral disc, after confirming the position, put the dorsal retractor to pull the psoas major muscle, pull the abdominal viscera and blood vessels away from the ventral side with the fingers, put gauze and retractor for protection, push the fascia layer on the surface of the intervertebral disc with the periosteal stripper for local 1 - 2 cm blunt separation, expose the fiber ring, cut the fiber ring with a long handled sharp knife and remove part of the fiber ring, alternately treat the intervertebral space with an annular curette, a toothed curette and a nucleus pulposus forceps, remove the nucleus pulposus, and break through the opposite fiber ring with a reamer, scrape spoon to remove the residual tissue of nucleus pulposus from the upper and lower endplates, select the appropriate size test mold to start and implant the test mold step by step, determine the size of the test mold by C-arm fluoroscopy, implant the artificial bone into the appropriate fusion cage, and then implant it vertically. The fusion location is located in 2/3 area. The C-arm fluoroscopy was confirmed again, and the incision was washed. After confirming that there was no active bleeding, the incision was closed layer by layer, and the sterile dressing was used to cover it. The right lateral position was changed to the prone position. Four bilateral percutaneous pedicle screws were routinely placed under the guidance of the C-arm after conventional disinfection and towel laying. The length of the titanium rod was appropriate. The incision was closed layer by layer after flushing.

2.3. Perioperative Treatment

Antibiotics were used 30 minutes before operation to prevent infection. Non steroidal anti-inflammatory analgesia, mannitol dehydration and symptomatic support treatment were routinely selected according to the degree of pain of patients after surgery. After surgery, lumbar X ray and CT were routinely reviewed and they walked out of bed under the protection of thoracolumbar brace. All pa-

tients were regularly reviewed in outpatient department.

2.4. Observation Indicators and Evaluation Criteria

The operation time, intraoperative blood loss and postoperative complications were recorded, and the internal fixation was observed on CT 6 months after operation for looseness, displacement, fracture, and intervertebral fusion cage subsidence. The clinical efficacy was evaluated by the Japanese Orthopedic Association (JOA) score before operation, 1 week after operation and at the last follow-up. Intervertebral height = (anterior edge of vertebral body+middle of vertebral body + posterior edge of vertebral body)/3, degree of spondylolisthesis = distance of posterior edge of upper vertebral body/length of lower vertebral body × 100%.

2.5. Statistical Methods

The data were statistically analyzed with Graphpad Prism 5 software. The measurement data were expressed by mean ± standard deviation (x ± s), and the comparison before and after operation was performed by paired t-test; inspection level $\alpha = 0.05$.

3. Results

3.1. Perioperative Condition

All patients successfully completed the operation, the average operation time was (103.9 ± 21.1) min, and the average intraoperative bleeding volume was (72.3 ± 16.4) ml. There was no vascular injury during the operation, and all incisions were healed in Grade I A.

3.2. VAS Score of Low Back Pain

VAS score of leg pain and ODI comparison before and after operation were followed up. The VAS scores of low back pain and leg pain in patients 1 week after operation, 3, 6, 12 months after operation and at the last follow-up were lower than those before operation, the difference was statistically significant ($P < 0.05$); the ODI at 3, 6, 12 months after operation and at the last follow-up was lower than that before operation, and the difference was statistically significant ($P < 0.05$). See Table 1.

3.3. Imaging Related Indexes

Compared with the preoperative and postoperative imaging indexes, the intervertebral space height, intervertebral foramen height and dural sac sagittal diameter of the patients at 1 week, 6 months and the last follow-up were significantly higher than those before surgery ($P < 0.05$); the spondylolisthesis rate was lower than that before operation, the difference was statistically significant ($P < 0.05$). See Table 2. In 32 patients, 128 pedicle screws were inserted with the aid of G-arm, and the accuracy rate was 100.0% (32/32), Table 2.

Table 1. Comparison of VAS score of low back pain, VAS score of leg pain and ODI before and after operation (x ± s).

index	Postoperative	Postoperative 1 week	Postoperative 3 month	Postoperative 6 month	Postoperative 12 month	Last follow-up
Low back pain VAS score	6.3 ± 1.8	2.2 ± 1.0[1]	0.7 ± 0.6[1]	0.6 ± 0.8[1]	0.6 ± 0.6[1]	0.8 ± 0.5[1]
Leg pain VAS score	5.7 ± 1.6	1.3 ± 0.9[1]	0.6 ± 0.5[1]	0.9 ± 0.6[1]	1.0 ± 0.8[1]	0.8 ± 0.7[1]
ODI/%	55.1 ± 10.2	-	18.7 ± 5.6[1]	15.3 ± 4.2[1]	12.3 ± 3.1[1]	11.0 ± 2.0[1]

Note: compared with that before operation, [1]P < 0.05.

Table 2. Comparison of imaging related indexes of patients before and after operation.

index	Postoperative	Postoperative 1 Week	Postoperative 6 Month	Last follow-up
Intervertebral height (mm)	8.3 ± 2.4	11.0 ± 1.5[1]	10.9 ± 0.9[1]	10.8 ± 1.0[1]
Degree of spondylolisthesis (%)	21.1 ± 12.2	4.1 ± 2.1[1]	3.9 ± 2.0[1]	3.8 ± 1.9[1]
Intervertebral foramen height (mm)	105.4 ± 17.9	162.1 ± 16.2[1]	160.6 ± 15.2[1]	157.5 ± 14.5[1]
Sagittal diameter of spinal canal (mm)	6.5 ± 1.7	10.8 ± 0.9[1]	11.3 ± 0.8[1]	11.7 ± 1.0[1]

Note: compared with that before operation, [1]P < 0.05.

3.4. Complications

Left thigh surface numbness occurred in 2 cases (7.8%) and disappeared after 1 week; hip flexion weakness was found in 2 cases (7.8%), which recovered after 2 weeks. There were no complications such as retroperitoneal hematoma, ureteral injury, retrograde ejaculation, intestinal and lumbar plexus injury.

4. Typical Cases

A 63 year old female patient with lumbar spondylolysis underwent OLIF combined with posterior percutaneous pedicle screw internal fixation, as shown in **Figure 1**.

5. Discussion

With the aggravation of aging in China, the incidence rate of lumbar degenerative diseases is increasing year by year. Although the symptoms of most patients can be alleviated after conservative treatment, considering the large population in China, a large part of patients still need surgical treatment to relieve pain and achieve maximum functional improvement. At present, the commonly used clinical surgical method is posterior lumbar interbody fusion (PLIF, TLIF, MIS-TLIF). These surgical methods need to remove the vertebral lamina and the upper and lower ganglia by stripping the spinal erector muscle to varying degrees, and complete the removal and decompression of the intervertebral disc, bone grafting, and interbody fusion and de implantation under the protection of the nerves by pulling in the spinal canal, which inevitably leads to the risk of damage to the posterior column structure of the spine, nerve root and dura mater. In recent years, clinical and imaging studies tend to choose indirect decompression rather

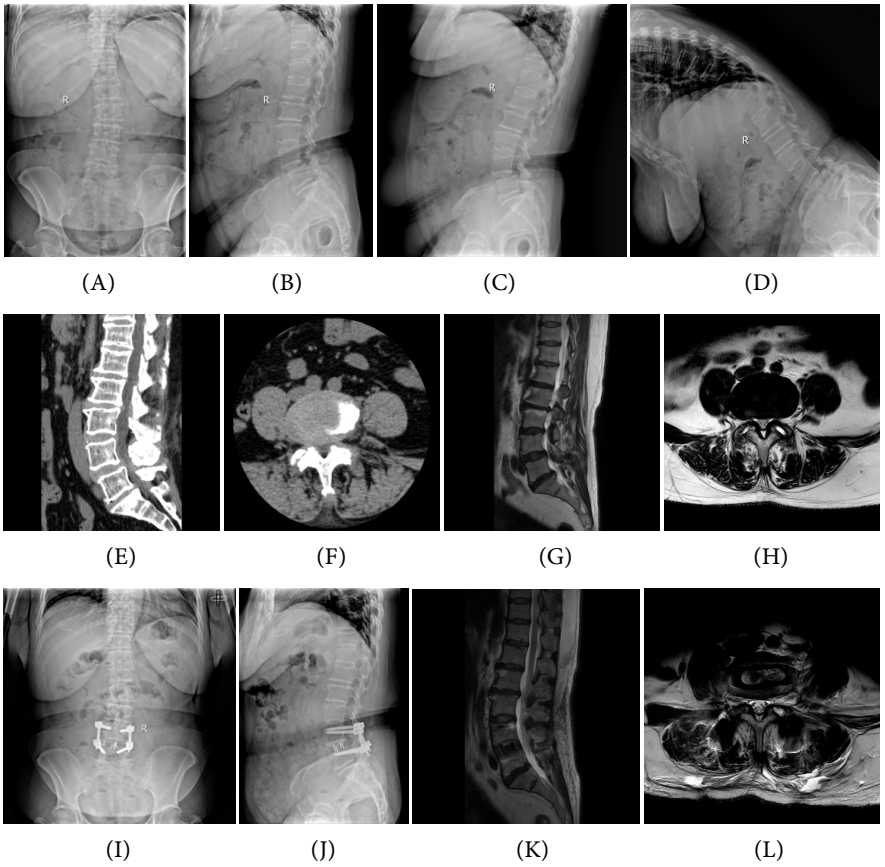

Figure 1. Imaging pictures of patients with lumbar spondylolysis type spondylolisthesis before and after surgery ((A-D) preoperative X-ray showed L4 vertebral instability with degree I spondylolisthesis; (E-F) preoperative CT showed bilateral spondylolysis of L4 vertebral body; intraoperative localization of responsible segments; (G-H) preoperative MRI showed no compression in the vertebral canal intraoperative height of L4 - L5 intervertebral space after the placement of OLIF fusion cage; the recovery is good, and the slipping reset is good; (I-J) Postoperative X-ray showed that L4 - L5 intervertebral space height recovery and spondylolisthesis reduction were good and stable; (K-L) Postoperative MRI showed good reduction of spondylolisthesis and no compression in the spinal canal).

than direct decompression [5] [6] [7] [8]. OLIF operation is a new approach first reported by Silvestre *et al.* [3] in 2012 through the natural anatomical gap between the retroperitoneal great blood vessel and the psoas major muscle. After blunt separation of the external oblique abdominal muscle, internal oblique abdominal muscle and transverse abdominal muscle, the anterior and lateral sides of the lumbar spine are exposed under the use of channels or special hooks, and the psoas major muscle is stripped and pulled backward to expose the lumbar intervertebral disc in the target space, and the intervertebral disc resection is completed under direct vision, the purpose of indirect decompression of the dura mater is to restore the intervertebral space, the height of the intervertebral foramen and the area of the central canal by implanting a larger interbody fusion cage. The OLIF operation does not peel off the vertical spinal muscles, does not damage the facet joints, interspinous ligaments, supraspinal ligaments and other

midline supporting structures, and retains the stability of the posterior column structure of the spine to the greatest extent to avoid the occurrence of stubborn low back pain; do not operate in the spinal canal. Keep the ventral blood vessels of the dura and the structure behind the dura sac to avoid the risk of injury to the nerve root and hemorrhage of the vein plexus in the spinal canal. It has been reported that the incidence of complications of OLIF is 0% - 48.3% [9] [10]. The most common complications are hip flexion weakness, numbness and discomfort in the anteromedial thigh and inguinal region; the most serious intraoperative complications were the injury of the major celiac vessels (abdominal main or common iliac artery and vein), followed by the poor position of the interbody fusion cage, occasional vascular, ureteral, sympathetic nerve injuries, neurological damage, and changes in the fusion cage position, such as sinking. In this study, there were 2 cases (7.8%) with postoperative numbness on the left thigh surface, which disappeared after 1 week; hip flexion weakness was found in 2 cases (7.8%), which recovered spontaneously after 2 weeks. It was considered that excessive traction injury of lumbar plexus and sympathetic nerve was related to this; all patients had no complications such as large vessel rupture, retroperitoneal hematoma, ureteral injury, retrograde ejaculation, intestinal and lumbar plexus injury. For major vascular injury during operation, this study should fully combine CT and other imaging data before operation, and carefully evaluate the space between psoas major muscle and blood vessels, as well as careful and gentle operation during operation to avoid the risk. For the poor position of interbody fusion cage, this study used "vertical manipulation" during interbody processing and trial model placement. Under fluoroscopy, the fusion cage can be placed in Zone 1 and Zone 2 of Moro Division as much as possible to ensure the placement of interbody fusion cage. Combined with posterior percutaneous pedicle screw rod system internal fixation, all patients were followed up 6 months after surgery, and no subsidence of intervertebral fusion cage was found on CT. Therefore, we believe that OLIF is safe and effective. However, in view of the small number of samples and short follow-up time in this study, there is a lack of randomized controlled research; the improvement effect of early low back and leg pain is obvious, but the long-term clinical effect observation needs to further extend the follow-up time and multi center large sample system research to further verify. Since the special approach and indirect decompression principle of OLIF also determine the characteristics of its complications, we should strictly grasp the surgical indications, be familiar with the surgical approach, abdominal cavity and vascular anatomy, and reduce complications.

To sum up, OLIF combined with posterior percutaneous pedicle screw internal fixation for the treatment of single level lumbar spondylolisthesis has a significant early clinical effect, which is minimally invasive, safe and effective, can significantly reduce the amount of intraoperative bleeding, reduce the risk of postoperative complications, facilitate the reduction of spondylolisthesis, and expand the intervertebral foramen and the area of dural sac to play an indirect role in decompression and improve the symptoms of low back and leg pain.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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