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Comparison of the therapeutic effects of ulif and plif in the treatment of lumbar spondylolisthesis

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Abstract: Purpose: To compare the therapeutic effects of unilateral biportal endoscopic lumbar interbody fusion (ULIF) and posterior lumbar interbody fusion (PLIF) in the treatment of lumbar spondylolisthesis. **Method:** To retrospectively analyze the clinical data of 66 patients with lumbar spondylolisthesis in Qianfoshan Hospital of Shandong Province, 31 cases were treated with ULIF (ULIF group) and 35 cases were treated with PLIF (PLIF group). The operation time, intraoperative blood loss, hospitalization days, postoperative complications, low-back pain vas scores, and odi scores, were all measured. The operation time, intraoperative blood loss, postoperative drainage volume, hospitalization days, postoperative complications, low-back pain vas scores, and Oswestry Disability Index (ODI) were compared between the two groups. **Results:** The operation time in the ULIF group was longer than that in the PLIF group, and the difference was statistically significant ($p < 0.05$). There were statistically significant differences in intraoperative blood loss, postoperative drainage volume, and hospital stay ($p < 0.05$). There were 1 case of cerebrospinal fluid leakage in the ULIF group, and 1 cases of infection in the PLIF group. No other complications occurred. The difference in the incidence of complications between the two groups was statistically significant ($p < 0.05$). Patients in both groups were followed for 6 months. **Conclusion:** For patients with lumbar spondylolisthesis, ULIF group can achieve similar efficacy to PLIF group. They are similar in terms of pain relief and improvement in functional disability. ULIF has less intraoperative and postoperative bleeding and shorter hospitalization days, lower infection rate and less damage to muscle tissue. However, ULIF takes a long time, has a long learning curve and requires expensive equipment, Surgeons and patients need to undergo more X-ray fluoroscopy sessions.

Keywords: lumbar spondylolisthesis; endoscopic lumbar fusion; unilateral biportal endoscopic lumbar interbody fusion; posterior lumbar interbody fusion 3D printed fusion cage

1. Introduction

Lumbar spondylolisthesis (LS) is defined as a slip of one vertebra relative to another. Lumbar spondylolisthesis causes low back pain, neurogenic claudication, and is a major cause of paraplegia in middle-aged and elderly people, and with the further development of an aging society, lumbar spondylolisthesis will become a major health threat. With the further development of the aging society, lumbar spondylolisthesis will become a major health threat, conventional open surgery exists with muscle stripping and pulling will lead to severe muscle damage and atrophy, in recent years surgical minimally invasive techniques reduced the medical origin damage and favored by the patients and doctors. In this study, we used a retrospective approach to compare unilateral biportal endoscopic lumbar fusion (ulif) with posterior approach

lumbar fusion (plif) for the treatment of lumbar spondylolisthesis in terms of hemorrhage, operative time, hospital stay, postoperative complications, VAS scores for low back and leg pain, and oswestry dysfunction index (ODI). Analysis of the advantages, disadvantages and clinical efficacy of the two surgical procedures are reported as follows.

2. Methods

2.1. Inclusion criteria

(1) Lumbar spondylolisthesis diagnosed by preoperative X-ray, magnetic resonance imaging (MRI) and CT, and the etiology analyzed to be non-invasive; (2) Clinical manifestations of typical lumbar and leg pain, intermittent claudication, or accompanied by lower extremity radicular nerve symptoms and signs, with no significant improvement of the symptoms and lumbar pain could not be relieved by regular non-surgical treatments for more than 6 months [1,2]. The clinical symptoms were typical of lumbar and leg pain, with no significant improvement of symptoms [1,2]. (3) First time surgical treatment. Exclusion criteria: (1) History of lumbar spine surgery. (2) Patients referred with severe comorbidities. (3) Lower limb paralysis or presence of cauda equina syndrome. (4) Postoperative loss to follow-up [3,4].

The clinical data of 66 patients with lumbar spondylolisthesis who met the selection criteria from April 2021 to April 2024 at Qianfoshan Hospital in Shandong Province were retrospectively analyzed. Among them, 31 cases were treated with ULIF (ULIF group) and 35 cases were treated PLIF (PLIF group). The baseline data of the two groups such as basic information (age gender height and weight), time of illness and preoperative lumbar and leg pain scores, dysfunction index, total slipped segments were the same (slipped angle, intervertebral space height vertebral canal width and other baseline data were compared, and the difference was not statistically significant ($p > 0.05$)).

2.2. Inclusion criteria

There were 66 cases in this group, 25 male and 41 female, aged 21–82 years, average 60 years. Clinical manifestations were mainly lumbar pain or lower limb radiating pain, which was accompanied by intermittent claudication in 4 cases, sensory abnormality in 15 cases, and decreased muscle strength in 3 cases, and all of the patients were ineffective after strict systematic conservative treatment for more than 6 months, with progressive aggravation of symptoms. Preoperative X-ray films of lumbar spine in front and side position, hyperflexion and hyperextension power position, CT or MRI of lumbar spine were taken. According to Mexerding classification: 62 cases of I degree slip, 4 cases of II degree slip, 0 cases of III degree slip; 2 cases of L2 slip, 2cases of L3 slip, 15cases of L4 slip, 27cases of L5 slip, and 20cases of multi-segmental slip. MRI suggested that the intervertebral discs had different degrees of degeneration, among which there were 40 cases of combined spinal stenosis, and 25 cases of combined intervertebral disc herniation. A total of 48 lesions were treated in the Ulif group, and 54 lesions were treated in the Pilf group, ensuring the similar number of segments. The infrmatian is shown in **Table 1**.

Table 1. Preoperative patient information.

	age	Male	female	Unilateral symptoms	Bilateral symptoms
ulif	62.8 ± 11.4	13	18	20	11
plif	57.1 ± 12.0	12	23	22	13
<i>p</i>	0.052	0.530		0.891	

2.3. Surgical methods

Both groups were operated by the same group of surgeon, and the patients were operated in the prone position under general anesthesia.

ULIF group: C-arm fluoroscopy was used to determine the position of the vertebral interspace and the pedicle of the target segment. Sterilization of the sheet, under c-arm fluoroscopy along the arch root penetration guidewire, to the right side, for example, in the responsible intervertebral space above and below positioning point to cut a small incision, the incision is located in the line of the upper and lower arch root medial side, the cephalad incision for the upper vertebral plate caudal side, the caudal side of the incision from the cephalad incision of 2.5–3.0 cm. step by step socket dilatation, the establishment of the operation channel and the observation channel. Ipsilateral decompression: radiofrequency treatment of the dorsal soft tissues of the vertebral plate, gradually reveal the intervertebral window, use a grinding drill, a bone knife, and a spatula to remove the lower edge of the cephalad vertebral plate, the inner edge of the articular eminence, and the upper edge of the caudal vertebral plate in order to gradually reveal the stopping point of the ligamentum flavum; then use a spatula to peel the stopping point of the ligamentum flavum away from the vertebral plate, and the vertebral plate biting forceps and the nucleus pulposus forceps to remove the dorsal white part of the ligamentum flavum and retain the ventral yellow part of the ligamentum flavum, to fully reveal the nerve root shoulder and axilla The lateral saphenous fossa is decompressed and the distal end of the lateral saphenous fossa is explored. After destroying the intervertebral disc with a progressive reamer, the nucleus pulposus was extracted with a nucleus pulposus forceps, the inner edge of the apical portion of the superior articular eminence was adequately removed, and the cartilaginous endplates were scraped with a scraping spoon, preserving the osseous endplates. Intervertebral bone grafting was performed with a bone grafting device, and an appropriately sized 3d printed or ordinary fusion cage was implanted. After sufficient nerve exploration and dural decompression, percutaneous pedicle screws were implanted under C-arm X-ray fluoroscopy. After adequate hemostasis, drainage was placed and the incision was closed (**Figures 1–2**) [5–7].

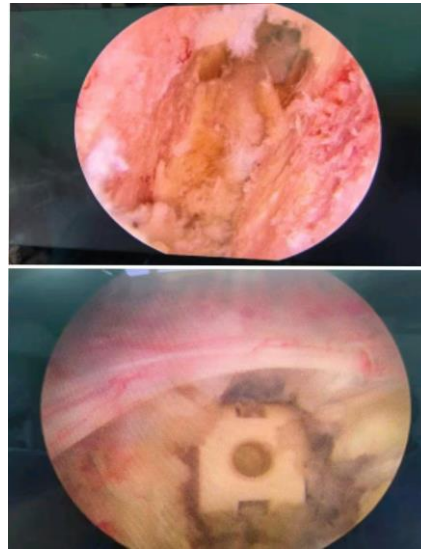


Figure 1. place the fusion cage.



Figure 2. Postoperative fluoroscopy of the front and side positions to determine the solid internal fixation and good position of the fusion cage.

PLIF group: the responsible space was determined under X-ray fluoroscopy, the sheet was sterilized, the skin was incised along the spinous process in the posterior median, the deep fascia was incised, the paraspinal muscles were peeled off under the periosteum, and the vertebral plate and articular synchondrosis were exposed. The pedicle screws were placed bilaterally, and good position of the screws was determined by fluoroscopy. The plate of the superior vertebra and the medial portion of the bilateral articular synchondrosis were removed, and after removing the ligamentum flavum, the dural sac and nerve roots were exposed, and the nerve tissue was retracted to expose the intervertebral discs. After revealing the bony structure, the vertebral plate of the superior vertebral body is completely removed, the medial portion of the articular eminences is removed bilaterally, the dural sac and nerve roots are revealed after removing the ipsilateral ligamentum flavum, and the intervertebral discs are revealed after retracting the dural sacs and walking the nerve roots toward the midline. The diseased disc was resected, and the nucleus pulposus and endplate cartilage were scraped with a spatula, and the autogenous fragmented bone block and the appropriate size of 3d printed or ordinary fusion cage were implanted after adequate

rinsing. Bilateral rods were installed, the nail-rod system was adjusted, and fixation was completed by re-fluoroscopy to confirm that the fusion cage was in good position. Find the bleeding point and carefully stop the bleeding, leave the drainage tube, and suture the incision [8–10].

2.4. Evaluation indicators

Perioperative indicators were recorded, including: operation time, intraoperative bleeding, number of intraoperative fluoroscopies, postoperative drainage, hospitalization days, and incision healing, and the occurrence, management and regression of postoperative complications were recorded. Pain visual analogue scale (VAS), Oswestry disability index (ODI), and outcome were used. [11,12]

2.5. Statistical methods

SPSS 23.0 statistical software was applied All evaluation indexes preoperative and postoperative follow-up data were analyzed using $\bar{x} \pm s$. The paired *t*-test was performed, and <0.05 was set as a significant difference. The information is shown in Table 2.

Table 2. Surgical data.

Evaluation indicators	Surgical time (min)	Intraoperative bleeding (ml)	Number of fluoroscopy (times)	Hospitalization time (d)
ulif	232.22 ± 70.00	226.83 ± 146.68	27.22 ± 6.48	8.93 ± 2.9
plif	184.85 ± 57.12	335.71 ± 139.09	9.511 ± 2.65	12.28 ± 4.2
<i>P</i> -value	0.004	0.003	$P < 0.00001$	$P < 0.00001$

3. Results

3.1. Perioperative data

Preoperatively, all patients practiced urination with urinary basin in bed, smoking patients stopped smoking, practiced coughing, enhanced nutrition, hypertensive patients controlled blood pressure with antihypertensive drugs, diabetic patients controlled blood glucose with insulin, painkillers controlled pain, and prohibited from drinking and fasting before surgery.

All the patients completed the surgery successfully, the duration of the surgery was 120 min–435 min, average 210 min, and there were no complications such as hematoma formation, nerve damage, sensory abnormality and weakness, etc. There was one case of cerebrospinal fluid leakage in the ulif group, and the symptom was improved after giving rehydration solution of mannitol and elevation of the end of the bed, and the headache was alleviated, and one patient in the Plif group had infection, and the symptoms were improved after being given antibiotics after the surgery. Three patients developed vomiting symptoms after surgery, one in the ulif group and two in the plif group, which improved after the administration of onsetron hydrochloride; there was no recurrence of symptoms of incomplete decompression, nerve injury leading to cauda equina syndrome, and loosening of built-in objects. There was no redness, swelling or large scar tissue affecting the aesthetics of the surgical incisions in both groups, and they all healed well to achieve Grade A healing. The patients could

perform extension and flexion activities of the lower limbs after 2–3 h after the operation. The ulif group was discharged from the hospital 7–9 days after the operation and the plif group was discharged from the hospital 10–14 days after the operation, and the patients resumed their normal work after 3–6 weeks after discharge from the hospital. All patients were fitted with lumbar external fixation to maintain lumbar stability after surgery. ulif was significantly better than plif in terms of intraoperative bleeding, Cut length, and hospitalization time ($P < 0.05$).

3.2. Follow-up results

All patients were followed up for 6 months, with a mean follow-up time of (5.4 ± 2.7) months. Both groups recovered well after the operation, with reduced pain and a significant decrease in vas score and odi index, but the difference between the two groups was not statistically significant ($P > 0.05$). During the follow-up period, there were no patients who required reoperation due to recurrence or loosening of internal fixation in both groups. The information is shown in **Table 3**.

Table 3. Comparison of VAS score and ODI index in 66 patients at the last follow-up after surgery.

Index	ulif	plif	P value
vas score	1.64 ± 1.14	1.68 ± 0.96	0.876
Odi index	8.96 ± 1.89	9.31 ± 1.92	0.464

4. Discussion

By comparing the related indexes of 66 patients, this study found that at present, when dealing with the disease of lumbar spondylolisthesis, most hospitals still use posterior approach lumbar fusion, which can deal with most problems, relieve pain and improve dysfunction, but it also has the disadvantage of destroying the muscles and bone structures of the back, which often leads to severe intractable pain in the back. In order to solve these problems, various minimally invasive methods have gradually emerged. We treat patients with lumbar spondylolisthesis with ulif. We take four two centimeter holes in the back of the waist, treat the lumbar intervertebral space with surgery tools, and fix the adjacent lumbar segments with a pedicle screw, which preserves the integrity of muscle and bone tissue. The most important thing in the operation is the step of treating the intervertebral space under the endoscope, and the most important thing is to be familiar with the anatomical structure under the mirror, so as not to lose the direction of the mirror and the operating channel. After establishing the preliminary operating space, we should make sure the lumbar segment is correct. Bone structure should be treated with osteotome and grinding drill, ligamentum flavum and lumbar disc should be treated with nucleus pulposus forceps and electrotome. When the endplate is treated under endoscopic, care should be taken not to damage the bony endplate and anterior longitudinal ligament, and then the fusion cage should be implanted. When implanting the fusion cage, care should be taken to avoid continuous washing to prevent bone fragments from being lost. Many literatures believe that ulif is a minimally invasive operation with definite curative effect.

Spinal endoscopic fusion is as effective as traditional open fusion and internal fixation, and it has advantages in incision size, muscle damage, blood loss, time to get out of bed, hospital day and infection rate [13–15]. In terms of surgical incisions, ulif adopts four small incisions rather than one large incision, the transverse small incisions are often parallel to the skin pattern, which is easier to recover and at the same time the length of the incision is smaller than that of the longitudinal incision, because endoscopic treatment of diseased tissues maximizes the preservation of muscular tissues of the lumbar back and the bony structures, therefore, in terms of the amount of bleeding and the drainage flow in the postoperative period, the endoscopic surgery is more dominant [16,17] and the small destruction of muscles also accelerates patient recover and discharge time. The endoscopic procedure uses constant saline lavage, which is similar in principle to the “bullnose drainage” method of infection control, as bacteria are unable to multiply and grow rapidly in the fast-moving water. Endoscopic spinal fusion surgery is often difficult to differentiate from posterior lumbar fusion in terms of surgical outcomes. VAS scores and ODI scores improved dramatically in both groups at 12 months after surgery, with no statistical significance in comparison, and ulif and plif fusion rates were approximately the same [18–21]. Posterior lumbar spinal fusion and endoscopic fusion are useful in helping lumbar spine slippage patients with pain relief, bone misalignment and repositioning. Both procedures were equally effective in relieving pain, repositioning bony subluxations, and restoring intervertebral space height, with no recurrence of symptoms in the perioperative period or during follow-up. The ulif has many advantages, such as (1) the fusion device is inserted through a channel instead of a working trocar, so that a large-sized fusion device can be inserted into the intervertebral space (2) the ulif is operated under the endoscope from the beginning to the end, and there is a continuous saline lavage to provide a clear field of vision, which can enlarge the field to provide a clear image (3) it is less destructive to the muscular tissues, and most of the posterior structures are retained, so that the postoperative intractable low back pain is avoided [22,23], (4) Surgical instruments and operating channels can be moved independently, which increases the flexibility of the operation, and the field of vision and operation is not limited, so that the stenosis of the central spinal canal and intervertebral foramen can be treated directly, and the precision treatment of the endplates can be realized to reduce endplate injuries.

Due to the long learning curve and complexity of Ulif, there are many complications, including dural tear, postoperative hematoma, sinking and retraction of the fusion device, nerve root injury, and Complications related to water (e.g., peritoneal effusion, hypothermia, headache, seizure, and neck stiffness). Dural tears are usually treated with a collagen patch, and should be directly sutured under the endoscopy or repaired by microsurgery if they are larger than 10 mm. The reason for postoperative hematoma is that ulif is performed under the water channel, and there is water pressure to counteract it during surgery, so small bleeding points with ruptured blood vessels are not easy to be detected because they are suppressed by the water pressure. In order to avoid postoperative hematoma, we should carefully search for the bleeding points during the surgery and before suturing, and the bleeding on the bone surface should be coated with bone wax, and the part of the fibrous ring incision should be covered with fluid gelatin or gelatin sponge, and a proper drainage tube should be

used. For patients who have been taking aspirin for a long time, pay attention to coagulation factors before surgery, stop using anticoagulant drugs or change anticoagulant drugs, if the hematoma causes radicular symptoms after surgery, the original pathway should be used to clear the hematoma, (3) The general cause of fusion sinking is the destruction of the bone endplates, when dealing with the endplates of the patients, reduce the use of the curette, and use the endplate removers and double-ended strippers more often, especially for patients with osteoporosis. This is especially important in osteoporotic patients. Lateral placement of the fusion device and the use of pedicle screws for compression while locking the screws after the fusion device has been placed can avoid the occurrence of fusion device subsidence. (4) Avoid nerve root injury, first of all, familiarize yourself with the anatomical structure of the lumbar, understand what the nerve looks like under the mirror, avoid mis-cutting, avoid the use of sharp tools, and avoid the traction injuries resulting from excessive pulling of the nerve. (5) Headache, neck stiffness, epilepsy, and other common problems. headache, neck stiffness, epilepsy occurs due to continuous water perfusion caused by increased intracranial pressure, which in turn triggered on the neck pain, stiffness as a precursor symptom, followed by headache, tinnitus, visual disturbances, sense of dying, epileptic symptoms, most often in lumbar anesthesia or local anesthesia to do ulif, ulif surgery rarely occurs, in ulif surgery, when the patient has a headache, neck stiffness, you can give the patient to reduce the symptoms of massage. If epilepsy occurs, the surgery should be stopped immediately, but the main concern is to control the duration of the surgery. The longer the duration of the surgery, the higher the probability of epilepsy, headache, and neck stiffness, and epilepsy occurs on average after 96 min. (6) Abdominal or thoracic effusion is a problem that may occur during a paravertebral approach, which is caused by disruption of the transverse processes and ligaments. when it occurs, abdominal or chest distension is the first symptom to appear. In the case of a pleural effusion, the anesthesia machine will also report elevated airway pressures, which will require that the surgery be terminated as soon as possible and the patient be transported to the appropriate specialty for further treatment, such as medication or puncture of the effusion. (7) Chilliness, or postoperative chills, is another aquatic complication. The use of saline lavage during surgery lowers the patient's body temperature, which often leads to chills and postoperative shivering. This can be achieved by switching to warmer saline or using a warming blanket, and by controlling the duration of the surgery to avoid prolonged lavage under the water stream.

Ulif also has many limitations, such as high instrumentation requirements, many hospitals are not equipped with arthroscopes, indications are not broad, many patients with severe lumbar spondylolisthesis, deformities, and spinal stenosis are difficult to deal with, the learning curve is long, and the radiation exposure time is long, which can be a threat to the health of surgery doctor. In terms of operative time, ulif is much longer than plif [22], due to the high number of fluoroscopies and complexity of operations in ulif. Traditionally, ulif has the advantage of being minimally invasive and easier for patients to accept. However, it also has the disadvantages of complicated operation, few indications and high requirement of instrumentation. No study can prove that ulif can completely replace traditional surgery, and plif is still the mainstream surgery for the treatment of lumbar spondylolisthesis most of the time

[23]. However, with the progress of aging and the increase of elderly patients with lumbar spondylolisthesis, ulif will gradually develop and become another important treatment modality for lumbar spondylolisthesis [24,25]. The traditional surgical approach has problems such as high intraoperative bleeding, postoperative incision infection, loosening of the cage, and fusion failure. While spinal endoscopic fusion can reduce the incidence of these problems or decrease the severity of these complications. open surgical procedures tend to have greater trauma, larger decompression areas, and higher reoperation rates, which in turn affects the patient's prognosis [26,27]. In order to solve this problem, a series of minimally invasive spinal decompression surgical procedures have come into existence, and in recent years there have been intervertebral foraminoscopes, ube, and have gained increasing acceptance. ulif, as one of these emerging minimally invasive techniques, has the advantages of minimal tissue damage, low complication rate, and rapid recovery, and is becoming increasingly popular among spine surgeons [28,29]. Traditional surgery has extensive intraoperative muscle stripping, and muscle destruction, and ulif protects structures such as paravertebral muscles and achieves adequate decompression while maintaining better stability, which reduces postoperative pain, increases patient comfort, and reduces patient hospitalization time. This study proved that ulif is as effective as plif with internal fixation in treating patients with lumbar spondylolisthesis in a short period of time, and at the same time, ulif has the advantages of low infection rate, quick discharge from the hospital, less bleeding, and less tissue destruction, which means that this surgical procedure is safer than the plif. With the continuous development and popularization of the technology, ulif will continue to occupy a greater proportion of surgery [30,31].

The cost of ulif is usually higher than conventional surgical procedures, as endoscopic surgery often requires the introduction of expensive equipment, which hinders the further promotion of the surgery, The long learning curve of endoscopic surgery hinders its further promotion, and the long operation time increases the risks of surgery and the fatigue of doctors, all of which require further exploration of better treatment methods

Compared with traditional craftsmanship, using 3D printing technology to manufacture. The advantages of surgical implants are mainly reflected in the freedom of 3D printing. The molding feature allows for quick and precise customization of internal implants, which can overcome the incompatibility between the shape of traditional universal implants and the human body.

The problem of substandard mechanical properties; In the presence of complex structures and when manufacturing difficult to process products, personalized customization of microstructure is particularly important. It is a porous and interconnected structure that can not only meet specific physical and chemical properties. It can also enhance the compatibility of biological tissues. This series of advantages can effectively overcome the stress shielding and biological activity commonly present in implants low difficulty. Currently, 3D printed titanium alloys are commonly used and widely applied is SLM technology and EBM technology [32,33].

5. Shortcomings of this study

This study is a retrospective analysis that increases the risk of bias. Prospective analysis can be conducted in the future, while avoiding excessive promotion of endoscopic surgery that may lead patients to choose specific treatment plans. [34–36] This study is a retrospective cohort study with a small number of sample cases, which can not accurately reflect the difference in efficacy between the two, and the postoperative follow-up by telephone is prone to missing visit bias and some patients are unable to obtain postoperative imaging data. The short follow-up period can only determine the clinical efficacy in the early stage, and it is not possible to include the long-term complications such as adjacent segment syndrome in the study. In the future, more cases should be included, more complete and scientific experiments should be designed, and longer follow-up should be conducted to verify the effectiveness and safety of this procedure, longer follow-up is also needed to determine the impact of fusion on other stages. VAS scoring has a certain degree of subjectivity and may not necessarily reflect the true pain relief effect [37–39].

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