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Original Article

Evaluation of the value of enhanced recovery after surgery in postoperative recovery following unilateral biportal endoscopic lumbar interbody fusion

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Abstract: Objective: To evaluate the effect of enhanced recovery after surgery (ERAS) on postoperative recovery after unilateral double-channel endoscopic lumbar disc fusion. Methods: A retrospective analysis was performed on 128 patients undergoing surgery between May 2024 and May 2025. The patients were divided into a conventional group (n=68) and an ERAS group (n=60). Baseline data, intraoperative parameters, complications, pain scores, functional ability, and quality of life were compared between the two groups. Results: The ERAS group had significantly better intraoperative blood loss, postoperative drainage volume, drainage time, bed rest, and length of hospital stay than the control group (P<0.05). Three days after surgery, the ERAS group had significantly lower limb and back Visual Analog Scale (VAS) scores and ODI (Oswestry disability index) than the control group (P<0.05). Three months after surgery, there was no statistically significant difference in fusion grade and excellent/good rate (P=0.595). The ERAS group had significantly better quality of life than the control group (P<0.05). Conclusion: The ERAS protocol can promote postoperative recovery, alleviate early pain, and improve quality of life, which is worthy of clinical promotion.

Keywords: Enhanced recovery after surgery, spinal fusion, quality of life, complications, endoscopy

Introduction

Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is a commonly used technique in spinal surgery. Through a small incision, this procedure enables removal of the diseased intervertebral disc, decompression of neural structures, and implantation of an interbody cage to achieve therapeutic outcomes [1, 2]. Unilateral biportal endoscopy (UBE) is another widely applied surgical approach that combines the minimally invasive advantages of endoscopic surgery with the flexibility and efficiency of conventional open techniques. Compared with traditional surgery, UBE significantly reduces soft tissue and muscle damage, minimizes intraoperative bleeding, and accelerates postoperative recovery, while simultaneously providing greater freedom for instrument manipulation. Clinically, UBE has been increasingly applied in the minimally invasive treatment of various spinal disorders, including lumbar spinal stenosis and intervertebral disc herniation [3, 4]. UBE-LIF has advantages in intraoperative visual field presentation, soft tissue protection and bleeding control, but its operation and anesthesia time is long, and continuous perfusion is prone to intraoperative hypothermia, and the technical learning curve is relatively steep. As a mature surgical method, MIS-TLIF has the characteristics of relatively controllable operation time and no interference from perfusion fluid, but its working channel may aggravate muscle tissue traction damage, relatively large intraoperative bleeding, and limited operating space [2].

Previous studies have confirmed that perioperative trauma, pain, and stress can induce insulin resistance, thereby increasing protein catab-

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olism and delaying postoperative recovery [5, 6]. The primary targets of Enhanced Recovery After Surgery (ERAS) include alleviating insulin resistance through multimodal strategies such as optimized pain management, tailored nutritional support, and early mobilization, ultimately reducing protein breakdown. ERAS has demonstrated favorable clinical outcomes in the field of orthopedics; however, its application in patients undergoing unilateral biportal endoscopic lumbar interbody fusion (ULIF) remains limited, and few studies have investigated insulin-related functional indicators in this context [7-9]. Therefore, this study aimed to evaluate the clinical utility of ERAS combined with ULIF in spinal surgery, with the goal of improving overall management and recovery in this patient population.

General data and methods

General data

A retrospective analysis was conducted on 128 patients who underwent lumbar interbody fusion surgery at our hospital between May 2024 and May 2025. According to the perioperative management strategy, patients were divided into two groups: the conventional control group (n=68) and the ERAS group (n=60). Inclusion criteria: (1) Age between 18 and 80 years; (2) Met the surgical indications for ULIF, including lumbar spinal stenosis, lumbar spondylolisthesis, or lumbar disc herniation; (3) Failure of conservative treatment for 3 to 6 months prior to surgery; (4) Complete clinical data available; (5) Completed the entire treatment course at our hospital; (6) First-time recipients of ULIF. Exclusion criteria: (1) History of lumbar spine trauma; (2) Underwent multilevel fusion during surgery; (3) Presence of other spinal pathologies; (4) Poor cardiopulmonary function; (5) Pregnant or lactating women. This study was approved by the Ethics Committee of our hospital (Approval No.: KY2025627).

Methods

Surgical procedure: All patients in both groups underwent general anesthesia and were placed in the prone position. After intraoperative localization of the affected segment using C-arm fluoroscopy, two paraspinal incisions of approximately 1 cm each were made to serve as the viewing and working portals. Soft tissue was gradually separated to expose the lamina and facet joint. With the assistance of a high-speed drill, partial bone resection of the posterior canal was performed, followed by removal of the hypertrophic ligamentum flavum and decompression of the stenotic nerve root canal to achieve complete neural decompression. In cases with concomitant disc herniation, the herniated nucleus pulposus was excised. Hemostasis was meticulously achieved at the end of the procedure, and all instruments were withdrawn before closing the incision. No drainage was required.

Intervention methods: Conventional Group Plan: Preoperative care included diagnosis based on clinical symptoms, signs, and imaging findings, assessment of anxiety and depression, education on disease mechanisms and treatment processes, nutritional management including a low-salt, low-fat diet for hypertension and a low-sugar diet for hyperglycemia. Patients with albumin levels below 35.0 g/L received human albumin transfusions. A strict 12-hour preoperative fasting for food and water was implemented. No prophylactic analgesia or anti-infective measures were administered. Active and passive lower limb muscle exercises were used to prevent venous thrombosis, and no pre-anesthetic medications were used. Intraoperative management utilized endotracheal intubation, routine disinfection, and a standard infusion regimen. The operating room temperature was maintained at 21-25°C, and no topical analgesia was administered. Postoperative care included oral celecoxib for analgesia within 3 days after surgery, a 6-hour fasting for food and water, reduced opioid use to control nausea and vomiting, routine drainage management, continuation of the preoperative lower limb venous thrombosis prevention plan, discharge criteria determined based on recovery progress, and patients were required to follow their physician's instructions for regular follow-up. The ERAS protocol was developed by a multidisciplinary team comprised of orthopedic surgeons, anesthesiologists, psychotherapists, nurses, pharmacists, and physical therapists at our hospital. Based on literature review, group discussions, and case analysis, the team drafted a preliminary plan. They then solicited opinions from 10 experts at three tertiary hospitals via email. The final plan was finalized after two rounds of Delphi expert consultations

and was implemented after ethical review and approval by the hospital. The ERAS protocol: In addition to routine preoperative diagnosis, psychological assessment, education, and dietary management, an optimized fasting regimen was implemented, including a 6-hour preoperative fasting period and 50 ml of 10% maltodextrin-containing drinking water before anesthesia. Preoperative analgesia was provided with oral administration of 200 mg of celecoxib and 150 mg of pregabalin one hour before surgery. Prophylactic anti-infectives were administered with 1.5 g of cefuroxime one hour before surgery. Pre-anesthetic medications included acetaminophen, nonsteroidal anti-inflammatory drugs, or gabapentin. In addition to conventional anesthesia, intraoperative antimicrobial prophylaxis (combined with wound prophylactic antibiotics) was strengthened, fluid management was individualized (fluid volume was reduced based on patient characteristics), temperature protection was enhanced (maintaining core temperature above 36°C and covering the limb), and wound infiltration was increased, combined with local analgesia using long-acting local anesthetics. Postoperative management utilized multimodal analgesia (combined with local incisional anesthesia and oral celecoxib). A carbohydrate diet was resumed after anesthesia recovery. Oral dexamethasone combined with a serotonin receptor antagonist was used to prevent vomiting. The drainage tube was removed as soon as possible. A comprehensive post-discharge follow-up system was established (including regular follow-up by a dedicated person, personalized dynamic visits, ongoing outpatient treatment, and a green channel for readmission). Other measures were the same as those in the conventional plan.

Primary outcome measures

Intervertebral fusion grade assessment: All patients were followed up 12 months after surgery. Two senior spine surgeons who were unaware of the group assignments independently evaluated the fusion segments based on sagittal and coronal reconstruction images of the lumbar spine CT scans according to the Brantigan and Steffee criteria [10]. This criteria divides the fusion status into grades I to V: grade I is a clear pseudoarthrosis, grade II is a possible pseudoarthrosis, grade III is an uncertain radiological judgment, grade IV is a possible fusion, and grade V is a clear fusion. The final result was determined by consensus between the two surgeons. In case of disagreement, a third senior surgeon was invited to arbitrate.

Perioperative index records: The following perioperative indexes of the two groups of patients were recorded and compared in detail: Surgery-related indexes: operation time (from skin incision to suture completion, in minutes), intraoperative blood loss (estimated by weighing the suction bottle and gauze, in milliliters). Postoperative recovery indicators included: postoperative drainage volume (in milliliters), drain removal time (in hours, from the end of surgery to drain removal), first bed ambulation time (in hours, from the end of surgery to the patient's first independent ambulation with assistance), and total length of stay (total number of days from admission to discharge).

Safety indicators: Perioperative complications were recorded in both groups, including but not limited to surgical wound infection, nerve root injury, dural sac tear, device failure, and cage subsidence.

Pain assessment: This description clarifies the specific assessment time points, tools, and methods, improving the standardization of the assessment.

Legg pain and back pain were assessed using a visual analog scale before surgery, 7 days after surgery, and at the final follow-up visit 12 months after surgery. Patients were presented with a 10-cm ruler with "0" (no pain) and "10" (unbearable, severest pain). Patients were asked to indicate the location of pain they felt, and researchers recorded the corresponding score. Higher scores indicated greater pain severity.

Lumbar spine function assessment: The Oswestry Disability Index questionnaire was used to assess the patient's lumbar spine function status before and 12 months after surgery. The questionnaire includes 10 aspects, including pain intensity, daily self-care ability, lifting, walking, sitting, standing, sleeping, social activities, and traveling. Each aspect is scored from 0 to 5 points. The actual total score is divided by the maximum possible score (50 points) and multiplied by 100%, expressed as a per-

centage (%). The higher the score, the more serious the impact of the dysfunction on daily life [11].

Clinical efficacy assessment: All patients who completed follow-up were evaluated for overall clinical efficacy 12 months after surgery. The assessment was conducted by a third-party senior physician who was not involved in the grouping and surgical operation through a structured interview combined with a physical examination using the modified MacNab standard. The specific evaluation criteria are as follows:

Excellent: The patient's symptoms completely disappeared, was able to resume daily work and life without activity restrictions.

Good: The patient occasionally had mild pain or numbness, but it did not affect daily life and work, and was satisfied with the treatment effect.

Acceptable: While functional function was improved, patients still experienced intermittent pain or numbness. Symptoms were less severe than before surgery but not completely resolved, and daily activities were somewhat impacted. The patient's response to treatment effectiveness was neutral.

Poor: Patients' symptoms were not improved or worsened compared to preoperative levels, or new neurological symptoms developed, severely limiting daily activities and requiring or having already received further intervention.

After the efficacy assessment, the excellent and good rate was calculated using the following formula: Excellent and good rate = (number of excellent cases + number of good cases)/ total number of evaluated cases × 100%.

Secondary outcome measures

(1) Laboratory indicators: Fasting venous blood samples were collected one day before surgery and on the morning of postoperative day 3. An automated biochemical analyzer was used to measure blood glucose (Glu), alanine aminotransferase (ALT), aspartate aminotransferase (AST), serum creatinine (Scr), and C-reactive protein (CRP). Interleukin-6 (IL-6) concentration was determined by chemiluminescence immunoassay, while white blood cell count (WBC) was measured using an automated hematology analyzer. Serum insulin, fasting C-peptide (FCP), and insulin resistance index were assessed using electrochemiluminescence.

(2) Quality of life assessment [12]: The 36-Item Short Form Health Survey (SF-36) was applied to evaluate patients' quality of life. This questionnaire comprises 36 items across eight dimensions: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health, along with a self-rated health transition item. The total score ranges from 0 to 100, with higher scores indicating better health status or quality of life in the corresponding dimension.

Statistical analysis

All data were analyzed using SPSS version 23.0. Normally distributed continuous variables were expressed as mean ± standard deviation (Mean ± SD). For within-group comparisons of normally distributed data with homogeneity of variance, the paired t-test was applied; for between-group comparisons, the independent-samples t-test was used. Categorical variables were presented as n (%) and compared using the chi-square test. A P value <0.05 was considered statistically significant.

Results

Comparison of baseline characteristics between the two groups

The results showed no statistically significant differences between the two groups in terms of age, BMI, sex, smoking history, alcohol consumption, hypertension, diabetes, coronary heart disease, stroke, or disease type (all P>0.05). Details are presented in **Table 1**.

Comparison of liver and renal function, serum albumin, and total protein between the two groups

The results showed no statistically significant differences between the two groups in liver function indicators (ALT/AST), renal function indicators (Scr/BUN), serum albumin, or total protein levels (all P>0.05). Details are presented in **Table 2**.

Table 1. Comparison of general information of the two groups of patients

Category	ERAS groups (n=68)	Control group (n=60)	Statistical value	P
Age	67.4 ± 5.7	68.0 ± 5.8	-0.589	0.557
BMI	23.5 ± 2.6	23.9 ± 2.5	-0.884	0.378
Gender (Male/Female)	32/36	32/28	0.502	0.479
History of smoking	17	14	0.048	0.826
History of alcohol consumption	21	18	0.012	0.914
History of hypertension	11	15	1.533	0.216
History of diabetes	9	6	0.322	0.570
Stroke	8	7	0.002	0.983
Disease type				
Spondylolisthesis	28	19	1.350	0.509
Spinal canal stenosis	20	22		
Lumbar intervertebral disc protrusion	20	19		

Note: BMI: body mass index.

Table 2. Comparison of liver and kidney function indicators between the two groups of patients

Category	ERAS groups (n=68)	Control group (n=60)	Statistical value	P
ALT (U/L)	24.4 ± 8.6	24.7 ± 8.7	-0.196	0.845
AST (U/L)	25.4 ± 8.1	25.3 ± 8.0	0.070	0.944
Scr (μmol/L)	79.8 ± 4.7	79.5 ± 4.5	0.368	0.714
BUN (mg/dl)	11.5 ± 2.4	11.7 ± 2.6	-0.452	0.652
TP (g/L)	73.5 ± 4.0	72.9 ± 4.4	0.808	0.421
Alb (g/L)	38.6 ± 1.9	38.8 ± 2.0	-0.580	0.563

Note: ALT: alanine aminotransferase; AST: aspartate aminotransferase; Scr: aerum creatinine; BUN: blood urea nitrogen; TP: total protein; Alb: albumin.

Comparison of peripheral blood inflammatory markers between the two groups

Preoperatively, there were no significant differences between the two groups in peripheral blood leukocyte count, IL-6, or CRP levels (all P>0.05). Postoperatively, all of these indicators increased in both groups; however, the levels in the control group were significantly higher than those in the ERAS group (all P<0.05). Details are shown in **Figure 1**.

Comparison of perioperative data between the two groups

The results showed that the ERAS group had shorter drainage tube removal time, lower postoperative drainage volume, and reduced ambulation and hospitalization times compared with the control group (P<0.05). No significant differences were observed in operative time and intraoperative blood loss between the two groups (P>0.05) (see **Table 3**).

Comparison of postoperative pain, lumbar function, and excellent-to-good rate between the two groups

The results showed no significant differences between the two groups in preoperative limb/back VAS scores or ODI scores. After treatment, the ERAS group demonstrated significantly lower pain and ODI scores compared with the control group (P<0.05). Follow-up results indicated no significant differences in the excellent-to-good rate between the two groups. Details are shown in **Figures 2**-**4** and **Table 4**.

Comparison of pancreatic function and insulin resistance index between the two groups

Preoperatively, there were no significant differences between the two groups in fasting C-peptide (FCP), 2-hour postprandial C-peptide (2hCP), or HOMA-IR levels. Postoperatively, both groups showed decreases in FCP and 2hCP and an increase in HOMA-IR compared with preoperative values. However, the ERAS group had higher FCP and 2hCP levels and lower HOMA-IR levels than the control group, with all differences reaching statistical significance (P<0.05) (see **Table 5**).

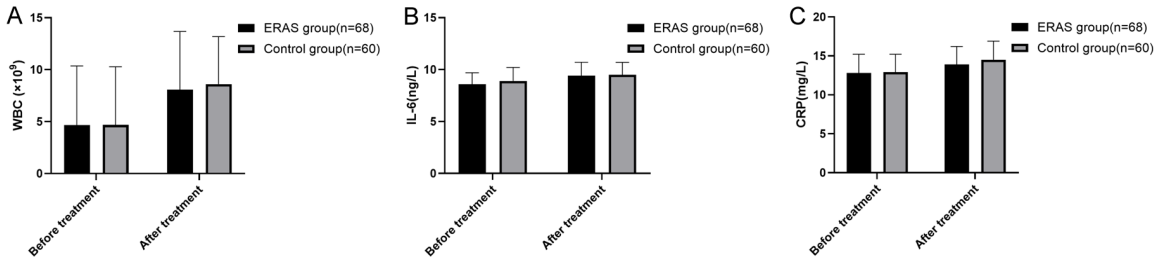

Figure 1. Comparison of inflammatory factor contents between the two groups of patients. A. Comparison of peripheral blood white blood cell content between the two groups of patients; B. Comparison of IL-6 content in peripheral blood between the two groups of patients; C. CRP content in the peripheral blood of the two groups of patients. *: indicates a significant difference between the ERAS group and the control group, P<0.05. ERAS: enhanced recovery after surgery.

Table 3. Comparison of intraoperative and postoperative data of the two groups of patients

Category	ERAS groups (n=68)	Control group (n=60)	t	P
Operation time (min)	179.5 ± 14.1	176.8 ± 13.7	1.096	0.275
Intraoperative blood loss (ml)	142.6 ± 31.4	152.7 ± 35.6	1.706	0.091
Postoperative drainage volume (ml)	228.2 ± 42.2	270.5 ± 34.8	-6.138	<0.001
Drainage tube removal time (in days)	2.5 ± 0.6	3.7 ± 0.6	18.550	<0.001
Time to get out of bed (in days)	3.4 ± 1.5	5.9 ± 1.5	-9.030	<0.001
Total length of hospital stay (days)	6.5 ± 1.3	8.6 ± 1.2	-9.450	0.001

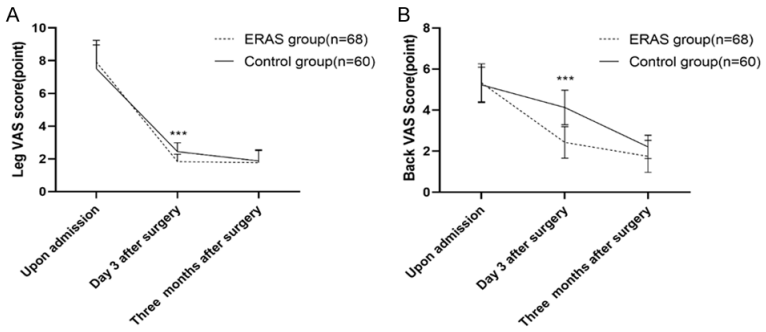

Figure 2. VAS pain score for limbs and back. A. Limb pain score; B. Back pain score. VAS: Visual Analogue Scale.

Comparison of SF-36 quality of life scores between the two groups

After treatment, the ERAS group had higher SF-36 scores across all dimensions compared with the control group, and the differences were statistically significant (all P<0.05) (see **Table 6**).

Discussion

ULIF (Unilateral Laminotomy for Bilateral Decompression) is a common minimally invasive lumbar spine surgery in orthopedics, mainly used to treat degenerative spinal diseases such as lumbar spinal stenosis, intervertebral disc herniation, and lumbar spondylolisthesis [13]. Clinical practice has confirmed that ULIF achieves bilateral decompression through a unilateral approach, effectively contacting nerve compression while maximally preserving the integrity of the posterior spinal ligament complex structure, significantly improving surgical reliability and safety, and ultimately having the advantage of less trauma. In addition, studies have confirmed that preoperative and postoperative pain reactions can activate the body's neuroendocrine and inflammatory-immune response pathways, thereby causing insulin resistance, increased blood sugar, and enhanced protein catabolism, hindering the patient's postoperative recovery [14].

Although literature has confirmed that ULIF reduces surgical stress and reduces postoperative inflammation, pain, and the risk of complications compared to traditional treatments, patients may still experience insulin resistance after surgery, thereby delaying the postopera-

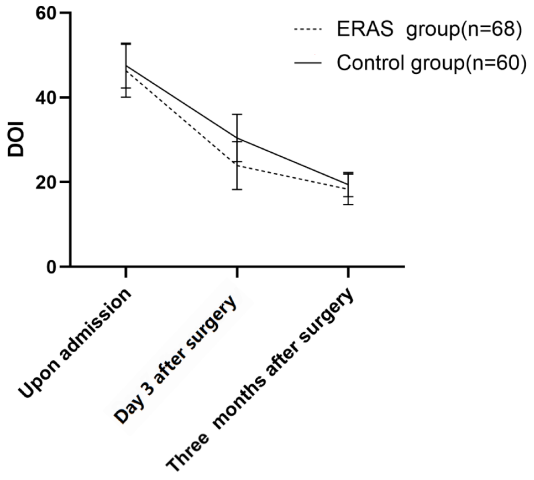

Figure 3. Comparison of DOI scores of patients in the two groups. ***: indicates a significant difference between the ERAS group and the control group, P<0.001.

tive recovery of patients undergoing lumbar surgery [15]. The latest research has confirmed that ERAS is a multidisciplinary collaborative rehabilitation method that covers the entire treatment process from preoperative to postoperative. It reduces surgical stress, restores digestive function and accelerates patient recovery through a variety of interventions [6]. In clinical practice, ERAS has been shown to shorten the hospital stay of patients undergoing lumbar spine surgery, reduce postoperative complications, relieve pain and reduce the risk of patients being readmitted to the hospital in a short period of time. Based on this, the authors envision introducing the ERAS concept into ULIF surgery, which will be of great value in improving the quality of postoperative recovery of ULIF patients [15].

Previous research results have shown that rehabilitation surgery can accelerate postoperative recovery of patients. The results of this study showed that after using ERAS, the time to remove the drainage tube during surgery, the amount of drainage after surgery, the time to get out of bed and the length of hospital stay in the accelerated recovery group were all lower than those in the control group. The mechanism is as follows: the amount of drainage after surgery in the accelerated recovery group was less, so the drainage tube was removed earlier, and the pain score and early mobilization time were better than those in the control group. First, ULIF causes minimal trauma, mild tissue damage, and minimal bleeding, thereby reducing postoperative drainage volume. ERAS emphasizes early extubation, allowing patients to get out of bed and engage in rehabilitation exercises early. Second, ERAS significantly reduces postoperative surgical stress and inflammation levels through preoperative rehabilitation, postoperative analgesia, and optimized intraoperative anesthesia management. In addition, the ERAS pathway emphasizes early extubation of various catheters, goal-directed fluid management, and early self-feeding, ultimately promoting the recovery of patients' physiological functions and reducing their length of hospital stay, confirming previous research reports [16-18].

The literature reports that postoperative joint function is an important reflection of surgical effectiveness, and the Oswestry Disability Index is an important tool for evaluating lumbar spine joints [19]. The results of this study showed that the Oswestry disability index of patients in the ERAS group was better than that of patients in the control group at one week, and their quality of functional life was also better than that of patients in the control group. To some extent, the ERAS pathway suggests that it can promote recovery. The reasons are as follows: ERAS significantly reduces acute postoperative pain by optimizing analgesia (such as multimodal analgesia and regional blockade techniques), thereby enabling patients to resume early postoperative mobility. Secondly, ERAS emphasizes early ambulation and standardized functional exercise, which reduces lower limb muscle atrophy, improves joint stiffness, and increases physical fitness, promoting rapid recovery of motor function and daily living abilities in patients undergoing minimally invasive lumbar spine surgery. Finally, ERAS reduces the intraoperative stress response, restricts fluid management during anesthesia to reduce the risk of lung injury, and provides early prophylactic antibiotics and enhanced gastrointestinal adverse reactions such as nausea and vomiting, thereby reducing the impact of surgery on various systems and achieving rapid recovery. Ultimately, ERAS significantly reduces patients' lumbar spine ODI scores and improves their quality of life. Similar research has also been found in previous studies [20, 21]. Furthermore, combined with previous studies

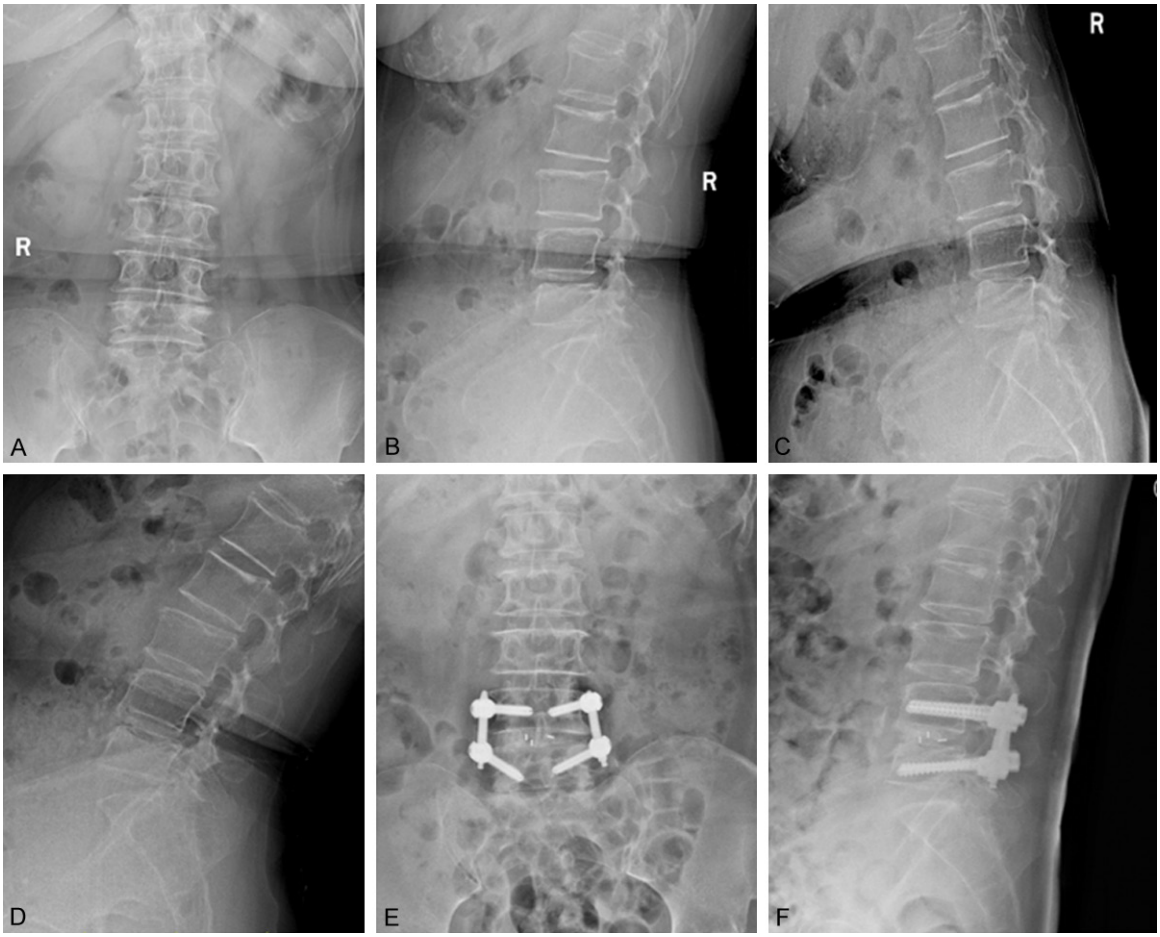

Figure 4. Imaging manifestations of the patient before and after treatment. A-D. Preoperative imaging examinations for lumbar spinal stenosis (L4-S1) and lumbar intervertebral disc protrusion (L4-S1); E, F. Postoperative imaging examination of the patient.

Table 4. Comparison of excellent and good joint Rates between the two groups of patients

Group	Excellent	Good	Poor	Excellent and good rate
ERAS groups (n=68)	62	3	3	62/68 (91.18%)
Control group (n=60)	53	4	3	53/60 (88.33%)
χ^2			0.282	
P			0.595	

Note: ERAS: enhanced recovery after surgery.

demonstrating that ERAS can improve insulin resistance, the results of this study showed that ERAS significantly improved postoperative islet function and insulin resistance in patients undergoing lumbar ULIF [22]. The specific reasons for this are as follows: ERAS emphasizes preoperative carbohydrate loading to provide energy substrates, reduce postoperative catabolism, and avoid blood sugar fluctuations and decreased insulin sensitivity associated with fasting in patients with lumbar spine lesions. Furthermore, the use of short-acting anesthetics and effective fluid management during surgery mitigates inflammation and the release of stress hormones (such as cortisol and catecholamines), thereby reducing the antagonistic effects of these hormones on insulin. Finally, postoperative multimodal analgesia significantly reduced pain stress, and early self-directed diet, functional exercise, and digestive symptom control further promoted enhanced glucose utilization. The synergistic effect of these measures reduced insulin resistance, thereby protecting pancreatic β-cell function and ultimately maintaining perioperative glucose homeostasis, consistent with previous studies [23-25].

Table 5. Comparison of islet function-related Indicators between the two groups of patients

Group	HOMA-IR	FCP (ng/mL)	2 hCP (ng/mL)
ERAS groups (n=68)			
Before treatment	3.42 ± 0.52	1.56 ± 0.41	5.14 ± 1.05
After treatment	3.66±0.53*	1.47±0.40*	4.78±0.99*
Control group (n=60)			
Before treatment	3.44 ± 0.56	1.55 ± 0.42	5.08 ± 1.02
After treatment	3.50 ± 0.46*,#	1.40 ± 0.41*,#	4.65 ± 1.01*,#

Note: Compared with before treatment within the same group, *P<0.05; Compared with the control group after treatment, #P<0.05.

Table 6. Comparison of SF-36 Scores between the two groups of patients after treatment

Dimension	ERAS groups (n=68)	Control group (n=60)	t	P
Physiological function (PF)	72.4 ± 8.5	85.6 ± 7.2	8.352	<0.01
Physiological Function (RP)	65.8 ± 10.1	80.3 ± 9.4	7.456	<0.01
Somatic pain (BP)	68.9 ± 9.3	82.1 ± 8.7	7.234	<0.01
General Health Condition (GH)	60.2 ± 11.5	75.8 ± 10.2	7.123	<0.01
Energy (VT)	58.7 ± 12.3	73.5 ± 11.6	6.178	<0.01
Social Function (SF)	70.5 ± 9.8	84.2 ± 8.5	7.456	<0.01
Emotional Function (RE)	62.3 ± 13.6	78.9 ± 12.1	6.432	<0.01
Mental Health (MH)	64.8 ± 10.7	79.4 ± 9.8	7.012	<0.01

Note: ERAS: enhanced recovery after surgery.

Conclusion

In summary, the results of this study confirmed that the ERAS protocol can optimize perioperative outcomes in ULIF patients, reduce insulin resistance, improve pancreatic function, alleviate early postoperative pain, and promote functional recovery, thereby accelerating rehabilitation and enhancing quality of life. However, several limitations should be noted: (1) This was a single-center study with a relatively small sample size, which may limit the generalizability and strength of the evidence; multicenter studies with larger cohorts are needed to further validate these findings; (2) Quality supervision during ERAS implementation requires improvement to minimize the influence of human factors; (3) Although ERAS facilitates short-term recovery, its long-term efficacy showed no statistically significant difference compared with conventional care, necessitating further research to confirm its clinical benefits.

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Disclosure of conflict of interest

None.

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