

RESEARCH

Open Access



Comparison of a novel hand-held retractor-assisted transforaminal lumbar interbody fusion by the wiltse approach and posterior TLIF: a one-year prospective controlled study

Xing Shen^{1†}, Fu Tao Li^{1†}, Yong Quan Cheng¹, Ming Hui Zheng¹, Xin Qiang Yao¹, Hai Ming Wang², Jian Ting Chen^{1*} and Hui Jiang^{1*}

Abstract

Background This study aims to compare the clinical outcomes and safety of a novel hand-held retractor system-assisted Wiltse TLIF with that P-TLIF and assess whether this hand-held retractor system assisted Wiltse TLIF can yield less paraspinal muscle injury.

Methods 56 patients (P-TLIF: 26, Wiltse TLIF: 30) were included in this one year prospective controlled study. The operation time, intraoperative blood loss, postoperative drainage, mobilization time, and discharge time were recorded. The clinical outcomes were evaluated by ODI, VAS, JOA, and SF-36 scores (7 days, 3, 6, and 12 months after surgery). Paraspinal muscle injury was assessed by postoperative MRI (6 months after surgery). CK and C-reaction protein were measured pre and postoperatively, and CT or X-ray (one year postoperatively) was used to assess bony union/non-union.

Results The Wiltse (study) group was associated with significantly less estimated blood loss (79.67 ± 28.59 ml vs 192.31 ± 59.48 ml, $P=0.000^*$), postoperative drainage (43.33 ± 27.89 ml vs 285.57 ± 123.05 ml, $P=0.000^*$), and shorter mobilization (4.1 ± 1.2 d vs 3.0 ± 0.9 d, $P < 0.05$) and discharge times (7.7 ± 1.9 d vs 6.1 ± 1.2 d, $P=0.002^*$) than the P-TLIF (control) group. Serum CK activity at 24 h postoperatively in the study group was significantly lower than in the control group (384.10 ± 141.99 U/L vs 532.76 ± 225.76 U/L, $P=0.018^*$). At 7 days after surgery, VAS (2.3 ± 0.6 vs 3.2 ± 0.7 , $P=0.000^*$) and ODI scores (43.9 ± 11.9 vs 55.2 ± 12.9 , $P=0.001^*$) were lower, while the JOA scores (18.4 ± 3.4 vs 16.3 ± 4.2 , $P=0.041^*$) was higher in the control group than in the study group. Results observed at 3 months of follow-up were consistent with those at 7 days. After six months postoperatively, paraspinal muscle degeneration in the control group was more significant than in the study group ($P=0.008^*$).

[†]Shen X and Li FT contributed equally to this work and should be considered to be the first authors.

*Correspondence:
Jian Ting Chen
chenjt@smu.edu.cn
Hui Jiang
jianghui@smu.edu.cn

Full list of author information is available at the end of the article



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Conclusion Our study showed that this novel hand-held retractor system assisted Wiltse approach TLIF can significantly reduce paraspinous muscle injury, postoperative drainage, and intraoperative blood loss, mobilization and discharge time, as well as yield better short-term outcomes compared to P-TLIF.

Trial registration 25/09/2023 NCT06052579.

Keywords Wiltse approach TLIF, Open, Transforaminal lumbar interbody fusion, Hand-held retractors system

Background

Posterior transforaminal lumbar interbody fusion (P-TLIF) has been performed for many years to fuse and stabilize the spine, yielding excellent results [1]. However, P-TLIF requires significant tissue dissection, and many researchers have put forward that excessive paraspinous muscle dissection and retraction can have deleterious effects during lumbar procedures [2, 3]. During surgical procedures, the over dissection of the paraspinous muscles can result in more intraoperative bleeding, postoperative drainage, and even postoperative paraspinous muscle degeneration. Paraspinous muscles play an important role in maintaining lumbar segmental stability, and recent studies have shown that atrophy of paraspinous muscles is a significant cause of intractable lumbar pain following surgery which seriously affects the quality of life of the patients [4]. Therefore, reducing paraspinous muscle injury caused by lumbar fusion surgery has become a focus of attention among many surgeons.

With the development of minimally invasive spine surgery, Foley and Smith first introduced minimally invasive TLIF (MIS-TLIF), using a tubular retractor system to perform spinal canal decompression through the gap between the multifidus and the longissimus (Wiltse approach) [5]. Compared with P-TLIF, MIS-TLIF can reduce paraspinous muscle damage, intraoperative blood loss, postoperative drainage and lead to better postoperative clinical outcomes, which has been extensively

documented in the literature [6]. However, some scholars have cautioned that the use of the tubular retractor system for spinal canal decompression via the Wiltse approach may potentially capture a portion of the paraspinous muscles inside the retractor, causing disruption of the surgical field [7]. As a result, the surgeon may have to remove the paraspinous muscles from the retractor, which can increase the likelihood of iatrogenic injury to the paravertebral muscles.

In recent years, hand-held retractors have been applied to assist in Wiltse approach to perform canal decompression, causing less paraspinous muscle injury and yielding better postoperative clinical outcomes than P-TLIF [8, 9]. However, few prospective studies have been conducted comparing the clinical and radiological outcomes between Wiltse TLIF and P-TLIF, both assisted by hand-held retractors. Therefore, further research is warranted to assess whether hand-held retractor-assisted Wiltse TLIF can yield less paraspinous muscle injury and better postoperative clinical outcomes.

In present study, we introduce a new type of hand-held retractor system (Fig. 1) primarily utilized for the Wiltse approach TLIF. The aims of this study was to compare the clinical outcomes and safety of this retractor-assisted Wiltse TLIF with that of P-TLIF and assess whether this novel hand-held retractor-assisted Wiltse TLIF can yield less paraspinous muscle injury.

Methods

This one-year prospective controlled study, comparing two approaches (Wiltse TLIF vs. P-TLIF) for hand-held retractors-assisted TLIF, was approved by the Institutional Review Board (IRB) of our hospital and has registered on *clinical trial*. Gov(25/09/2023 NCT06052579). Written informed consent was obtained from all study participants. From August 2016 to February 2017, 56 eligible patients were included in this study and were divided into two groups. 30 patients (18 males, 12 females) were included in the study group and underwent Wiltse TLIF, and 26 (16 males, 10 females) were included in the control group and underwent P-TLIF. All patients underwent one or two-level spinal fusion surgery due to lumbar stenosis, grade 1 or 2 spondylolisthesis, or lumbar disc herniation with lumbar instability and mechanical lower back pain. The types of surgery were not completely randomly assigned and were determined

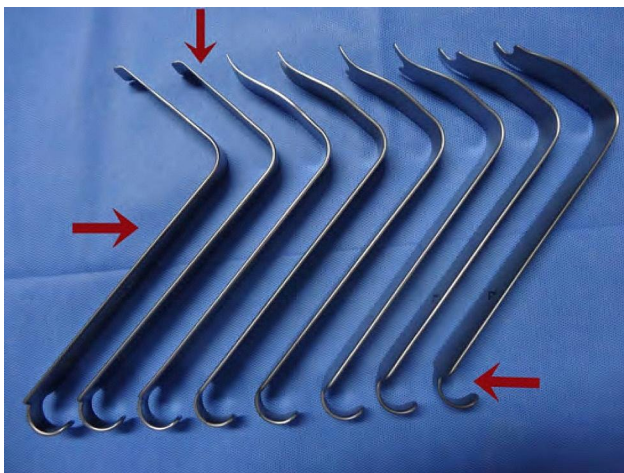


Fig. 1 Novel hand-held retractor system (↓: top part; →body part; ←end part)

by the time of visit. Patients with lumbar infection (i), spinal tumor (ii), severe osteoporosis (iii), pregnant and lactating women (iv), severe lumbar stenosis (v), and severe comorbidities (vi) were excluded from this study.

Description of new hand-held retractor system

According to their functions, the novel hand-held retractor system can be divided into soft tissue retractor, articular process retractor, and pedicle screw retractor (Fig. 2).

1. Soft tissue retractor: The head of the soft tissue retractor (Fig. 2a) is flat, exhibiting a 30° inward angle within the initial 3 mm. The body of the soft tissue retractor is flat and takes on a “7” shape, while the tail forms a pointed hook, curving upward in a semi-circular shape. The soft tissue retractor is mainly used to pull the multifidus muscle inward and longissimus muscle outward.

1. Articular process retractor: The head of the articular process retractor has long and short arms in an “L” shape, with a 45° outward angle within the initial 5 mm. The body of the articular process retractor is flat and takes on a “7” shape, while the tail forms a pointed hook, curving upward in a semi-circular shape. The “L”- shaped top part of articular process retractor comprises a short arm and a long arm, the pedicle screw entry point of lumbar vertebrae can be exposed by clamping its short arm at the basement of the transverse process and the long arm at the lower edge of the transverse process. The pedicle screw entry point of S1 can also be exposed by clamping its short arm at the lateral margin of the superior articular process and the long arm at the sacrum (Fig. 3a).
2. Pedicle screw retractor: The top part of pedicle screw retractor is “U” - shaped with a 45° outward angle within the first 5 mm. The body of pedicle screw retractor is flat and takes on a “7” shape, while the tail forms a pointed hook, curving upward in

a semi-circular manner., the surgical field can be exposed by clamping the “U” shaped head at the base of pedicle screw during the procedure.(Fig. 3b).

Assessment of preoperative data

Preoperative data including patients' age, gender, anterior-posterior, lateral and dynamic (flexion/extension) plain lumbar spine radiography, MRI, and/or CT. Visual analog scale (VAS), Oswestry disability index (ODI) SF-36 quality of life and JOA scores were obtained from all patients(). The SF-36 measures eight scales: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH). In addition, the serum creatine kinase (CK) and C-reactive protein (CRP) were measured preoperatively.

Surgical procedure

Study group

A posterior midline skin incision was made, and the skin and subcutaneous tissue were incised to expose the lumbodorsal fascia. On the normal side, the lumbodorsal fascia was split to form a gap between the multifidus and longissimus muscles (Fig. 4a). The inferior facet joint was exposed, and pedicle screws were placed with the help of the articular process retractor (Fig. 4b) under direct vision. On the symptomatic side, the above steps were repeated to place the cephalad pedicle screws, prepare the caudal pedicle screw channel and expose the inferior facet joint and part of the vertebral vertebral plate inside the screw channel. The multifidus muscle was pulled inward using the tissue retractor while clamping the screw pedicle retractor at the base of pedicle screw, then the vertebral plate is exposed. Next the lateral edge of the vertebral plate was dissected to expand the intervertebral foramen (Fig. 4c), expose the nerve root and dural sac, remove the herniated nucleus pulposus and excise the cartilaginous endplate. A cage filled with local bone was

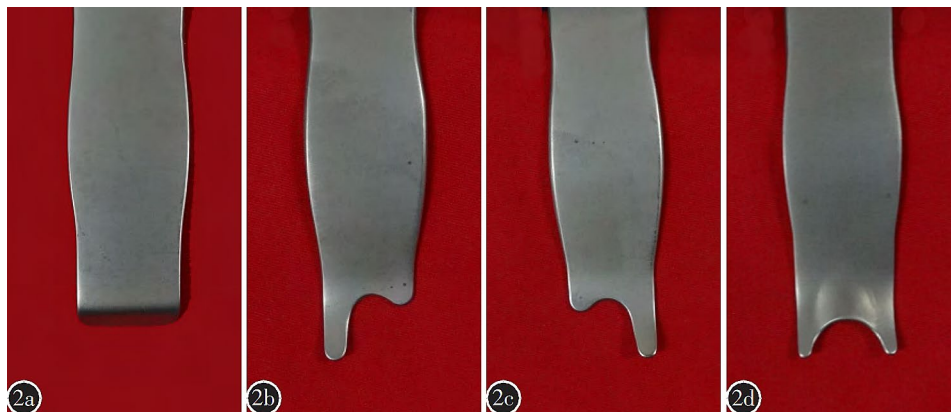


Fig. 2 a:top part of tissues retractor; b and c:top part of articular process retractor; d:top part of pedicle screw

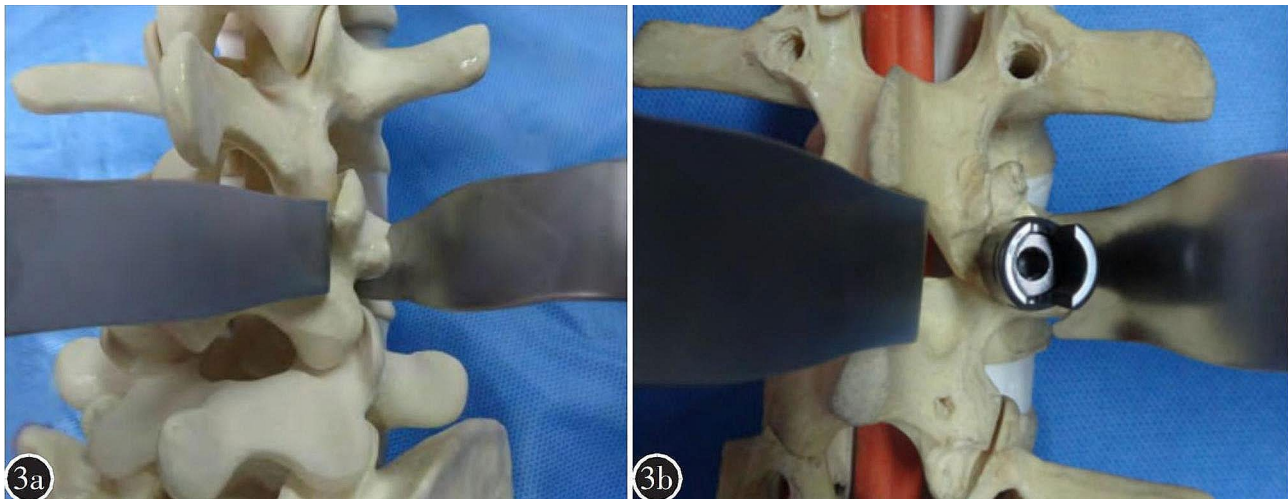


Fig. 3 Illustration of the usage for this novel hand-held retractor system: **a**: the left is tissue retractor and the right is articular process retractor **b**:right is the pedicle screw retractor

inserted into the disc space restoring the spacing between the vertebrae (Fig. 4d), and was finally locked into place using a screw and rod system (Fig. 4e). Finally, a drainage tube was placed through the incision on the decompression side, and stitched the incision layer-by-layer (Fig. 4f).

Control group

A posterior midline incision was made directly over the lumbar vertebra to be fused, and paraspinal muscles were dissected from the spinous process, vertebral plate. Then the vertebral vertebral plate and lateral aspect of the facet joint were exposed, and bilateral pedicle screws were inserted. On the symptomatic side, the lower half part of the superior vertebral plate and the upper half of the inferior vertebral plate were dissected, followed by an incision of the ligamentum flavum to expose the nerve root, the dural sac and the intervertebral disc. Then the nucleus pulposus was removed, and the cartilaginous endplate was excised. A cage filled with local bone was inserted into the disc space restoring the spacing between the vertebrae, and was finally locked into place using a screw and rod system. Finally, a drainage tube was placed through the incision on the decompression side, and stitched the incision layer-by-layer.

Assessment of perioperative and follow-up time parameters

The perioperative and follow-up time data of all patients were collected, including the operation time, intraoperative blood loss, postoperative drainage, mobilization time, and discharge time. The CK and CRP levels were measured 24 h after surgery. All patients were evaluated by independent surgeons using VAS, ODI, and JOA scores during the follow-up (7 days, 3, 6, and 12 months after surgery).

In this study, the method described by Kader D. F [10] was used to assess the fatty infiltration and fibrosis severity of affected layers based on lumbar MRI at 6 months after surgery. At one year postoperatively, lumbar CT or anteroposterior-lateral lumbar X-ray was used to assess bone healing according to the method described by Bridwell [11].

Statistical analysis

A student's t-test was used to compare measurement data that conformed to normal distribution and homogeneity of variance. A paired t-test was used to compare the measurement data of the same patient before and after surgery. Classification data were compared by χ^2 [2] tests. When the sample size was less than 40 or the expected or theoretical frequency in any cells was less than 1, Fisher's exact test was adopted. The Mann-Whitney U test was used to assess data that did not conform to normal distribution. When there were significant differences between groups, the LSD method was used for pairwise comparison. A P -value < 0.05 was statistically significant.

Results

Demographic

The mean age of the control and study groups was 53.2 ± 11.3 and 54.0 ± 12.1 , respectively. There was no significant difference between the two groups in age, gender and operated segments ($P > 0.05$).

Perioperative metric

The operation time was comparable between the control and study groups (171.73 ± 34.25 min vs. 179.60 ± 21.77 min, $P = 0.289$). The intraoperative blood loss and postoperative showed significant differences between two groups. The study group was

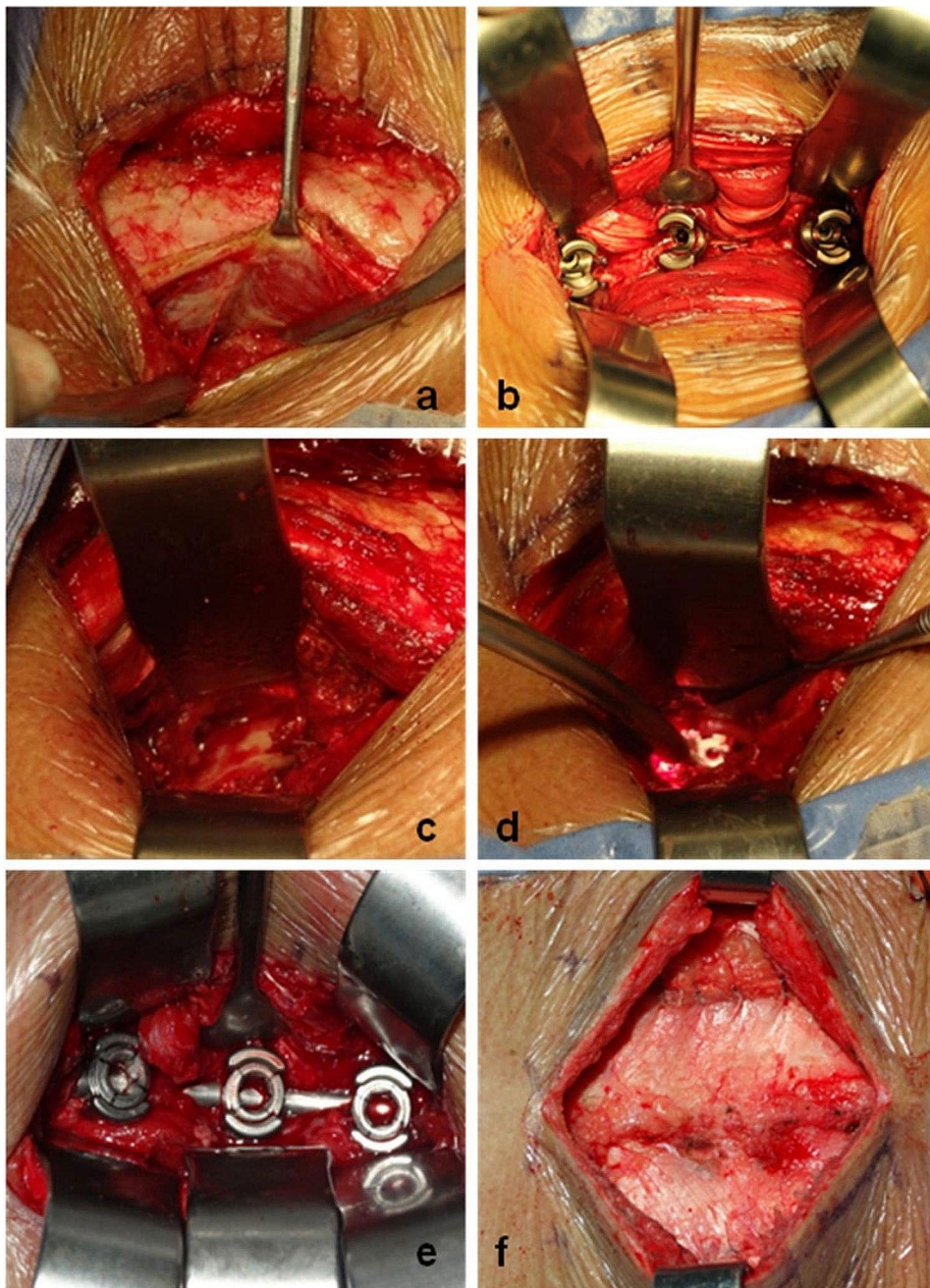


Fig. 4 Hand-held retractors system assisted Wiltse approach TLIF, **a:** exposure; **b:** screw-setting; **c:** decompression; **d:** fusion; **e:** rod-setting; **f:** suture

associated with significantly less intraoperative blood loss (79.67 ± 28.59 ml vs. 192.31 ± 59.48 ml, $P=0.000^*$) and postoperative drainage (43.33 ± 27.89 ml vs. 285.57 ± 123.05 ml, $P=0.000^*$) than the control group. In addition, the study group was associated with significantly shorter mean mobilization time (4.1 ± 1.2 d vs. 3.0 ± 0.9 d, $P=0.000^*$) and discharge time (7.7 ± 1.9 d vs. 6.1 ± 1.2 d, $P=0.002^*$) compared to the control group (Table 1).

Evaluation of paravertebral muscle injury

There was no significant difference between the two groups in peripheral blood serum CRP concentrations and CK activity before surgery ($P>0.05$). A significant increase in serum CRP concentration and CK activity was observed 24 h after the operation. However, the postoperative 24 h serum CK activity in the study group was significantly lower than the control group (384.10 ± 141.99 U/L vs. 532.76 ± 225.76 U/L, $P=0.018^*$),

Table 1 The demographic and clinical characteristics and perioperative data of the patients of P-TLIF and wiltse approach TLIF

	P-TLIF	Wiltse approach TLIF	P Value
No. of patients	26	30	
Sex (M/F)	16/10	18/12	<i>P</i> =0.906
Age, yr	53.2±11.3	54.0±12.1	<i>P</i> =0.808
Operation segment			
L4-L5	11	19	-
L5-S1	7	3	-
L3-L5	4	3	-
L4-S1	4	5	-
Operation time, min/segment	171.73±34.25	179.60±21.77	<i>P</i> =0.289
Estimate blood loss, mL/segment	192.31±59.48	79.67±28.59	<i>P</i> =0.000*
postoperative ambulation time,d	4.1±1.2	3.0±0.9	<i>P</i> =0.000*
Discharge time, d	7.7±1.9	6.1±1.2	<i>P</i> =0.002*
Postoperative drainage, ml	285.57±123.05	43.33±27.89	<i>P</i> =0.000*
Serum creatine kinase, IU/L			
Preoperatively	84.53±37.52	74.75±24.73	<i>P</i> =0.349
1 day postoperatively	532.76±225.76	384.10±141.99	<i>P</i> =0.018*
C relative protein(mg/L)			
Preoperatively	1.72±0.33	1.71±1.14	<i>P</i> =0.980
1 day postoperatively	28.95±24.32	29.50±13.27	<i>P</i> =0.754

and the postoperative 24 h serum CRP concentration remained comparable (Table 1).

VAS scores

There were no significant differences in VAS scores between two groups before the operations (5.96±1.6 VS 5.73±1.6; *P*>0.05), at 7 days after the operation, the study group was associated with significantly lower VAS (2.3±0.6 vs 3.2±0.7; *P*=0.000*); The results at 3 months postoperatively were consistent with the results at 7 days postoperatively (1.43±0.97 VS 2.38±0.63; *P*=0.000*), however, there was no significant difference between the two groups in VAS scores at 6 and 12 months (Table 2).

Table 2 Preoperative and follow-up time VAS、ODI、JOA scores

	preoperative	7 days	3 months	6 months	1 year
VAS (P-TLIF)	5.96±1.6	3.2±0.7	2.38±0.63	1.31±1.07	0.88±0.65
VAS (Wiltse approach TLIF)	5.73±1.6	2.3±0.6	1.43±0.97	1.10±0.88	0.70±0.75
<i>P</i> value	0.605	0.000*	0.000*	0.434	0.334
ODI (P-TLIF)	56.8±21.7	55.2±12.9	29.46±9.42	15.92±7.65	14.19±5.87
ODI (Wiltse approach TLIF)	54.1±20.0	43.9±11.9	16.13±7.10	12.93±4.39	13.30±5.72
<i>P</i> value	0.630	0.001*	0.000*	0.074	0.568
JOA (P-TLIF)	11.8±5.8	16.3±4.2	21.77±2.66	24.80±3.14	25.65±2.33
JOA (Wiltse approach TLIF)	12.8±5.8	18.4±3.4	23.83±1.86	25.53±1.11	26.10±1.75
<i>P</i> value	0.51	0.041*	0.001*	0.241	0.418

ODI scores

There were no significant differences in ODI scores between two groups before the operations (56.8±21.7 VS 54.1±20.0; *P*>0.05), At 7 days after the operation, the study group was associated with significantly lower ODI (43.9±11.9 vs 55.2±12.9; *P*=0.001*). The results at 3 months postoperatively were consistent with the results at 7 days postoperatively (16.13±7.10 VS 29.46±9.42; *P*=0.000*), however, there was no significant difference between the two groups in ODI scores at 6 and 12 months (Table 2).

JOA scores

There were no significant differences in JOA scores between two groups before the operations (11.8±5.8 VS 12.8±5.8 ; *P*>0.05), At 7 days after the operation, the control group was associated with significantly lower JOA scores (16.3±4.2 vs 18.4±3.4; *P*=0.041*). The results at 3 months postoperatively were consistent with the results at 7 days postoperatively (21.77±2.66 VS 23.83±1.86 ; *P*=0.001*), however, there was no significant difference between the two groups in JOA scores at 6 and 12 months (Table 2).

SF-36 scores

There were no significant differences in SF-36 scores between two groups before the operations. Study group only yielded a significant improvement in SF-36 PF (68.7±14.3vs. 60.0±12.0; *P*=0.018*), SF-36 GH (68.2±16.5 vs. 58.8±14.8; *P*=0.030*), SF-36 RE (63.3±33.2 vs 43.6±36.2 ,*P*=0.038*), SF-36 PCS (62.8±13.9 vs. 54.8±13.3 ; *P*=0.033*) at 3 months compared to control group. There was no significant difference in other SF-36 items at other follow-up time points between two groups (Table 3).

Evaluation of paravertebral muscle atrophy and fatty infiltration

In this study, paraspinal muscle fatty infiltration and fibrosis rates in both groups were comparable before surgery (*P*>0.05), and only 37 patients (17 in the control group and 20 in the study group) underwent lumbar MRI

Table 3 Preoperative and follow-up time items of physical scale SF-36 scores

	peroperative	3 months	6 months	1 year
Physical Functioning (P-TLIF)	37.3 ± 28.6	60.0 ± 12.0	70.8 ± 15.3	79.8 ± 11.2
Physical Functioning (Wiltse approach TLIF)	40.7 ± 26.5	68.7 ± 14.3	75.8 ± 13.8	81.5 ± 10.8
P Values	0.65	0.018*	0.198	0.567
Role-Physical (P-TLIF)	2.9 ± 8.1	29.8 ± 30.0	62.5 ± 37.6	71.2 ± 28.0
Role-Physical (Wiltse approach TLIF)	5.8 ± 14.2	42.5 ± 30.9	63.3 ± 32.7	69.2 ± 29.1
P Values	0.355	0.126	0.930	0.796
Bodily Pain (P-TLIF)	32.7 ± 19.1	70.5 ± 9.3	69.0 ± 10.5	75.4 ± 12.2
Bodily Pain (Wiltse approach TLIF)	37.5 ± 21.9	71.3 ± 11.7	72.2 ± 9.6	72.5 ± 10.8
P Values	0.382	0.658	0.238	0.692
General Health (P-TLIF)	45.6 ± 15.2	58.8 ± 14.8	65.4 ± 12.9	73.0 ± 10.1
General Health (Wiltse approach TLIF)	48.0 ± 17.6	68.2 ± 16.5	70.1 ± 14.1	72.5 ± 10.8
P Values	0.569	0.030*	0.200	0.859
Vitality (P-TLIF)	51.9 ± 16.7	65.6 ± 17.1	75.5 ± 8.9	71.5 ± 12.8
Vitality (Wiltse approach TLIF)	51.8 ± 17.1	69.8 ± 12.2	72.2 ± 8.6	70.3 ± 12.0
P Values	0.984	0.284	0.887	0.718
Social Functioning (P-TLIF)	49.6 ± 23.8	63.2 ± 23.6	74.4 ± 21.3	79.1 ± 14.8
Social Functioning (Wiltse approach TLIF)	52.6 ± 21.6	70.7 ± 22.9	78.1 ± 16.4	76.7 ± 14.4
P Values	0.621	0.284	0.443	0.544
Role-Emotional (P-TLIF)	38.5 ± 46.8	43.6 ± 36.2	66.7 ± 36.5	93.6 ± 23.1
Role-Emotional (Wiltse approach TLIF)	60.2 ± 14.7	63.3 ± 33.2	70.0 ± 29.5	95.6 ± 19.0
P Values	0.151	0.038*	0.707	0.729
Mental Health (P-TLIF)	60.2 ± 14.7	68.2 ± 18.8	70.5 ± 9.9	74.9 ± 6.6
Mental Health (Wiltse approach TLIF)	54.0 ± 20.26	72.9 ± 15.6	72.0 ± 8.8	74.5 ± 8.5
P Values	0.205	0.303	0.541	0.850
Physical Component Summary (P-TLIF)	29.6 ± 13.2	54.8 ± 13.3	66.9 ± 16.1	74.8 ± 12.0
Physical Component Summary (Wiltse approach TLIF)	33.0 ± 11.0	62.8 ± 13.9	70.4 ± 14.1	74.2 ± 13.3
P Values	0.291	0.033*	0.397	0.862
Mental Component Summary (P-TLIF)	50.0 ± 17.7	60.1 ± 20.2	71.0 ± 13.5	79.8 ± 9.5
Mental Component Summary (Wiltse approach TLIF)	45.2 ± 17.0	69.2 ± 17.0	73.1 ± 10.2	79.3 ± 8.7
P Values	0.299	0.073	0.540	0.837

Table 4 MRI signal rank of paraspinal muscles at pre- and 6 months after surgery

Rank	P-TLIF (n = 17)				Wiltse approach -TLIF (n = 20)				P Value
	I	II	III	IV	I	II	III	IV	
Preoperation	2	9	6	0	2	9	6	3	P = 0.399
Postoperation	0	1	9	7	0	9	8	3	P = 0.008*

examination in 6 months after surgery. At six months, paraspinal muscle fatty infiltration and fibrosis in the control group were significantly higher than in the study group ($P=0.008^*$), (Table 4; Fig. 5).

Surgical complications

There were one case of postoperative cerebrospinal fluid leakage and one case of surgical site infection in the control group, but no severe complication. In the study group, one cases of FBSS and one case of cage displacement were observed. No significant difference in the incidence of complications was observed between the control and study groups (7.7% vs. 6.7%, $P>0.05$, Table 5).

Intervertebral fusion rate

There was no significant difference in the intervertebral fusion rate between two groups ($P=0.582$). The intervertebral fusion rate was 89% in the Wiltse group, and 86% in the P-TLIF group (Table 6; Fig. 6).

Discussion

It is well-established that the P-TLIF technique enables neural canal decompression without exposing the important structures in the spinal canal [12]. However, bilateral paraspinal muscles and require stripping during P-TLIF, which results in paraspinal muscle atrophy, fibrosis, and fat deposition. Emerging evidence suggests that intraoperative paraspinal muscle injury may lead to postoperative pain syndromes [12–15]. In 1968, Wiltse introduced an approach involving leveraging a natural

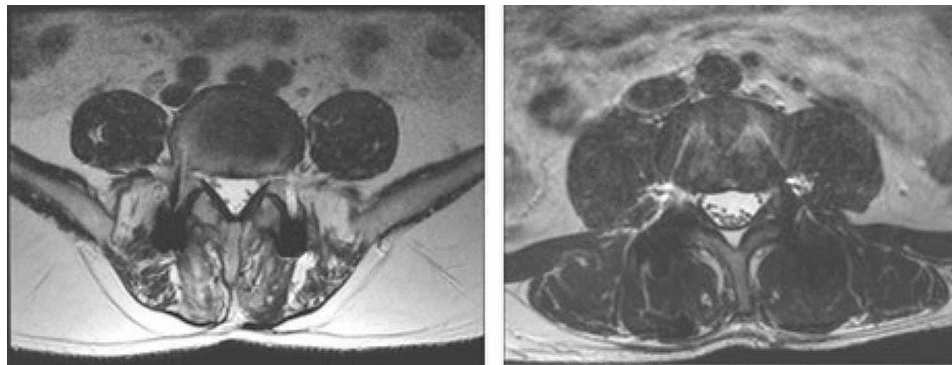


Fig. 5 Paraspinal muscles MRI signal 6 months after operation :right is wiltse approach TLIF group left is P-TLIF group

Table 5 Complications at 12-month minimum follow-up

	Wiltse approach TLIF	P-TLIF
Screw malposition	0	0
Cage migration	1	0
CSF leakage	0	1
Surgical site infection	0	1
Neurologic deficit	0	0
DEEP venous thrombosis	0	0
Pulmonary embolus	0	0
FBSS	1	0
Total incidence	6.7%	7.7%
P value	P > 0.5 P > 0.5	

Table 6 Fusion rate at 12-month minimum follow-up

	Wiltse approach TLIF	P-TLIF	P
Interbody fusion rate, %	89	86	0.582

cleavage plane between the multifidus and longissimus muscles to avoid dissecting muscular attachments of the paraspinal musculature to gain entry to the posterior elements [16]. Therefore, using this particular approach leads to improved retention of the multifidus muscle's

physiological functions, maintains stability in the spine, and reduces the incidence of Failed Back Surgery Syndrome (FBSS) [17]. However, there are some limitations in the traditional Wiltse approach TLIF. This procedure traditionally uses a laminectomy retractor to expose the pedicle screw entry point, anchored by assistants on the lateral margin of the superior articular process joint while retracting the longissimus muscle laterally. Due to the design flaws in the laminectomy retractor, it is difficult for assistants to use the retractor to pull the multifidus muscle inward and expose the vertebral plate, making it challenging to achieve spinal canal decompression during surgery. Thus, performing spinal canal decompression through traditional Wiltse approaches poses a great challenge for surgeons. To further increase the surgical convenience of this approach, we independently designed a new hand-held retractor system.

New hand-held retractor assisted Wiltse TLIF can get better perioperative outcomes than P-TLIF

The results of this study showed the novel hand-held retractor assisted Wiltse TLIF is significantly

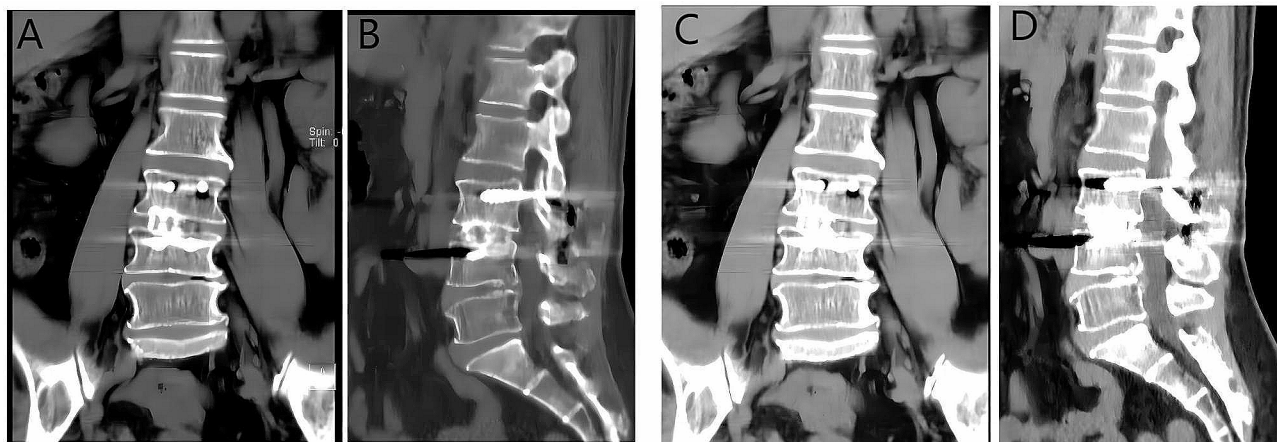


Fig. 6 WiltseTLIF and P-TLIF group showed definite bone connection. (A) and (B): 12 months CT of a Wiltse approach TLIF patient. (C) and (D): 12 months CT of a P-TLIF patient

superior to P-TLIF in terms of intraoperative bleeding (79.67 ± 28.59 ml vs. 192.31 ± 59.48 ml, $P=0.000^*$), postoperative drainage (43.33 ± 27.89 ml vs. 285.57 ± 123.05 ml, $P=0.000^*$), mobilization time (4.1 ± 1.2 d vs. 3.0 ± 0.9 d, $P=0.000^*$), and discharge time (7.7 ± 1.9 d vs. 6.1 ± 1.2 d, $P=0.000^*$), and the results were consistent with previous studies [9, 18]. In the Wiltse TLIF procedure under this novel hand-held retractor system, pedicle screw placement, facet joint resection and interbody bone implantation are conducted under direct vision, which can be easily completed through the natural gap between the longissimus muscles and multifidus muscles, without distraction of the paraspinal muscles, thereby minimizing the extent and duration of muscle distraction compared to the traditional approach, which result in less intraoperative blood loss and postoperative drainage. In Wiltse TLIF surgery, blood loss is mainly caused by bone surface bleeding after osteotomy and rupture of the spinal venous plexus.

New hand-held retractor assisted wiltse TLIF more effectively reduce intraoperative paraspinal muscle injury compared to P-TLIF

It is widely acknowledged that CK can be released into peripheral blood during skeletal muscle injury, peaking on day 1 and declining to normal levels on day 5 [19]²⁰. Accordingly, peripheral blood CK levels can reflect the degree of intraoperative paraspinal muscle injury. Liu et al. [8, 9, 18] showed that postoperative serum creatine kinase levels were significantly lower in the Wiltse TLIF group compared with the P-TLIF group. In our study, the CK levels in the P-TLIF group at 24 h after surgery (384.10 ± 141.99 U/L) were significantly higher than in the Wiltse TLIF group (532.76 ± 225.76 U/L), indicating that the Wiltse TLIF using hand-held retractors yielded less intraoperative lumbar paraspinal muscle injury. Over the years, MRI has been used to assess the degree of paraspinal muscle degeneration in several studies, the infiltration of fat and connective tissue are mainly manifested as enhanced signals on T2-weighted imaging [20–22]. The traditional posterior approach requires surgeons expose the vertebral plate and articular process by dissecting the paraspinal muscles on both sides of the spinous process which can result in damage to paraspinal muscles. In our study we found that the paraspinal muscle fatty infiltration and fibrosis in the P-TLIF group were significantly higher than in the Wiltse TLIF using hand-held retractors. This result is consistent with previous study [8].

New hand-held retractor assisted wiltse TLIF has advantage in improving the short-term clinical outcomes

Patient-reported outcome indicators, such as the VAS, ODI and JOA scores, play an irreplaceable role in assessing clinical efficacy [23]. Moreover, previous

studies have reported on the correlation between the degeneration of paraspinal muscles after lumbar surgery and these indicators [24]. In our study, the postoperative VAS, ODI and JOA scores in all groups were significantly improved compared with preoperative ones ($P < 0.05$). Similar to Kim's review [25], postoperative outcomes at or within 6 months were defined as short-term outcomes, and outcomes beyond 1 year were defined as long-term outcomes in this study. Previous studies have substantiated that Wiltse TLIF could improve short-term clinical outcomes [9, 18]. At 7 days after the operation, the Wiltse TLIF group was associated with significantly lower VAS and ODI scores but higher JOA scores, and the results at 3 months postoperatively were consistent with the results at 7 days postoperatively. Although most researchers proved that the Wiltse approach TLIF could improve short-term clinical outcomes, the long-term effects remain subject to debate. It has been reported that patients who underwent Wiltse TLIF have lower ODI and VAS scores one year after surgery compared with P-TLIF [9], and no significant difference in the long-term VAS and ODI scores was present between the two groups [8]. In our study, the VAS, ODI and JOA scores in the two groups were similar one year after surgery.

Hand-held retractor assisted wiltse TLIF can safely and effectively treat lumbar degenerative disc disease, yielding a similar fusion rate compare to TLIF

The incidence of complications can be used to evaluate the safety profile of a technique [26]. There is a rich literature substantiating that the Wiltse approach TLIF technique is generally limited to a narrow surgical space, which may lead to more complications, such as the dural sac tear and cerebrospinal fluid leakage [26, 27]. Importantly, no dural sac tear was observed in cases that underwent the Wiltse TLIF in our study. In the P-TLIF group, one patient experienced cerebrospinal fluid leakage, while another had a surgical site infection after surgery. In the Wiltse TLIF group, one patient suffered cage displacement 3 months later, but a CT examination one year after surgery showed that cage displacement had fused with the upper and lower endplate. The incidence of complications in the two groups was comparable (control group: 7.7%, study group: 6.7%, respectively). Overall, the results of the current study are consistent with findings reported by Liu et al. [9]. Growing literature suggests that the fusion rate of the intervertebral cage may affect the clinical outcomes of patients [28–31]. The present study found no significant difference in the fusion rate between the two surgical methods at the one-year postoperative, suggesting that both techniques can achieve the expected fusion results (Fig. 6).

Advantages of this new hand-held retractor system

The hand-held retractor system is specifically designed for Wiltse approach surgery, with a focus on Wiltse TLIF procedures. In the novel hand-held retractor assisted Wiltse TLIF procedure, surgeons can use the articular process retractor to expose the pedicle screw entry point of lumbar vertebrae by clamping its short arm at the basement of the transverse process and the long arm at the lower edge of the transverse process. Additionally, surgeons can also expose the pedicle screw entry point of S1 by clamping its short arm at the lateral margin of the superior articular process and the long arm at the sacrum. After the pedicle screw is inserted, a greater intraoperative field is obtained as surgeons clamp the “U”-shaped head of pedicle screw retractor at the base of the pedicle and pull outward, and the vertebral plate is exposed as assistants use the soft tissue retractor to pull the multifidus inward. The advantages of this retractor system are as follows: (i): the vertebral plate can be exposed by pulling through multifidus muscle inward, making the spinal canal decompression more convenient; (ii): The articular process joint retractor is designed with consideration of the anatomical structure of the surgical field to ensure a stable contact between the retractor and the bone (facet joint, transverse process and sacrum), with minimal risk of injury to these structures. therefore, surgeon can insert the pedicle screw in the meanwhile reduce the incidence of intraoperative accident (such as superior articular process joint fracture and transverse process fracture). (ii). The Wiltse approach typically employs a laminectomy retractor for surgical field exposure. An assistant secures it to retract the longissimus muscle towards the lateral margin. In patients with muscularity or obesity, the multifidus muscle can impede the surgical view. In our study, after the pedicle screw inserted, the surgical field can be exposed by the assistant fixing the pedicle screw retractor on the pedicle screw and pressing the end part of the retractor. It can facilitate the exposure of the vertebral plate, aiding in spinal canal decompression.

Limitation

The limitations and shortcomings of the present study should be acknowledged. First of all, all cases were performed by one surgeon, which affects the generalizability of our findings. In this study, we didn't set the laminectomy retractor assisted Wiltse TLIF group to further explore the advantage of this novel hand-held retractor system. Further more, There was not only one level fusion surgery patients but also two levels fusion surgery included which might impact the results of this study. In addition, the sample size was small, which may have affected the reliability of our comparison between Wiltse TLIF and P-TLIF to a certain extent. Moreover, whether the Wiltse approach TLIF can achieve better long-term effects

has not been established. Further studies are warranted to assess whether Wiltse TLIF using hand-held retractors can significantly improve the long-term outcomes compared with P-TLIF.

Conclusion

Our study showed that the Wiltse approach TLIF can significantly reduce paraspinal muscle injury, postoperative drainage, and intraoperative blood loss, mobilization and discharge time, as well as yield better short-term outcomes compared to P-TLIF.

Abbreviations

P-/Wiltse-/MIS TLIF	Posterior/Wiltse/Mini invasive transforaminal lumbar interbody fusion
CT	Computed Tomography
LBP	Low back pain
VAS	visual analog scale
ODI	Oswestry disability index
SF-36	Short-Form 36
CK	Serum creatine kinase
CRP	C-reactive protein
BMI	Body mass index
CSF leakage	Cerebrospinal fluid leakage
FBSS	Failed back surgery syndrome

Acknowledgements

We would like to give special thanks for the language editorial support provided by Division of Spinal Surgery, Department of Orthopaedics, Nanfang Hospital, Southern Medical University.

Author contributions

Chen JT designed the study and coordinated the resources; All of the surgery in this article is made by Jiang H, Chen YQ and Wang HM. Shen X and Zheng MH performed the research and collected data; Yao XQ and Shen X analyzed the results; Li FT drafted the manuscript; Jiang H and Chen JT revised the manuscript. Jiang H supervised the study.

Funding

This study was sponsored by the Clinical Research Program of Nanfang Hospital, Southern Medical University (2018CR003).

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This current study has been approved by the the Institutional Review Board (IRB) of Nanfang Hospital Guangzhou, China and has registered on **clinical trial. Gov(2016/01/15 NCT06052579)**. with all patients signing the written informed consent. All methods were performed in accordance with the relevant guidelines and regulations approved by the IRB of Nanfang Hospital.

Consent for publication

Not applicable.

Conflict of interest

The authors have no personal, financial, or institutional interest and ethical / legal conflicts involved in this article. In this study we introduced a novel hand-held retractor system. According to their functions, the retractor can be divided into soft tissues retractor, articular process retractor, and pedicle screw retractor. The hand-held retractor system was independently researched and developed by Division of Spinal Surgery, Department of Orthopaedics, Nanfang Hospital, Southern Medical University.

Author details

¹Division of Spinal Surgery, Department of Orthopaedics, Nanfang Hospital, Southern Medical University, 1838 North Guangzhou Avenue, Guangzhou, China

²Center for Orthopaedic Surgery, The Third Affiliated Hospital of Southern Medical University, Guangzhou, China

Received: 27 September 2023 / Accepted: 1 February 2024

Published online: 14 February 2024

References

1. Davis H. Increasing rates of cervical and lumbar spine surgery in the United States, 1979–1990. *Spine (Phila Pa 1976)*. 1994;19:1117–23. discussion 23–4.
2. Gejo R, Matsui H, Kawaguchi Y, Ishihara H, Tsuji H. Serial changes in trunk muscle performance after posterior lumbar surgery. *Spine (Phila Pa 1976)*. 1999;24:1023–8.
3. Sihvonen T, Herno A, Paljärvi L, Airaksinen O, Partanen J, Tapaninaho A. Local denervation atrophy of paraspinal muscles in postoperative failed back syndrome. *Spine (Phila Pa 1976)*. 1993;18:575–81.
4. Onesti ST. Failed back syndrome. *The neurologist* 2004;10:259–64.
5. Foley KT, Holly LT, Schwender JD. Minimally invasive lumbar fusion. *Spine (Phila Pa 1976)*. 2003;28:26–35.
6. Jin YM, Chen Q, Chen CY, et al. Clinical Research and technique note of TLIF by Wiltse Approach for the treatment of degenerative lumbar. *Orthop Surg*. 2021;13:1628–38.
7. Lee CW, Yoon KJ, Ha SS. Comparative analysis between three different lumbar decompression techniques (microscopic, tubular, and endoscopic) in Lumbar Canal and lateral recess stenosis: preliminary Report. *BioMed research international* 2019;2019:6078469.
8. Zhou C, Tian YH, Zheng YP, Liu XY, Wang HH. Mini-invasive Transforaminal Lumbar Interbody Fusion through Wiltse Approach to treating lumbar spondylytic spondylolisthesis. *Orthop Surg*. 2016;8:44–50.
9. Liu H, Li J, Sun Y, et al. A comparative study of a new retractor-assisted WILTSE TLIF, MIS-TLIF, and traditional PLIF for treatment of single-level lumbar degenerative diseases. *Orthop Surg*. 2022;14:1317–30.
10. Kader DF, Wardlaw D, Smith FW. Correlation between the MRI changes in the lumbar multifidus muscles and leg pain. *Clin Radiol*. 2000;55:145–9.
11. Bridwell KH, Lenke LG, McEnery KW, Baldus C, Blanke K. Anterior fresh frozen structural allografts in the thoracic and lumbar spine. Do they work if combined with posterior fusion and instrumentation in adult patients with kyphosis or anterior column defects? *Spine (Phila Pa 1976)*. 1995;20:1410–8.
12. Humphreys SC, Hodges SD, Patwardhan AG, Eck JC, Murphy RB, Covington LA. Comparison of posterior and transforaminal approaches to lumbar interbody fusion. *Spine (Phila Pa 1976)*. 2001;26:567–71.
13. German JW, Foley KT. Minimal access surgical techniques in the management of the painful lumbar motion segment. *Spine (Phila Pa 1976)*. 2005;30:52–9.
14. Mummaneni PV. Percutaneous transforaminal lumbar interbody fusion for the treatment of degenerative lumbar instability. *Neurosurgery*. 2008;62:E1384. author reply E.
15. Schwender JD, Holly LT, Rouben DP, Foley KT. Minimally invasive transforaminal lumbar interbody fusion (TLIF): technical feasibility and initial results. *J Spin Disord Tech* 2005;18 Suppl:S1–6.
16. Wiltse LL, Spencer CW. New uses and refinements of the paraspinal approach to the lumbar spine. *Spine (Phila Pa 1976)*. 1988;13:696–706.
17. Kawaguchi Y, Matsui H, Tsuji H. Back muscle injury after posterior lumbar spine surgery. A histologic and enzymatic analysis. *Spine (Phila Pa 1976)*. 1996;21:941–4.
18. Cheng WY, Zeng XX, Xiang X, Liu D, Zheng JP, Hu B. [A case control study of lumbar fusion surgery with the Wiltse approach and the traditional approach]. *Zhongguo Gu shang = China J Orthop Traumatol*. 2019;32:965–70.
19. Kawaguchi Y, Matsui H, Tsuji H. Changes in serum creatine phosphokinase MM isoenzyme after lumbar spine surgery. *Spine (Phila Pa 1976)*. 1997;22:1018–23.
20. Mengiardi B, Schmid MR, Boos N, et al. Fat content of lumbar paraspinal muscles in patients with chronic low back pain and in asymptomatic volunteers: quantification with MR spectroscopy. *Radiology*. 2006;240:786–92.
21. Yanik B, Keyik B, Conkbayir I. Fatty degeneration of multifidus muscle in patients with chronic low back pain and in asymptomatic volunteers: quantification with chemical shift magnetic resonance imaging. *Skeletal Radiol*. 2013;42:771–8.
22. Fischer MA, Nanz D, Shimakawa A, et al. Quantification of muscle fat in patients with low back pain: comparison of multi-echo MR imaging with single-voxel MR spectroscopy. *Radiology*. 2013;266:555–63.
23. Kim CW, Lee YP, Taylor W, Oygur A, Kim WK. Use of navigation-assisted fluoroscopy to decrease radiation exposure during minimally invasive spine surgery. *Spine J*. 2008;8:584–90.
24. Tandon R, Kiyawat V, Kumar N. Clinical correlation between muscle damage and Oswestry Disability Index score after open lumbar surgery: does open surgery reduce functional ability? *Asian Spine J*. 2018;12:518–23.
25. Kim CH, Easley K, Lee JS, et al. Comparison of minimally invasive Versus Open Transforaminal interbody lumbar Fusion. *Global Spine J*. 2020;10:143s–50s.
26. Khan NR, Clark AJ, Lee SL, Venable GT, Rossi NB, Foley KT. Surgical outcomes for minimally invasive vs open transforaminal lumbar Interbody Fusion: an updated systematic review and Meta-analysis. *Neurosurgery* 2015;77:847–74; discussion 74.
27. Habib A, Smith ZA, Lawton CD, Fessler RG. Minimally invasive transforaminal lumbar interbody fusion: a perspective on current evidence and clinical knowledge. *Minim Invasive Surg*. 2012;2012:657342.
28. Videbaek TS, Christensen FB, Soegaard R, et al. Circumferential fusion improves outcome in comparison with instrumented posterolateral fusion: long-term results of a randomized clinical trial. *Spine (Phila Pa 1976)*. 2006;31:2875–80.
29. Tsutsumimoto T, Shimogata M, Yoshimura Y, Misawa H. Union versus non-union after posterolateral lumbar fusion: a comparison of long-term surgical outcomes in patients with degenerative lumbar spondylolisthesis. *Eur Spine J*. 2008;17:1107–12.
30. Kornblum MB, Fischgrund JS, Herkowitz HN, Abraham DA, Berkower DL, Ditkoff JS. Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective long-term study comparing fusion and pseudarthrosis. *Spine (Phila Pa 1976)* 2004;29:726–33; discussion 33–4.
31. Lu ML, Cheng CH, Chen WC, Fu CJ, Niu CC. Comparisons of lumbar muscle performance between minimally-invasive and open lumbar Fusion surgery at 1-Year Follow-Up. *Global Spine J* 2020;2192568220979666.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.