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# Posterior Vertebroectomy via the Unilateral Pedicle or Bilateral Pedicle Approach in the Treatment of Lumbar Burst Fracture with Neurological Deficits: A Comparative Retrospective Cohort Study

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**Background:**

Posterior vertebroectomy with bilateral pedicle approach (BPA) is widely applied in lumbar burst fracture (LBF). However, some disadvantages exist, such as a prolonged operation time, extensive soft tissue injury, and excessive blood loss. Posterior vertebroectomy with unilateral pedicle approach (UPA) is a novel technique for decompression of spinal canal. Thus, we explored the potential of UPA to achieve better outcomes than BPA.

**Material/Methods:**

Of 47 patients who underwent posterior vertebroectomy for LBF, 23 patients were treated with UPA and 24 patients were treated with BPA. Clinical and radiographical outcomes were assessed with a follow-up of more than 24 months. Patients were evaluated before and after surgery according to the following parameter: duration of operation (DO), blood loss volume (BLV), the kyphotic angle (KA), the ratio of the height of anterior vertebral edge, the ratio of the sagittal injury, visual analog scale (VAS), Oswestry Disability Index (ODI), and Frankel scores.

**Results:**

The follow-up time ranged from 24 to 37 months (average 26.4 months). The UPA group had significantly decreased DO and BLV ( $P < 0.05$ ). The 2 cohorts showed similar performance at 6 months ( $P > 0.05$ ), 12 months ( $P > 0.05$ ), and 24 months ( $P > 0.05$ ) post-surgery, in terms of parameters including KA, the ratio of the vertebral anterior, the ratio of sagittal damage, Frankel scores, ODI, and VAS.

**Conclusions:**


UPA and BPA had a similar clinical performance for LBF. However, the shorter DO and lower BLV achieved in the UPA cohort suggested UPA is a better alternative for LBF.

**MeSH Keywords:**

**Fractures, Bone • Operative Time • Osteotomy • Spine**

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## Background

In recent years, the incidence of high-energy injury of lumbar burst fracture (LBF) caused by falls and traffic accidents has been rising [1]. According to the 3-column concept of the spine [2], LBF can be caused by the damage to 2 columns, leading to severe lumbar stenosis and catastrophic nerve root injury, as well as various of neurological deficiencies [3]. Open surgery with vertebrectomy and intervertebral fusion is required to treat the severe damage to the 3-column structure in LBF [4].

Posterior partial vertebrectomy via a bilateral pedicle approach (BPA) combined with 360-degree decompression and intervertebral fusion is the conventional and widely accepted technique in LBF. It has been reported that vertebrectomy and intervertebral fusion via a BPA provides full decompression, adequate mechanical support, and effective fusion for treating LBF [5]. However, this conventional technique also has some disadvantages, such as a prolonged operation time, extensive soft tissue injury, and excessive blood loss, as well as the high cost to the patients [6].

Partial vertebrectomy via a unilateral pedicle approach (UPA) is a novel alternative technique for sufficient decompression of the spinal canal. Using this mode, the stability of the vertebral 3 columns can be reconstructed via a single posterior approach without the need for additional anterior surgery. Furthermore, half of the posterior structure can be retained, and the partial stability of the vertebra can be retained. In addition, the pressure in the spinal canal can be removed completely by the feasible 270 degree decompression space [7].

However, few previous studies have focused on comparing the efficacy and safety of the UPA and BPA techniques. In this retrospective study, we explored the potential of the UPA mode to achieve better outcomes than the conventional BPA, and thereby provide a better alternative for the treatment of LBF.

## Material and Methods

### Patient eligibility

From June 2013 to June 2017, 47 patients with LBF were included and evaluated retrospectively. Ethical approval and informed consent to participate in this study were obtained from each patient. The following inclusion criteria were applied: 1) Dennis classification Type B fracture of the vertebra with neural damage, 2) adult and in full possession of their mental faculties, 3) able to tolerate the operation, and 4) more than 30% compromise of the spinal canal resulting from the fracture. The excluded criteria were as follows: 1) no obvious neural dysfunction, 2) recent active inflammation, 3) severe

anemia, 4) with severe heart and lung disease, and 5) unable to tolerate surgery.

### Surgical treatment and the rehabilitation protocol

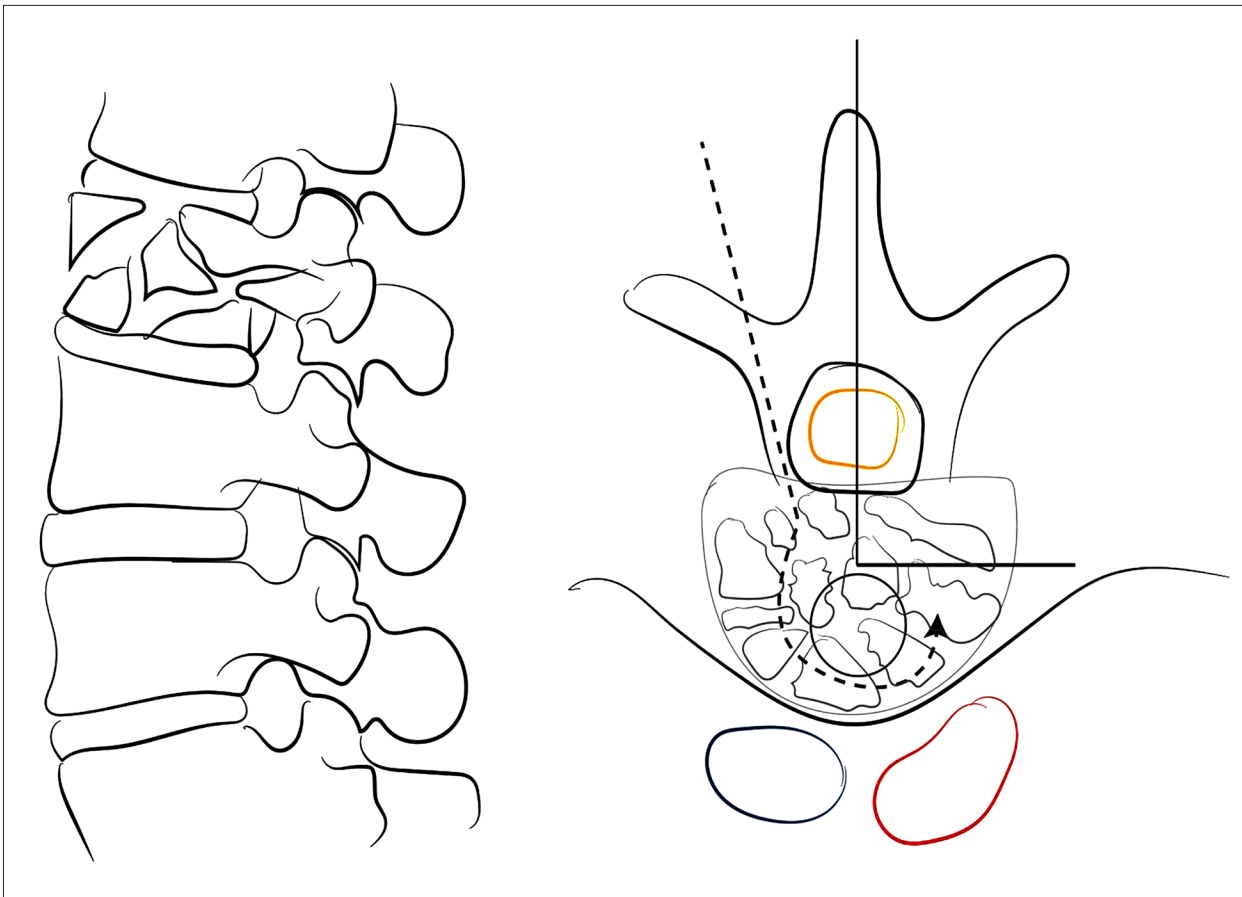
All patients were treated by the same senior surgeon. The operation was performed under general anesthesia. With the patient in the prone position, the spinous process, lamina, articular process, and transverse process base of the injured vertebrae and the upper and lower vertebrae were exposed by a posterior median incision. In the UPA cohort, intraspinal decompression was performed by entering the severe side of the space-occupying side or the severe side of the nerve damage (Figure 1). In the BPA cohort, this procedure was performed via the 2 pedicles. The decompression procedure was performed as follows: the vertebral pedicle was removed, and the fractured vertebral body was exposed in front of the spinal canal. Bone fragments were then removed until the pressure of spinal canal was completely relieved. The appropriate length of vertebral lamina was removed depending on the length of the dural sac of the rupture in order to repair the ruptured dural sac. The vertebral body reduction was then performed as follows: a connecting rod of the appropriate length and curvature was installed on the opposite side, the lateral displacement was corrected by rotating the rod, the anterior dislocation was corrected by lifting the rod, the vertebral body height was restored by stretching and the posterior convex was corrected.

Finally, bone graft fusion with a titanium cage was performed as follows: the injured upper and lower intervertebral discs and vertebral cartilaginous endplates were removed, and the distance between the upper and lower vertebrae was measured at the posterior superior iliac spine. The corresponding length of titanium cage was cut and implanted into the vertebral body.

The same rehabilitation strategy was applied for all patients included in the study. Patients received 20% mannitol for 72 hours postoperatively to alleviate postoperative edema. The drainage system was dismantled 48 hours post-surgery. Starting at 48 hours post-surgery, the straight leg raise exercise was advised and the patient was encouraged to wear a vertebral brace for 1–2 months.

### Evaluation index

The DO and BLV during surgery were assessed. Patients in the 2 cohorts were assessed before and immediately after surgery, and 3, 6, and 12 months postoperatively. Radiographic images and data was obtained for comparisons of the improvements in KA, the ratio of the height of the anterior vertebral edge (ratio=the height of the anterior vertebral edge in the injured lumbar vertebra/the height of the anterior vertebral edge in adjacent intact vertebrae×100%). Accordingly, the sagittal



**Figure 1.** The operation diagram of the unilateral pedicle approach.

**Table 1.** The baseline characters of the two cohorts.

	UPA (n=23)	BPA (n=24)	p Value
Age, y, mean±SD	52.9±7.4	53.8±8.5	.4634
Sex, Male: Female, n	13: 10	14: 10	.0917
BMI, kg/m <sup>2</sup> , mean±SD	28.2±3.2	29.0±5.4	.0537
VAS pain score (0–100), mean	75.2±4.1	74.9±3.7	.5153

BMI – body mass index; VAS – visual analog scale.

damage ratio (ratio=the loss of sagittal diameter/the longest sagittal diameter×100%) between the 2 cohorts. Pain degree was assessed by VAS. Functionality was evaluated by Frankel scores and ODI. The ODI and VAS results were collected before and after the operation, and at 3, 6, and 12 months post-surgery. The Frankel functional scores were evaluated before the operation and at 12 months postoperatively.

### Statistical analysis

The Wilcoxon rank sum test was used to analyze non-parametric data and  $P<0.05$  was considered to indicate statistical

significance. Statistical Product and Service Solutions (SPSS) software (version 15.0.1, SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

### Results

In the present study, 23 patients were treated via the UPA and 24 patients were treated via the BPA. The 2 cohorts had the similar characteristics (Table 1), including average age (52.9±7.4 and 53.8±8.5 years,  $P=0.4634$ ), gender distribution (male: female, n, 13: 10 and 14: 10,  $P=0.0917$ ), body mass

index (BMI, kg/m<sup>2</sup>, 28.2±3.2 and 29.0±5.4, *P*=0.0429), and average VAS (75.2±4.1 and 74.9±3.7, *P*=0.5153).

The UPA cohort had significantly decreased DO and BLV as compared with the BPA cohort (*P*<0.05) (Table 2). In the UPA

cohort, patients exhibited non-significant reductions in VAS and ODI (*P*>0.05) (Table 3). There were no significant differences between the 2 cohorts in terms of the KA, the anterior vertebral ratio of the damaged vertebra, and the sagittal canal ratio at any of the follow-up points (*P*>0.05) (Table 4). Satisfactory Frankel score outcomes were observed both in the UPA and BPA cohorts (*P*<0.05). However, there were no significant differences between the 2 cohorts (Table 5). Typical cases treated by the UPA case and the BPA are shown in Figures 2 and 3, respectively.

**Table 2.** DO and BLV between the two cohorts.

	UPA	BPA
DO (min)	156±37.3*	189±41.7
BLV (ml)	307±65.3*	473±76.9

DO – duration of operation; BLV – blood loss volume. Mean±SD.

\* *p*<0.05 UPA compared with BPA.

**Table 3.** VAS and functional outcome (ODI) between the two cohorts.

	VAS		ODI	
	UPA	BPA	UPA	BPA
Pre-surgery	75.2±4.1	74.9±3.7	86.7±5.2	84.3±4.9
3 months post surgery	40.7±5.3	42.1±4.9	45.7±4.3	46.2±4.7
6 months post surgery	23.2±3.2	24.1±2.9	28.4±3.5	27.9±3.2
12 months post surgery	18.7±2.6	19.7±3.1	16.5±2.9	15.9±2.1
24 months post surgery	11.2±2.1	12.7±1.6	10.1±1.7	9.7±1.3

VAS – visual analog scale; ODI – Oswestry disability index. Mean±SD.

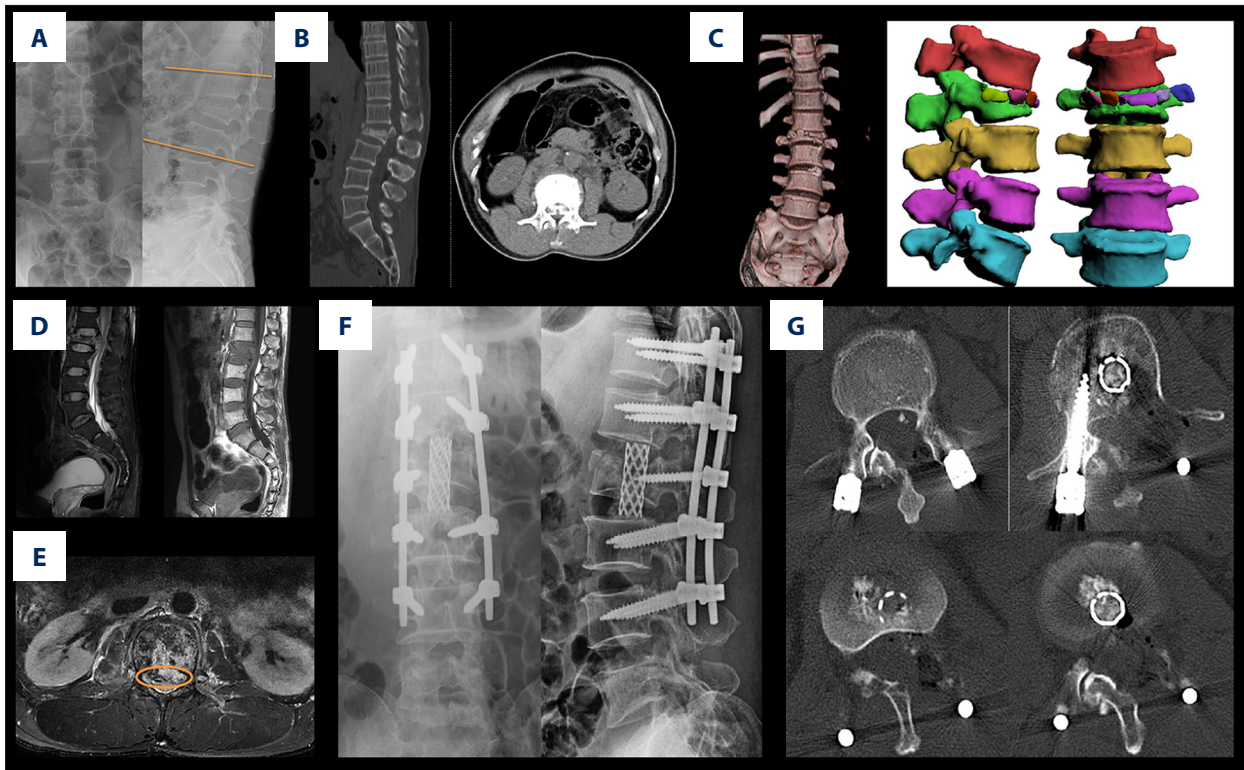
**Table 4.** X-radiography and CT results between the two cohorts.

	KA (°)		Height ratio of anterior edge of the injured vertebra (%)		Ratio of sagittal canal compromise (%)	
	UPA	BPA	UPA	BPA	UPA	BPA
Pre-surgery	25.7±7.6	26.5±7.2	61.2±9.2	62.3±8.4	45.7±12.4	46.1±13.3
Post-surgery	7.3±4.6	7.1±4.2	86.5±8.6	85.9±8.9	6.2±4.3	6.5±4.1
3 months post surgery	7.9±3.9	7.7±4.3	85.7±9.3	84.8±11.2	6.5±3.9	6.7±4.5
6 months post surgery	8.2±4.1	8.5±3.1	84.8±9.5	84.2±9.7	5.7±3.5	5.3±3.9
12 months post surgery	9.4±4.5	9.1±4.9	84.2±8.9	83.9±9.1	4.2±3.1	4.1±3.3
24 months post surgery	10.4±3.5	9.9±4.4	80.2±7.6	80.1±7.1	3.7±2.6	3.5±2.3

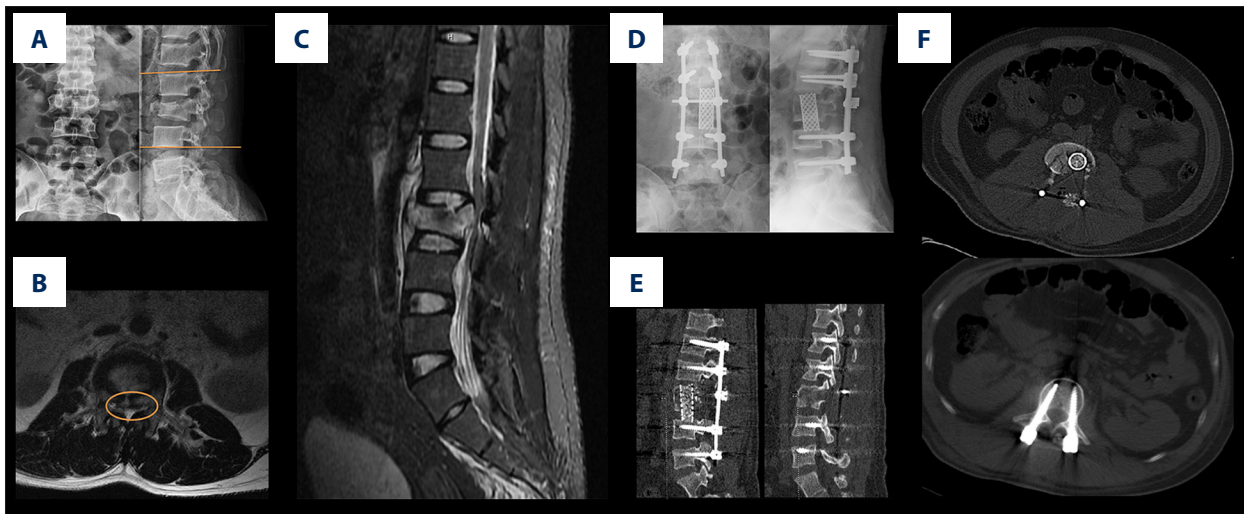
KA – kyphotic angle. Mean±SD.

**Table 5.** Improvement in the Frankel score.

Group	Total	Pre-surgery					24-month post				
		A	B	C	D	E	A	B	C	D	E
UPA	23	0	4	6	13	0	0	1	2	5	15
BPA	24	0	4	8	12	0	0	1	3	6	14



**Figure 2.** An unilateral pedicle approach typical case. A 52-year-old male with lumbar burst fracture; (L2). (A) X-rays of lumbar pre-surgery. (B) Computed tomography (CT) images of the injured lumbar both in sagittal and coronal plane. (C) Three-dimensional CT images of lumbar. (D, E) Magnetic resonance imaging (MRI) images of lumbar. (F) X-rays of lumbar post-surgery. (G) CT results indicated the contralateral pedicle had been retained.



**Figure 3.** A bilateral pedicle approach typical case. A 57-year-old male with lumbar burst fracture. (A) X-rays of lumbar pre-surgery. (B) The coronal plane of magnetic resonance imaging (MRI) for the injured lumbar. (C) The sagittal plane of MRI. (D) X-rays of lumbar post-surgery. (E, F) The sagittal and coronal plane of computed tomography indicates the pedicles had been removed.

## Discussion

For the treatment of severe LBF, the objective of surgery is to restore the stability of spine, recover the normal sequence and curvature of spine, as well as to achieve complete decompression in order to create conditions for the recovery of patients with spinal cord nerve injury [8]. Conventional surgical strategies involve the use of the posterior approach to adopt laminectomy for thorough decompression and fracture reduction by using a posterior pedicle screw and rod system. Reconstruction of the stability of the anterior and middle columns of the spine cannot be achieved using this mode of surgery, and laminectomy results in further destruction of the posterior stable structure with a high rate of failure for internal fixation [9]. The anterior approach, which is also widely used, which has some advantages, such as the potential to achieve complete decompression, effective internal support, and solid fusion [10]. However, the injured posterior column and the rupture dural sac cannot be repaired by using this approach [11]. In addition, the reduction performance and the anti-shear ability for patients combined with dislocation is not satisfactory [12]. It has been demonstrated that the combined anterior and posterior approaches is an effective technique to deal with severe LBF, providing complete decompression, satisfactory reduction, and effective reconstruction of the 3-column stability [13,14]. However, there are some concerns should be considered, such as long operation time, huge trauma, and injury to the chest or abdominal organs, as well as the high cost to the patients [15].

In the present study, we found that the UPA is suitable for severe LBF patients requiring the stabilization of the anterior column. This technique can provide good performance of partial vertebrectomy, adequate decompression of the spinal canal, and strong internal fixation. The main advantage of UPA is that the stability of the tri-column can be reconstructed through a single posterior approach without adding an anterior surgery. Furthermore, the stability of the half posterior column is restored, and complete decompression of spine canal can be obtained by the feasible 270 degree decompression space. Moreover, the UPA can avoid the disadvantages of the anterior approach, such as the limited ability to repair the injured posterior column and the ruptured dural sac. Thus, the UPA not only achieves similar outcomes to the anterior-posterior approach, but also provides additional advantages, including decreasing the surgical trauma, preventing injury to the chest or abdominal organs, and reducing cost of the operation. Furthermore, in the UPA cohort, the mean BLV was  $307 \pm 65.3$  mL, which that associated with the BPA. Thus, indicating that UPA results in a shorter DO and smaller volume of BLV during the operation. The BLV is closely related to the duration of blood transfusion time of a patient. The less blood loss a patient has, the less period of blood transfusion they

need, reducing the incidence of complications associated with transfusion. The improvements in Frankel assessment also affirmed the feasible and effective outcomes of UPA technique in neurological recovery. All these results corroborated the validity and effectiveness of UPA technique as a useful minimally invasive operation for LBF. However, in our present study, we found no significant differences between the cohorts regarding improvements in the VAS and ODI scores, and the collapse in the KA. Three factors may contribute to this result. First, the pain relief from the preservation of the half posterior column may be offset by the extensive dissection of the paravertebral muscles. Furthermore, correction and retention of the KA may be restricted by the limited operation space. Studies with more cases and a longer follow-up period are required to verify the effect of UPA for the treatment of LBF.

The exposure and pedicle screw placement via the UPA are similar to that of conventional BPA. However, in the specific operation, the following points relate specifically to the UPA. During the operation, one lateral posterior stable structure was selectively retained, as well as the spinous process and its collateral ligament. For this type of fracture, intraspinal compression mainly originates from the front. After removing the pedicle and semi-lamina of the injured vertebral body, the partial vertebrectomy can be performed conveniently, thereby removing the occupation of the spinal canal. Moreover, the surgical procedure is simplified, and the operation time and bleeding reduced accordingly. It should also be noted that the order of the surgical procedure in this study was decompression, reduction, and fusion fixation. During decompression, the laminectomy was not temporarily performed, but performed after the pedicle was removed and the anterior occupation was gradually removed outside of the spine canal. The reason for this order was that the vertebral canal occupation is often quite serious in severe LBF (the spinal canal occupation can exceed 90% of the space in some patients), which means that there is insufficient space for nerve tissue, and if the lamina is removed with any instrument, secondary damage to the spinal cord may be caused. Therefore, in the surgical treatment of such fractures, we do not support use of the surgical method of opening the lamina before reduction.

Bleeding during surgery should also be controlled. Due to the relatively long operation time and huge trauma associated with the surgery, it is important to be aware of blood loss. The non-operating area should be filled with gauze to prevent muscle bleeding after exposure. Segmental vessels can be blocked laterally along with the paravertebral soft tissues after ligation with the spinal branch of the segmental nerve root.

In summary, the results of our study revealed that the UPA and the BPA provide a similar clinical performance for the treatment of LBF. The shorter DO and lower BLV obtained in

the UPA cohort suggest that the UPA is a better alternative for LBF. However, there were some limitations of this study that should be noted. First, it was a retrospective study, with a small number of patients included. Additionally, 24 months of follow-up can be considered a short-term follow-up, which does not provide consequences of long-term period between the 2 approaches. Future studies should include a larger number of patients with longer follow-up times to reinforce the credibility of the current conclusion.

## Conclusions

UPA and BPA provide a similar surgical performance for the treatment of LBF. However, the shorter DO and lower BLV achieved in the UPA cohort suggests that UPA is a better alternative for the treatment of LBF.

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## Ethics approval and consent to participate

The study was approved by the clinical research ethics committee of Wuhan Puren Hospital. Reference No. 2012–047-01.

## Availability of data and materials

Please contact corresponding author Fan Ding for data requests.

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## Conflicts of interests

None.