Spine

SPINE Volume 44, Number 12, pp 896–901

SURGERY

A Novel Technique for Total En bloc Spondylectomy of the Fifth Lumbar Tumor Through Posterior-Only Approach

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Study Design. A retrospective study.

Objective. To describe a new surgical technique for total en bloc spondylectomy (TES) of the fifth lumbar (L5) tumor and evaluate the efficacy and safety of this new technique.

Summary of Background Data. TES has been considered an optimal treatment for tumor, including certain spinal tumors, but it requires a combined posterior–anterior approach, which is often complicated by a long operation time, considerable blood loss and severe trauma.

Methods. Seven patients with primary or solitary metastatic tumors of L5 were treated with this new technique in our center between March 2014 and November 2017. The critical points were fabrication of the iliac graft, dissection, resection, and reconstruction. Other parameters including surgical time, blood loss, complications, pre- and postoperative neurological function, tumor control, and overall survival (OS) were presented and analyzed.

Results. All the included patients received one stage TES. The mean surgical time was 365.7 minutes with an average blood loss of 2514.3 mL. No serious perioperative complication was observed or reported during the mean follow-up period of 27.4 months. Wound disruption occurred in one patient and numbness of the left lower limb in another, but both recovered rapidly after appropriate management. Adventitial avulsion of the abdominal aorta occurred during dissection in one patient. Two patients died during the follow-up period due to advanced malignancy. One patient was alive but developed a newly diagnosed thoracolumbar tumor in 40 months. The other four patients recovered well without evidence of disease. All patients were able to walk independently 3 to 4 weeks after operation, with satisfied fusion of the iliac grafts in a mean period of 6.7 months after operation. No evidence of internal fixation failure occurred.

Conclusion. This new technique offers satisfactory surgical exposure, total en bloc spondylectomy, reliable reconstruction, and good tumor control for certain L5 tumors through the posterior-only approach.

Key words: fifth lumbar tumor, iliac graft, posterior-only approach, total en-bloc spondylectomy.

Level of Evidence: 4

Spine 2019;44:896–901

Presently, total en-bloc spondylectomy (TES) has been increasingly recognized, and widely accepted for the treatment of spinal tumors, especially for primary aggressive, malignant, and solitary metastatic lesion in thoracic and upper lumbar spine (L1–L3).[1,2] In all, TES can be performed successfully in these segments through the posterior-only approach,[2,3] which decreased the operative time, intraoperative blood loss, and perioperative complications remarkably compared with the posterior–anterior approach. The clinical outcomes of TES were excellent and favorable.[3,4]

The fifth lumbar vertebra is the largest vertebra in the human vertebral column with specific anatomical properties. To the best of our knowledge, only several case reports of TES for L5 tumors have been described in the literature.[2,4–8] TES here usually requires a combined posterior–anterior approach, which means longer operation time, more blood loss, larger trauma as well as other accompanying complications[9,10] due to the vital and complexed

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Acknowledgment date: September 26, 2018. First revision date: December 6, 2018. Acceptance date: January 21, 2019.

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The manuscript submitted does not contain information about medical device(s)/drug(s).

No funds were received in support of this work.

No relevant financial activities outside the submitted work.

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DOI: 10.1097/BRS.0000000000003003

anatomies like major vessels (common iliac arteries and veins, internal iliac arteries and veins, abdominal aorta, inferior vena cava), lumbosacral plexus nerves, psoas and iliac muscles, and iliac wings. Of these reasons, the most important obstacle is the obstruction of iliac wings that forbids enough exposure for resection and reconstruction through the posterior-only approach.

The aim of this study is to describe a novel surgical technique for TES of L5 tumors through a posterior-only approach and evaluate its safety and efficacy.

MATERIALS AND METHODS

From March 2014 to September 2017, this new technique was performed in seven patients with L5 tumors. Informed consent was obtained from the patients or their guardians after informing them of all details regarding the surgical procedures including potential benefits and risks and complications. The study protocol was approved by the Institutional Review Board of the hospital prior to initiation of the study.

All patients received lumbo-sacral x-ray, computed tomography angiography (CTA) and magnetic resonance imaging (MRI), positron-emission tomography/computed tomography (PET/CT) or SPECT bone scan. The inclusion criteria were (1) patients with primary malignant tumors, aggressive benign tumors, or isolated metastasis of L5; (2) patients with type 1–4 lesions according to the Tomita classification,[11] and (3) Karnofsky score was more than 60. The pre- and postoperative neurologic status were evaluated according to the Frankel score.[12] Visual analogue scale (VAS) was used to evaluate the pre- and postoperative low back and leg pain. Moreover, the Weinstein-Boriani-Biagini staging[13] was also used to assess the tumor stage and direct the surgical plan.

The follow-up strategy was defined from the first day after surgery to the last follow-up. All patients were followed up regularly at 3, 6, and 12 months after surgery, every 6 months for the next 2 years, and then annually.

PREOPERATIVE EMBOLISM AND BALLOONING

Embolism or/and ballooning was performed preoperatively according to the tumor pathologies and image features within 24 hours. Of the seven included patients, five patients underwent embolism and two received embolism combined abdominal aorta ballooning to decrease intraoperative blood loss (Table 1).

OPERATIVE TECHNIQUES

Exposure and Decompression

With patients in the prone position after general anesthesia, a standard midline incision was made from L3 to S2. Biopsy or previous surgical scars were excised. With the muscles and other soft tissues dissected from spinous, lamina, and transverse process, pedicle screws were placed into L3/4 and S1/2 routinely, followed by the decompression. With the paraspinal tissues retracted laterally by using the retractors, the caudal part of the L4 spinous process and lamina were removed. Then, the posterior spinous process, lamina and pedicles of L5 were removed as a whole with a thin and sharp osteotome. Subsequently, the dural sac and L4/5 nerves were dissected from the surrounding tissues and protected. Dissection of dura mater and tumor should be exact when the tumor invaded the spinal canal space.

Fabrication of the Iliac Graft

The gluteus maximus, gluteus medius, lliacus, and quadratus lumborum were partially detached from the iliac to expose the iliac crest (the lesion side for Tomita type 2–4 or the side that surgeons preferred for Tomita type 1). One or two hollow screws were placed into the iliac wing to reserve screw tunnel for replacement of the iliac graft, then taken out. The iliac graft osteotomy was made from the level of L5/S1 disc horizontally with a thin osteotome from the back of iliac, followed by another osteotomy made from the midpoint of the anterior superior iliac spine and posterior superior iliac spine paralleling with the spine or slightly oblique towards to the sacrum. The iliac graft was removed

TABLE 1. Surgical Related Information of the Seven Patients With L5 Tumor

No.	Sex	Age	WBB Staging	Tomita Classification	Pathology	Reconstruction	E/B	BL, mL	Time, min	Complication	AT	Outcomes
1	M	55	2–7, B–D	Type 4	Metastatic gastrointestinal	L3/4, S1/2, cage	E+B	3500	390	None	Bp+target	25 months, DOD
2	F	51	2–5, B–D	Type 4	Neurofibroma	L3/4, S1/2, cage	E	2000	445	None	None	51 months, NED
3	M	59	3–5, B–C	Type 1	Chondrosarcoma	L3/4, S1/2, cage	E	2000	290	None	Bp+R+C	15 months, DOD
4	F	62	3–5, B–C	Type 1	Metastatic thyroid cancer	L3/4, S1/2, cage	E+B	4000	380	Disruption of wound	Bp+R+I^{131}	42 months, alive with thoracolumbar tumor
5	M	68	4–9, B–C	Type 1	GCT	L3/4, S1/2, artificial vertebra	E	1500	320	Numbness of the left lower limb	De	9 months, NED
6	M	37	2–5, B–C	Type 1	GCT	L3/4, S1/2, cage	E	1600	335	None	De	15 months, NED
7	F	30	7–10, B–C	Type 2	GCT	L3/4, S1/2, cage	E	3000	400	None	De	35 months, NED

AT indicates adjuvant therapy; B, balloon; BL, blood loss; Bp, bisphosphonate; C, chemotherapy; De, denosumab; DOD, died of disease; E, embolism; GCT, giant cell tumor of bone; NED, no evidence of disease; R, radiotherapy; WBB, Weinstein-Boriani-Biagini.

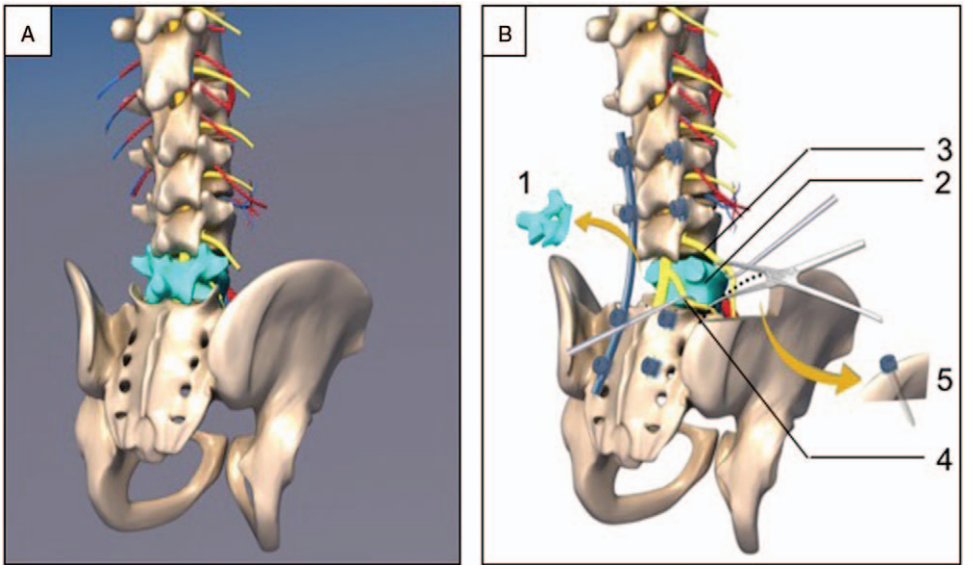

Figure 1. (**A**) Preoperative image of the lumbosacral spine using 3-dimensionnal computed tomography. (**B**) Diagrammatic drawing of the new technique: 1: the posterior spinous process, lamina and pedicles of L5 were removed as a whole; 2: L5 vertebra (tumor); 3: L4 nerve; 4: L5 nerve; 5: the iliac graft and the hollow screw.

successfully and preserved in normal saline temporarily. Simultaneously, a relatively enlarged space was attained (Figure 1A, B). In addition, we preferred to conduct the dissection of soft tissues and the L5 vertebra body contrary to the graft side as much as possible before the iliac osteotomy for the sake of decreasing blood loss from the osteotomy facet.

Total en Bloc Spondylectomy of L5 Tumor

After gaining the iliac graft, lumbar nerves of the iliac graft side were dissected caudally to gain larger space between L4 and L5 nerve. With the enlarged view and operation space, dissection between the prevertebral tissues and the vertebra wall was performed more easily, even extending through the middle line. During this process, the use of different types of arc dissectors, common gauze and hemostatic gauze was often necessary. Once dissection was completed from L4/5 to L5/S1 intervertebral disc, a feasible rod was fixed to the contrary side of the iliac graft and extended towards both ends slightly. Then the above two vertebral discs, corresponding posterior and anterior longitudinal ligament were cut with an osteotome. After complete discectomy, the fifth lumbar vertebra was pulled and rotated toward the lilac graft side, and then pushed from the contrary side to achieve the goal of total en bloc spondylectomy of L5 tumor (Figure 1).

Reconstruction

With verification of total tumor removal and exact hemostasis, the residual vertebral discs were handled. Subsequently, circumferential reconstruction of the lower lumbar was conducted. The titanium mesh cage cylinder or expandable artificial vertebra filled with allogeneic bone was adopted for anterior reconstruction. After finishing anterior reconstruction, the rods were fixed to the screws and compressed slightly. Moreover, rotational stability was enforced with a cross-link transverse fixator.

Replacement of the Iliac Graft

With reconstruction finished, the iliac graft was fixed back with hollow screws through the previous tunnel trajectories. Furthermore, distilled water containing cisplatinum was used to eliminate the possible tumor cell contamination. Finally, a drain was placed and the wound was closed routinely after careful hemostasis.

Postoperative Courses

All patients were recommended to get out of bed at 3 to 4 weeks after operation. A tailored supporter was required to restrict the lumbar motion for at least 6 months. Adjuvant therapies were given accordingly (Table 1). The follow-up course was carried out regularly.

RESULTS

Up to now, this new technique has been performed in four males and three females with a mean age of 51.7 (30–68) years. The pathologies were metastatic gastrointestinal, neurofibroma, chondrosarcoma, metastatic thyroid cancer in one respectively, and giant cell tumor of bone in three. All the operations were competed successfully in one stage using TES mode. The mean operation time was 365.7 (290–445) minutes, with mean intraoperative blood loss of 2514.3 (1500–4000) mL. As to reconstruction, two-column reconstruction was performed through the posterior-only approach. Anterior reconstruction was made using titanium mesh cage in six cases and expandable artificial vertebra in the remaining one. Posterior reconstruction was conducted through the screws-rods system.

Perioperative complications included undesirable wound healing with little effusion in Case 4, which healed up gradually after continuous suction and feasible dressing change. The other was traction injury of the left L4 and L5 nerves which resulted in numbness of the left lower limb in Case 5, which improved significantly after 4 weeks. No internal fixation failure occurred.

TABLE 2. Pre- and Postoperative FS and VAS of the Seven Patients With L5 Tumor

	FS		VAS	
No.	Preoperative	Postoperative	Preoperative	Postoperative
1	D	E	4	1
2	D	E	5	0
3	E	E	5	1
4	E	E	7	0
5	D	E	4	1
6	E	E	3	0
7	C	E	6	0

FS indicates Frankel score; VAS, Visual analogue scale.

The mean follow-up duration was 27.4 (9–51) months in this case series. All the patients were able to walk independently with certain protection about 3 to 4 weeks after the operation. In all, postoperative Frankel score and VAS score improved significantly compared with preoperation. At the last follow up, two patients died of systematic disease development. One patient was alive with metastatic tumor of thoracolumbar level after 42 months. The other four patients recovered well without evidence of disease (Tables 1 and 2).

ILLUSTRATIVE CASE PRESENTATION

A 68-year-old man (Case 6) with intermittent lumbar pain for 8 months came to our center for medical help. Lumbar MRI revealed patchy areas, a hypointense T1 signal, and a slightly hyperintense T2 signal in L5 vertebra, which were obviously enhanced after injection of the contrast. CT scan showed non-uniformity density of L5 vertebra and bone destruction. CT contrast-enhanced showed non-uniform enhancement. PET/CT revealed a single lesion in L5 vertebra. All the images suggested the diagnosis of primary tumor of L5 vertebra. To get the lesion resected through total en bloc mode, we decided to adopt the new technique after the needle biopsy. Preoperative embolization of the feeding arteries of the tumor was conducted.

A common straight midline incision was made from L3 to S2. After dissecting the essential muscles and soft tissue, eight suit pedicle screws were implanted into L3/4 and S1/2. Afterwards, the posterior elements of L5 were removed as a whole. The nerves and dura matter were dissected and protected. Subsequently, the right L5 vertebra and paravertebral tissues were dissected according to the methods mentioned above. After dissecting the muscles from the iliac crest, trajectories in the left iliac were made with two 60-mm screws inserted and then taken out. The iliac wing osteotomy was carried out using methods mentioned above. The iliac graft was removed and preserved temporarily (Figure 2A–G).

Nerves of the left were dissected caudally to gain larger space between L4 and L5 nerve. With the enlarged view and operation space, dissection between the left tissues and vertebra body was performed more easily and safely. After cutting the L4/5 and L5/S1 disc with an osteotome, a rod was fixed to the right screws. The L5 vertebra was pulled and rotated out from the expanded space (Figure 2). After complete hemostasis, an artificial vertebra filled with allogeneic bone was used to reconstruct the anterior column, followed by the left rod-screws connection. The iliac graft was fixed back with the previous screws and trajectory.

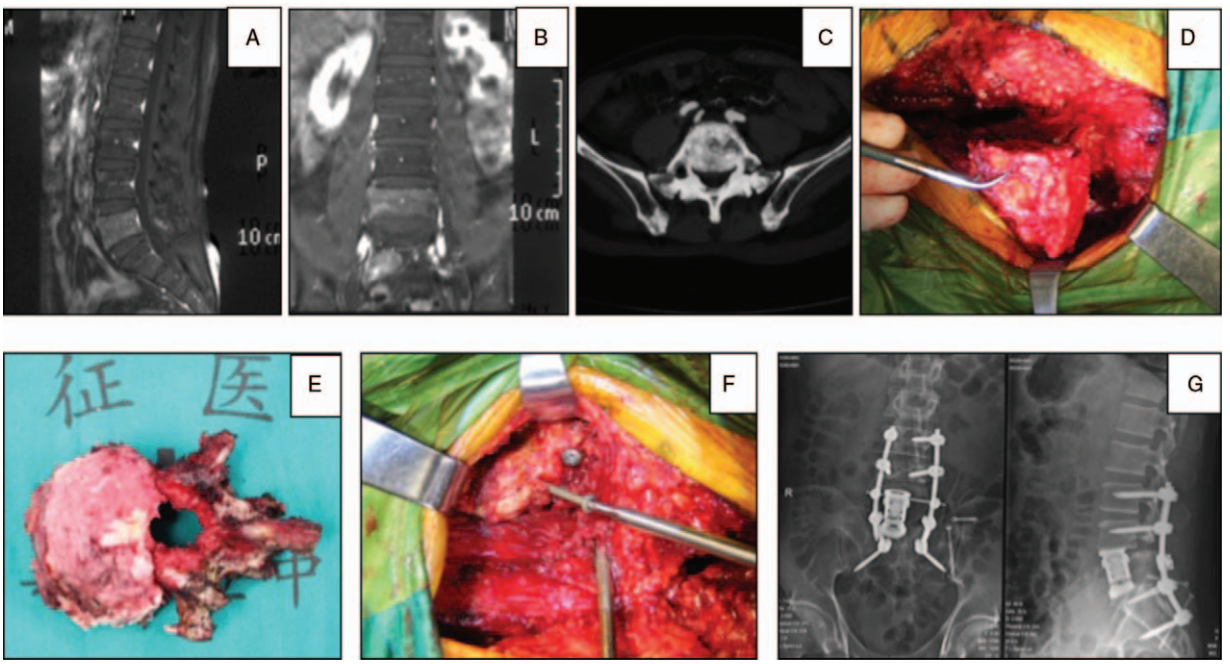

Figure 2. (**A**–**C**) Preoperative images revealed a vertebral lesion of the fifth lumbar. (**D**–**F**) Intraoperative images include fabrication of the iliac graft, en bloc spondylectomy of L5, and the replacement of the graft. (**G**) Postoperative x-ray.

DISCUSSION

The goal of surgical treatment for vertebral tumors is to achieve tumor removal, spinal decompression, reconstruction, and stabilization. Curettage and piecemeal resection may alleviate the symptoms and achieve tumor control to a certain degree, but it runs the high risk of tumor cell contamination and recurrence. As TES can improve the overall survival (OS) and tumor control effectively, it has been recommended as the optimal technique for primary malignant, aggressive, and solitary metastatic spine tumors.[1,3,9,14]

Although TES of the thoracic spine and upper lumbar spine (at L3 or cephalad) tumors through the posterior-only approach is a mature technique at present,[1,3,7,15] it remains a big challenge for tumors of the lower lumbar (L4/5). In our previous study,[10] we had reported total en bloc spondylectomy for solitary metastatic tumors of the fourth lumbar spine through the posterior-only approach with excellent results. However, it is rather difficult at the L5. On one hand, the vertebral body is buried deep because of the large degree of lumbosacral spine lordosis. On the other hand, blockage of the iliac wings adds difficulty for exposing and resecting the vertebral and paravertebral mass. And, the vital and complex anatomies including nerve roots and major vessels make posterior-only resection almost impossible. Brau *et al*[16] reported that the vessel injury appeared mainly at the L4 to L5 level, occupying about 1.9% when performing anterior surgery. In addition, as L5 is the largest vertebral body, the L4 and L5 nerve roots or the dural tube is likely to be injured when it is being dissected and rolled out. Finally, blockage of the iliac wings and limited space between L4/5 nerves increase difficulty of reconstruction through the posterior approach.[1,2] Therefore, posterior-only approached TES of the L5 tumor takes a great risk.[1,6,8]

With these challenging factors taken into account, a combined posterior–anterior approach is often strongly recommended, but it implies a longer operation time, larger trauma, more blood loss, and more complications.[1,2,4,6,14,17] Despite these difficulties, we still tried to explore feasible solutions for TES of L5 via the posterior-only approach. In our opinion, the above difficulties may be solved with the help of iliac graft. To the best of our knowledge, this is the first cases series report focused on the TES of L5 tumors through the posterior-only approach.

In this technique, osteotomy of the iliac crest was carried out from the level of L5/S1 disc horizontally with a thin osteotome, followed by another osteotomy made from the midpoint of the anterior superior iliac spine and posterior superior iliac spine, paralleling with the spine or slightly oblique to the sacrum. Such osteotomy avoids damage to the sacroiliac joint, important vessels, and nerves. In addition, it is of no influence to the stability of spine. And, muscle weakness due to the osteotomy is limited. With this newly designed approach, it not only provides a more expanded vision and space to expose to prevertebral space more easily and safely, but also makes it possible to dissect the nerves toward caudally. As the space between L4/5 nerves is enlarged, injury to the nerve roots and dural tube can be avoided during processing rolling out the tumor and installing the prosthesis.

Of course, completion of the L5 TES is a real challenge because it requires skillful technology. Instead of using the fingers, dissection of the tissue and vertebra was performed by using the dissectors that match the vertebra wall, which to some extent solves the problem of deep location of L5 vertebra. Simultaneously, surgical hemostatic gauze was filled into the dissection space to avoid or control blood loss. Due to the deep location of L5 vertebra and iliac blockage, it is difficult to cut the intervertebral disc with the surgical T-saw. Instead, we used a thin and sharp osteotome to divide the disc and perform iliac graft osteotomy. In addition, the trajectory for the iliac graft replacement should be designed before osteotomy to guarantee the accurate graft location. After finishing the resection and reconstruction, the iliac graft was fixed back via the primary screw holes.

Patients in our study were permitted to walk independently with the help of a walker and a protective clothing 3 to 4 weeks after operation. Data of Table 2 indicated significant improvement of the neurological function and degree of pain. During a mean follow-up period of 27.4 months, no serious perioperative complications such as hemorrhage, infection, internal fixation failure, prosthesis dislocation, serious nerve injury, or balloon-associated complications such as thrombosis, hematoma, and pseudoaneurysm occurred. Undesirable wound healing with little effusion occurred in one patient, which was cured gradually after continuous suction and meticulous dressing change. Another patient sustained traction injury of the L4 and L5 nerves, resulting in numbness of the left lower limb, which was alleviated significantly after 4-week treatment of mecobalamine without causing significant motion problem.

Some adjuvant measures, including the use of the distilled water containing cisplatinum, abdominal aorta ballooning and appropriate adjuvant therapy, guaranteed excellent follow-up results of this novel technique. Previous literatures[18,19] reported that balloon occlusion could decrease the intraoperative blood loss in patients of lower lumbar and sacral tumors and reduce related complications. All the cases in this study received preoperative embolization of the feeding artery including balloon occlusion in two patients within 24 hours before the operation to reduce blood loss. The abdominal aorta balloon was used for 1 to 1.5 hours with no associated complications. To our astonishment, the adventitia of the abdominal aorta was torn in Case 1 during dissection of the tumor mass. Thanks to the use of the abdominal aorta balloon, we were able to suture the vessel unhurriedly and avoided serious consequences. In conclusion, the use of embolization and balloon occlusion intraoperatively benefits this novel technique.

According to literatures,[1,14] distilled water with a high concentrated cisplatinum is beneficial to tumor control. Distilled water containing cisplatinum (0.5 mg/mL) was used in the present study to eradicate the possible

contaminated tumor cells. It is common knowledge that cancer treatment should be an integrated process. Adjuvant treatments including chemotherapy, radiotherapy, targeted therapy, and I131 were prescribed according to postoperative pathologies in all seven patients in this series to enhance the efficacy of total en bloc spondylectomy of L5 tumor through this technique.

CONCLUSION

Total en bloc spondylectomy of the L5 tumor can be achieved via this modified posterior-only approach with good results and limited complications. As an adjuvant method of the posterior approach, this transiliac approach widens the surgical field and space, therefore facilitating tumor resection and reconstruction at this level in a safer and more efficient manner.

➢ Key Points

- TES for L5 tumor through the posterior-only approach is still a great challenge. Usually, a combined posterior–anterior approach is required.
- ❑ In this study, we introduced a new technique that combined with the use of iliac graft. As a result, all the patients received one stage TES through the posterior-only approach with excellent results.
- ❑ With this new technique employed, satisfied exposure, total en-bloc spondylectomy, reliable reconstruction and well tumor control can be attained for certain L5 tumors through the posterior-only approach.

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