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Clinical Efficacy of Laminectomy with Instrumented Fixation in Treating Thoracolumbar Intradural Extramedullary Schwannomas: A Comparative Study

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Data Interpretation D
Manuscript Preparation E
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Background: This study investigated the clinical effect of laminectomy plus pedicle screw fixation in treating thoracolumbar intradural extramedullary schwannomas.

Material/Methods: Between October 2011 and May 2017, 57 patients undergoing resection of thoracolumbar schwannomas were retrospectively identified and included in the study. Based on the surgical procedures used, all participants were assigned to either the laminectomy-only group (n=33) or the combination group (laminectomy plus pedicle screw fixation, n=24). All participants were followed up for over 2 years. In the laminectomy, the spinal process, vertebral laminae, and bilateral upper articular processes of the surgical segments were completely resected and the lower articular processes were reserved. For further analysis, we evaluated the pain levels using visual analogue scale (VAS) score. The assessment of neurological function was performed with Japanese Orthopaedic Association (JOA) score and Oswestry disability index (ODI). The comparisons of Cobb angle changes were carried out pre-surgery and post-surgery.

Results: The demographic data were well matched between the laminectomy-only group and combination group, without significant differences ($P>0.05$). After surgery, both surgical procedures achieved significant improvement in VAS score, ODI, and JOA score ($P<0.001$), but no significant differences were found between these 2 surgical procedures ($P>0.05$). The postoperative change in Cobb angle indicated a significant difference in the laminectomy-only group, but not in the combination group ($P<0.05$). In addition, postoperative spinal instability/deformity was found in the laminectomy-only group ($P<0.05$).

Conclusions: In conclusion, the combination of laminectomy and pedicle screw fixation is a safe and effective surgical procedure when used to treat thoracolumbar schwannoma, and appears to be superior to the laminectomy-only procedure.

MeSH Keywords: **Laminectomy • Neurilemmoma • Spine • Surgical Instruments**

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Background

Primary tumors in the spinal column that derive from the neural elements account for only a small proportion (5%) of adult primary central nervous system tumors [1–3]. They can occur in various anatomical regions and can be intramedullary, extradural, intradural extramedullary, and intradural dumbbell-like tumors, which can be either intraspinal or extraspinal. Intramedullary tumors are primarily glial (ependymomas and astrocytomas), whereas extradural tumors include hematopoietic tumors, primary bony tumors, and metastases. Intradural extramedullary type spinal cord tumors primarily include peripheral nerve sheath tumors and meningiomas. Schwannoma, a neurogenic tumor originating from Schwann cells, is the most common intradural extramedullary tumor [4–7].

Neurogenic claudication and radiculopathy are the 2 main symptoms of intradural extramedullary schwannomas, and occur due to spinal cord compression as the tumor grows [8,9], and usually cause worsening sensory and even motor loss, as well as the back pain resulting from tumor compression. The annual incidence of spinal schwannoma is relatively low, and patients with these tumors are generally in their 4th or 5th decades of life [10]. Considering the similarity in clinical manifestations and characteristics of clinical imaging, intradural extramedullary schwannomas are sometimes incorrectly diagnosed as intervertebral disc herniation. Surgical resection of tumors by laminectomy is still the best therapeutic strategy for intradural extramedullary schwannomas. However, laminectomy without internal fixation can result in spinal instability, even spinal deformity formation, due to damage to the posterior column structure [11–14].

Thus, this study only focused on patients with thoracolumbar intradural extramedullary schwannoma in an effort to control potential bias. We concentrated on the clinical effect of the posterior resection of tumors in treatment of schwannomas by comparing laminectomy plus pedicle screw fixation *vs.* laminectomy-only, with a follow-up of at least 2 years.

Material and Methods

Ethics statement

The study was approved by the Ethics Committee of Hebei Medical University Affiliated Third Hospital. All participants provided informed consent. The methods used in this study complied with all relevant regulations and guidelines.

Patient selection

Before starting the study, we calculated the sample size needed in terms of the efficacy of the difference about Cobb angle changes (*http://powerandsamplesize.com/Calculators/*). The minimum sample size needed was n=46 (23: 23), when α=0.05, β=0.1, and loss of follow-up set as 0.1. Our sample size was n=57 (33: 24). As such, the power of test for the efficacy of the difference about Cobb angle changes showed more than 0.9. We searched the medical records of all patients to identify those who had undergone gross-total resection of thoracolumbar intradural extramedullary schwannomas by using total laminectomy, regardless of instrumented fixation, as shown in Figure 1. All patients received surgical treatment for the first time after the diagnosis and had no similar disease history previously. No other concurrent tumors existed at the same time. No other diseases that would cause any spinal column changes were diagnosed during the follow-up period, including severe osteoporosis, ankylosing spondylitis, and spine trauma. Patients were excluded if a reoperation was performed due to recurrence. All participants were followed up at 3 and 12 months after surgery and at the last follow-up after surgery (2 years or longer).

Clinical assessment

Clinical evaluation was carried out and the radiological Cobb changes in the sagittal plane were compared before surgery and at 3 and 12 months after surgery, and at the last follow-up after surgery (2 years or longer). The measurement of radiographic parameters used to assess spinal stability is shown in Figure 2, as reported previously [15–17]. All measurements were performed 3 times by our 3 investigators and mean±SD (standard deviation) were finally calculated and recorded. Spinal instability was defined as sagittal displacement between flexion and extension than 4 mm and sagittal rotation between flexion and extension more than 10° [17–19].

Pain was assessed using the visual analogue scale (VAS) score. Neurological and functional assessments were determined using the Japanese Orthopaedic Association (JOA) score and Oswestry disability index (ODI), respectively. The JOA score assigns 29 points for the lumbar spine [20] and 11 points for the thoracic spine [21,22]. In addition, postoperative complications were collected and analyzed. Finally, patient satisfaction analysis was made based on records in the questionnaires, which were graded into 3 levels: very satisfied, satisfied, and dissatisfied.

Statistical analysis

In this study, statistical analyses were performed using SPSS for windows 18.0 (IBM SPSS, Inc., Chicago, IL). VAS score, JOA score, and ODI are shown as median (interquartile range, IQR) and were compared with nonparametric tests. Measurement data are shown as mean±SD. The pre- and post-surgery comparisons of radiographic parameters were made using analysis of variance (ANOVA), followed by post hoc SNK-q tests or

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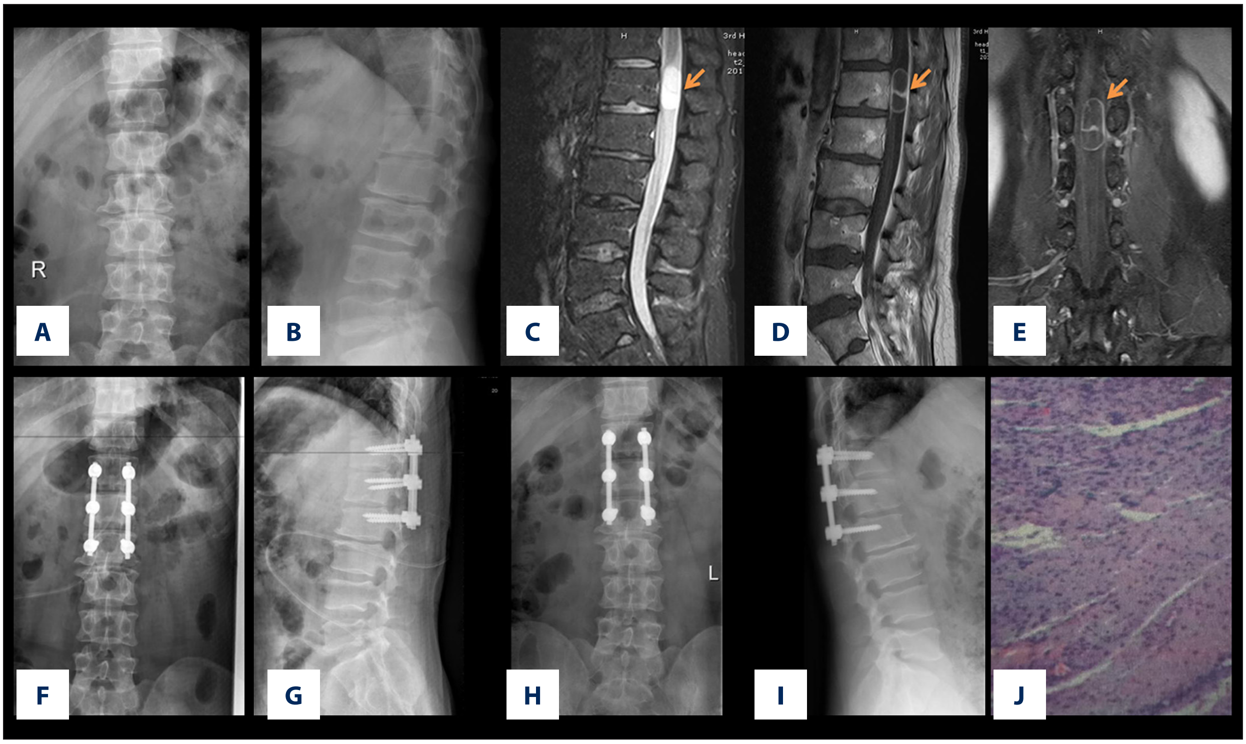

Figure 1. Pre- and postoperative radiological images and MRI scan. (**A, B**) preoperative X-ray images; (**C**) preoperative T2-weighted MRI scan; (**D, E**) preoperative enhanced T1-weighted MRI scan; (**F, G**) postoperative X-ray immediately; (**H, I**) postoperative X-ray at last follow-up; (**J**) histopathological test report: S-100 (+), GFAP (–), CD56 (+), Ki-67 (+, <5%), EMA (+), Desmin (–), SOX-10 (+).

Dunnett's T3 tests. Comparisons of demographic data and surgical parameters were conducted using the *t* test. Analyses of categorical data were carried out with chi-square tests (including Fisher's exact test). The significance level was set as $P<0.05$.

Results

Demographics and baseline data

Between October 2011 and May 2017, 57 patients undergoing resection of thoracolumbar intradural extramedullary schwannomas were identified and retrospectively enrolled into this study. There were 2 patient groups due to the different surgical approaches performed: the laminectomy-only group (n=33) and the laminectomy with instrumented fixation group (n=24), with a 2-year follow-up period as the minimum. As shown in Table 1, the mean age in the laminectomy-only group was 51 years, ranging from 17 to 83 years, and mean age in the instrumented fixation group was 49.3 years, ranging from 16 to 80 years. There were 18 males and 15 females in laminectomy-only group, and 12 males and 12 females in instrumented fixation group. Prior to surgery, duration of symptoms was 6.5±4.8 months in the laminectomy-only group and 7.4±5.3 months in the instrumented fixation group. The period of follow-up was 59.1±17.3 months in the laminectomy-only group and 54.8±16.1 months in the instrument fixation group. No significant differences were found between the 2 groups in terms of age, sex distribution, duration of symptoms, follow-up, amount of bleeding, or length of hospital stay (all $P>0.05$). However, the instrumented fixation group received more blood transfusions, had longer surgical times, and had higher expenses for medical treatment compared to the laminectomy-only group (all $P<0.01$). The segmental distribution of thoracolumbar schwannoma is displayed in Table 2.

VAS score and ODI

As shown in Table 3, the VAS score preoperatively was 5 (IQR 2) and 1 (IQR 1) at the final follow-up in the laminectomy-only group and 5 (IQR 3) and 1 (IQR 0) in the laminectomy+fixation group. As displayed in Table 4, the preoperative ODI was 60% (IQR 30%) and 10% (IQR 5%) at last follow-up in the laminectomy-only group and 60% (IQR 25%) and 10% (IQR 5%) in the laminectomy+fixation group. Statistically, VAS score and ODI in both groups were improved compared to preoperative scores (all $P<0.001$). However, no significant differences were identified between the 2 groups in VAS score or ODI score (all $P>0.05$).

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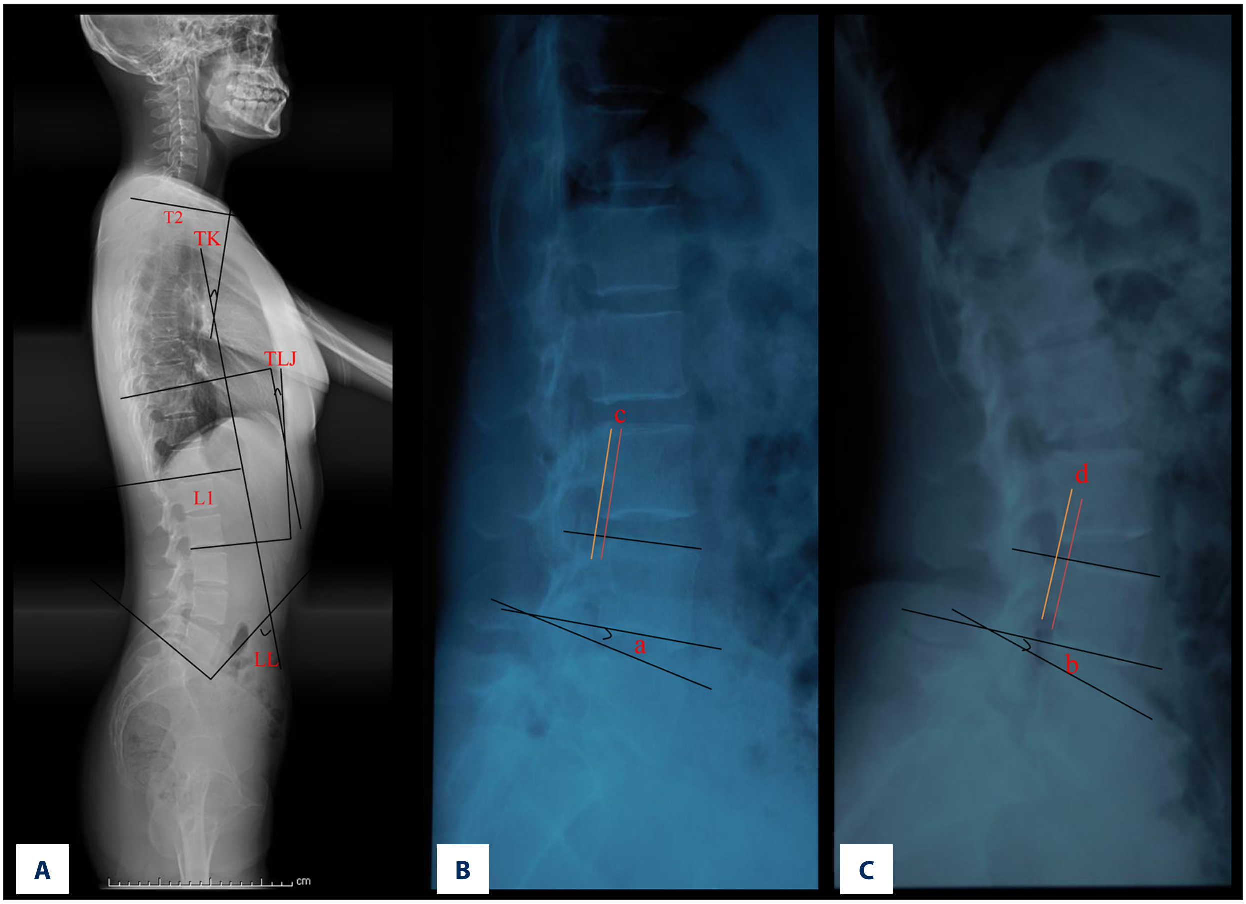

Figure 2. Radiographic parameter measurement used to evaluate spinal stability. (**A**) X-ray, sagittal plane of the full-length spine; (**B**) X-ray, sagittal plane with flexion; (**C**) X-ray, sagittal plane with extension. TK – thoracic kyphosis; TLJ – thoracolumbar junction; LL – lumbar lordosis; sagittal rotation=b–a; sagittal displacement=d–c.

Table 1. Demographic data and surgical information.

Items	Laminectomy-only (N=33)	Laminectomy+fixation (N=24)	P-value
Age (yr)	51.2±17.1 (17–83)	49.3±15.4 (16–80)	0.672
Sex	18/15 (M/F)	12/12 (M/F)	0.734*
Duration of symptom	6.5±4.8 months	7.4±5.3 months	0. 506
Follow-up (months)	59.1±17.3 (27–84)	54.8±16.1 (24–87)	0.342
Blood loss (ml)	460±270 (200–1500)	596±353 (250–1400)	0.107
Blood transfusion (ml)	79±180 (0–800)	268±279 (0–800)	0.006
Surgical duration (min)	146.1±40.6 (60–270)	197.5±58.2 (105–290)	0.001
Hospital stay (days)	18.5±5.9 (9–38)	17.9±4.8 (11–31)	0.648
Medical expenses	¥ 12284±3612	¥ 41508±4182	<0.0001

* By Pearson Chi-square test; the other analyses were determined by independent t tests.

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Table 2. Segmental distribution of schwannomas.

Level	Laminectomy-only (N=33)	Laminectomy+fixation (N=24)
T1–2	0	1
T4–5	0	1
T5–6	1	1
T6	0	1
T7–8	0	1
T9	0	1
T9–10	0	1
T9–11	1	0
T10–11	1	1
T11–12	1	1
T12–L1	3	1
T12–L2	1	0

Level	Laminectomy-only (N=33)	Laminectomy+fixation (N=24)
L1	2	1
L1–2	2	3
L1–3	1	0
L2	1	3
L2–3	4	3
L3	2	1
L3–4	5	1
L4	2	0
L4–5	4	1
L5	1	0
L5–S1	1	1

Table 3. Comparison regarding VAS score.

Groups	Pre	PO 3 months	1 year	Last follow-up	P-value*
Laminectomy-only	5 (IQR 2)	3 (IQR 1)	2 (IQR 1)	1 (IQR 1)	0.001
Laminectomy+fixation	5 (IQR 3)	3 (IQR 2)	2 (IQR 1)	1 (IQR 0)	<0.001

VAS – visual analogue scale; Pre – preoperation; PO – postoperation; IQR – interquartile range. * Comparison within groups.

Table 4. Comparison regarding ODI.

Groups	Pre (%)	PO 3 months	1 year	Last follow-up	P-value*
Laminectomy-only	60 (IQR 30)	30 (IQR 20)	15 (IQR 10)	10 (IQR 5)	<0.001
Laminectomy+fixation	60 (IQR 25)	25 (IQR 15)	15 (IQR 10)	10 (IQR 5)	<0.001

ODI – oswestry disability index; Pre – preoperation; PO – postoperation; IQR – interquartile range. * Comparison within groups.

Table 5. Comparison regarding JOA score.

Groups	Pre	PO 3 months	1 year	Last follow-up	P-value*
JOA-T (11 points)					
Laminectomy-only	4 (IQR 3)	6 (IQR 3)	7 (IQR 2)	9 (IQR 2)	<0.001
Laminectomy+fixation	4 (IQR 3)	6 (IQR 2)	8 (IQR 2)	9 (IQR 1)	0.0001
JOA-L (29 points)					
Laminectomy-only	10 (IQR 5)	13 (IQR 4)	17 (IQR 2)	20 (IQR 2)	<0.001
Laminectomy+fixation	10 (IQR 6)	13 (IQR 5)	16 (IQR 2)	20 (IQR 1)	<0.001

Pre – preoperation; PO – postoperation; JOA-T – Japanese Orthopaedic Association score (Thoracic spine); JOA-L – Japanese Orthopaedic Association score (Lumbar spine); IQR – interquartile range. * Comparison within groups.

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Table 6. Comparison regarding sagittal Cobb angle change.

Groups	PO 3 months	1 year	Last follow-up#	P-value*
Laminectomy-only	1.6±1.5	2.7±2.3	3.6±3.1	0.0014
Laminectomy+fixation	0.4±2.2	0.6±2.4	1.0±2.1	0.3389

PO – postoperative; Cobb angle change=postoperative angle–preoperative angle. # P=0.0007, comparing Laminectomy+fixation with Laminectomy group at last follow-up. * Comparison within groups.

Table 7. Summary of postoperative complications.

Complications	Laminectomy-only	Laminectomy+fixation	P-value*
New/worsening sensory symptom	3 (9.1%)	1 (4.2%)	0.847
New/worsening weakness	2 (6.1%)	1 (4.2%)	1.000
CSF leak/pseudomeningocele	2 (6.1%)	2 (8.3%)	1.000
Wound infection	1 (3.0%)	2 (8.3%)	0.776
Spinal instability	8 (24.2%)	1 (4.2%)	0.092
Spinal deformity	2 (6.1%)	0 (0.0%)	0.504
Spinal instability/deformity	10 (30.3%)	1 (4.2%)	0.033

CSF – cerebrospinal fluid. * By Pearson chi-square test or Fisher's exact test.

Table 8. Patient satisfaction grades.

Groups	Very satisfied	Satisfied	Dissatisfied	Statistic*
Laminectomy-only (N=33)	23 (69.7%)	8 (24.2%)	2 (6.1%)	χ^2=1.704
Laminectomy+fixation (N=24)	18 (75%)	3 (12.5%)	3 (12.5%)	P=0.427

* Pearson Chi-square test between Laminectomy+fixation and Laminectomy group.

JOA score

The JOA-T score was 4 (IQR 3) before surgery and 9 (IQR 2) at final follow-up in the laminectomy-only group, whereas JOA-T score was 4 (IQR 3) before surgery and 9 (IQR 1) at final follow-up in the laminectomy+fixation group (Table 5). The pre-surgical JOA-L score was 10 (IQR 5) and 20 (IQR 2) postoperatively at final follow-up in the laminectomy-only group, whereas the JOA-L score preoperatively was 10 (IQR 6) and 20 (IQR 1) postoperatively at last follow-up in the laminectomy+fixation group. We found significant within-group differences in JOA scores when comparing the postoperative data to the preoperative scores (P<0.001). However, no significant differences were found between the 2 groups in JOA-T score or JOA-L score (all P>0.05).

Radiographic parameters and complications

As shown in Table 6, postoperative Cobb angle change was 3.6±3.1 degrees at last follow-up in the laminectomy-only group, with a significant difference (P=0.0014), but not in the laminectomy+fixation group (1.0±2.1 degrees, P=0.3389). Additionally, the laminectomy+fixation group achieved better spinal stability in comparison with the laminectomy-only group at last follow-up (P=0.0007).

Table 7 summarizes the main postoperative complications. Statistical analyses revealed that spinal instability, even deformity formation, was more common in the laminectomy-only group compared to the laminectomy+fixation group (P=0.033). We found no other significant differences between these 2 surgical procedures regarding other complications (all P>0.05).

Patient satisfaction

We found no significant differences between the 2 groups in terms of patient satisfaction grades (χ^2=1.704, P=0.427) (Table 8), and most patients were very satisfied with their treatment results.

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Discussion

In a clinical setting, schwannomas are the most common spinal intradural nerve sheath tumors, followed by neurofibromas [23]. Schwannomas generally consist of many proliferative Schwann cells. The common clinical symptoms caused by schwannomas are similar to those of cauda equina syndrome, including muscle weakness and numbness of the lower limbs, bowel dysfunction, and urinary retention [11,24]. Due to the similarity in clinical symptoms and the characteristics of clinical imaging, intradural extramedullary schwannomas can be misdiagnosed as intervertebral disc prolapse or spinal canal stenosis. Surgical resection of tumors by laminectomy is still regarded as the best treatment for spinal intradural extramedullary schwannomas. Total laminectomy without internal fixation can lead to iatrogenic spinal instability, and even progress towards spinal deformity, due to damage to the posterior column structure, including the bony structure of the posterior ligament complex [6,11–14]. Standard surgery usually includes laminectomy for sufficient exposure of the tumor, with facetectomy needed in some cases. Instrumented fixation can be imperative to keep spinal stability and to decrease postoperative complications such as spinal deformity due to spinal instability. However, the contributing factors related to the need for instrumented fixation during tumor resection remain elusive. The factors influencing instrument fixation during the resection of intraspinal tumors have not been well documented. A recent study [14] (n=56) conducted logistic regression analysis and found that total facetectomy and cervicothoracic involvement are strongly associated with the need for instrumented fixation during an intraspinal tumor resection surgery. These findings can help surgeons to decide on the best surgical strategies for patients with intraspinal tumors.

Total laminectomy is regarded as a safe and effective technique when used to treat intraspinal schwannomas. However, some evidence indicates that the incidence of approach-related complications will increase, particularly the postoperative progression of spinal deformity due to spinal instability [6,11,14]. In contrast to the laminectomy-only approach, the advantages of instrumented fixation are evident, as indicated by the results observed in this study. Overall, there were 57 patients undergoing resection of thoracolumbar intradural extramedullary schwannomas; all were retrospectively identified and enrolled in the present study. According to the surgical procedures, the patients were divided into 2 groups: the laminectomy-only group (n=33) and the laminectomy with instrumented fixation group (n=24), with a minimum follow-up period of 2 years. The 2 groups were well matched and were suitable for comparisons. Between the 2 groups, no significant differences were identified in baseline demographics, including age, sex ratio, symptom duration, follow-up period, amount of bleeding, and length of hospital stay (all P>0.05). We found that the instrumented fixation group required more blood transfusion, had longer surgical time, and had higher expenses for medical treatment as compared to the laminectomy-only group. It makes sense that more blood transfusion was needed in instrumented fixation group because instrumented fixation surgery takes more time and entails more blood loss; however, because the surgeons were well-trained and proficient enough to control the bleeding during the operation, there was not a significant difference in blood loss between the 2 groups in this study. Use of instrumented fixation is inherently more expensive.

Adjacent segment degeneration is defined as radiographic changes reflecting degeneration at levels adjacent to a spinal fusion, while adjacent segment disease is the occurrence of new clinical symptoms due to adjacent segment degeneration [25]. Adjacent segment degeneration is an important complication that can occur after spinal surgeries, especially after spinal fusion and fixation, because of the increased facet loads and adjacent level motions [26,27]. However, there are conflicting results regarding the correlation between adjacent segment degeneration and spinal fusion (and instrumentation) [25,28,29]. Spinal instability is one of the radiographic changes that can be used to indicate adjacent segment degeneration. Thus, our study did not find any difference in terms of adjacent segment degeneration between the laminectomy-only group and the laminectomy+fixation group.

In this study, VAS score and ODI were analyzed for pain assessment. Statistically, the VAS score and ODI in both groups were greatly improved after surgery, but no significant differences were found between the 2 groups. Furthermore, JOA scores in both groups achieved postoperative improvements. However, no significant differences were detected between the 2 groups in JOA-T score or JOA-L score. The neurological function was much improved, which is not only indicated by most patients being very satisfied with their treatment results, but is also in line with some previous reports that documented the improvements caused by laminectomy with or without internal fixation [4,30]. Here, it cannot be neglected that there is a close correlation between functional scores and radiographic parameters, including sagittal balance parameters [31,32]. It has been reported that better functional outcomes and better quality of life would be achieved if the sagittal balance is restored in treating degenerative lumbar scoliosis [31]. In addition, sagittal vertical axis and T-1 spinopelvic inclination have been identified in as being closely correlated with some clinical scores [32].

To evaluate spinal column change resulting from different surgical procedures, Cobb angle changes in the sagittal plane were documented and analyzed in both groups. The postoperative Cobb angle change in the laminectomy-only group was significant, but not in the instrumented fixation group. Additionally, the instrumented fixation group achieved better spinal stability than the laminectomy-only group at last follow-up (1.0±2.1 degrees *vs.* 3.6±3.1 degrees, P=0.0007). The main postoperative complications we collected for analysis included new/worsening sensory symptoms, new/worsening weakness, CSF leak/pseudomeningocele, wound infection, and spinal instability/deformity.

The statistical analyses by Fisher's exact test showed no significant differences between the 2 groups in "spinal instability" or "spinal deformity" (P=0.092 and P=0.504, respectively). However, as a whole, the "spinal instability/deformity" between the 2 groups showed a significant difference (P=0.033). Such a statistical result is very interesting, indicating that pedicle screw fixation has indeed made a positive difference regarding the maintenance of spinal stability after laminectomy surgery. It was revealed that spinal instability, even deformity formation, tended to occur more in the laminectomy-only group. Also, we calculated the sample size needed for this study in terms of the effectiveness of the final Cobb angle changes, showing that the sample size needed was n=46 (23: 23), when α=0.05, β=0.1, and loss to follow-up set as 0.1. Our actual sample size was n=57 (33: 24). Hence, the power to demonstrate a significant difference in Cobb angle changes was more than 0.9, which is quite high.

Some limitations in this study should be stated. Firstly, the retrospective character of this study is likely to have produced a selection bias. In addition, this was only a simple comparative study. Last but not the least, the sample size we used in this study was not large, which might limit the power of tests. A prospective randomized clinical trial with a large enough sample is needed to confirm our results.

Conclusions

Laminectomy with instrumented fixation is an effective and safe treatment of thoracolumbar intradural extramedullary schwannoma, and is perhaps a better choice than laminectomy-only, especially in maintaining dynamic stabilization of the spinal column after surgery.

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