Effect of retention of posterior longitudinal ligament complex on Spinal deformity and motor after spinal intraspinal tumors in adult and pediatric

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Research Article

Keywords: posterior ligaments complex, Intradural spinal tumor, Spinal deformity, Laminoplasty, pain

Posted Date: March 14th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1421191/v1

Abstract

Backgrounds

In most cases, complete resection of intranervous tumors and long-term neurological function can be achieved. However, some patients consider progressive postoperative spinal deformity as a postoperative complication.

Objective

We investigated that the posterior ligament complex obtained during laminoplasty can reduce spinal deformities and improve mobility, pain, and quality of life.

Methods

We retrospectively reviewed the data of more than 218 consecutive patients who underwent intrascleral tumor resection at one institution. The quality of life, painful cortex, spinal cord movement, progressive kyphosis or scoliosis, perioperative morbidity, and neurological results were compared in the laminoplasty and laminoplasty ligament groups.

Results

155 patients underwent laminoplasty and 63 patients underwent ligament complex after laminoplasty. The patient's age was 42 ± 2.3 years, and the average modified McCormick score was 2. There were 158 (72.4%) intramedullary tumors and 115 (52.7%) extramedullary tumors. The average residence time of the ligament complex after laminoplasty was shortened (8 days vs. 6 days; $p = 0.023$) and hospital recovery time (48.4% vs. 26.9%; $p = 0.012$). 8 cases of laminoplasty (3%) and 3 cases of laminoplasty (1%) retained posterior ligament syndrome. Progressive spinal deformities occur an average of 20 months after surgery and an average of 18 months after surgery. Spine deformity. Maintaining the posterior ligament complex during laminoplasty can improve VAS assessment and spinal mobility.

Conclusion

The treatment of the posterior ligament complex during laminoplasty does not significantly affect spinal deformities, but significantly improves postoperative spinal activity, pain symptoms, and hospitalization.

Introduction

Intrathecal tumors was account for 30% of all primary vertebral body tumors[1]. In addition, the main symptom of intrathecal tumors is pain, headstand or nocturnal seizures[2]. With the advancement of microsurgery, the surgical treatment of intramedullary tumors has made great progress[3 4]. This type of surgery was usually associated with improved survival rates and better quality of life[5 6]. However, despite the promotion of minimally invasive surgical techniques, vertebral body deformities still has serious consequences [6].

Spinal deformity presents with severe, rigid, angular kyphoscoliosis or kyphosis with severe clinical symptoms, which often arises surgical management[7]. Spinal deformity was also a common complication in interadural spinal tumor resection, with an incidence rate of about 10% in adults and 22%-100% in children[8 9]. Retaining harmonious coronal and sagittal

spinopelvic alignment ligaments are one of the most important methods for spinal deformity surgery[10]. Besides, during interadural spinal tumor resection, it was very important to relieve nerve compression by removing all or part of the posterior elements, including the lamina, spinous process, supraspinous ligament and interspinous ligament, ligamentum flavum, and facet joints. However, posterior longitudinal ligament complex (including spinous process) plays an important role in maintaining spinal activity and preventing postoperative spinal deformity which acts as the posterior tension band and can be effective on preventing adjacent segment degeneration[11 12]. Therefore, the effect of retaining the posterior ligament complex on improving spinal malformation after surgery in patients with interadural spinal tumor resection needs further study.

In our study, we investigated the role of the posterior ligament complex on spinal deformity in patients after surgery, and our hypothesis was that retaining the posterior ligament complex can reduce the incidence of spinal deformity after resection of interadural spinal

tumors.

Materials And Methods

Patients and methods

This study was a retrospective study and included patients who underwent interscleral tumor resection at our hospital from 2000 to 2018. Before 2010, all patients chose laminoplasty without maintaining the integrity of the posterior ligament complex. After 2010, they chose single-port laminoplasty to maintain the integrity of the posterior ligament complex. The criteria for patient selection were that all patients have been diagnosed with intramedullary cancer. Preoperative and postoperative T1 and T2 ± axial, relaxation, and coronary magnetic resonance imaging (MRI), and if necessary, spinal computed tomography (CT). This study was approved by our Hospital’s Ethics Committee. All patients had the consent and sign an informed consent form(fIgure1).

Surgical Technique

For laminoplasty without retaining the posterior ligament complex described in pervious study[13], only the subperiosteal paravertebral muscles were removed, and the posterior ligament complex was not retained to expose the medial joints. We try to protect the joint capsule in all cases. The Leksell rongeur was used to remove the tail prosthesis and intervertebral ligaments from the laminoplasty segment. The spinal growth of the laminoplasty segment remained intact to maintain the intervertebral and yellow ligament. Then a small hole was made on tail plate with a 2-mm Kerrison puncture and partial laminectomy to create a groove for the purchase of the eyelid pedal, and to identify the hard shell before drilling. Besides a bilateral rosacea-caudal laminectomy was performed, and the entire laminectomy segment was continuously removed. the width of the laminoplasty was adjusted relative to the spinal canal. Then used 1-mm Kerrison Bite forceps to remove the yellow bandage, and used a curette to lift the laminoplasty segment to expose the sclera. The tumor was inserted and removed through an incision in the sclera along the midline of the tumor length. After the tumor was removed and the primary sclera was closed, the blade was re-approached and fixed with a titanium microplate. Finally, the paravertebral muscles were closed with a blade and sutured to the deep part of the intervertebral ligament.

During laminoplasty, the patient with posterior ligament syndrome was completely anesthetized, Mayfield's head was fixed, and his hands were placed on the operating table. The central incision of the left lumbar spine was about 12 cm long, exposing the scapula regularly. This swing was based on the cross section of the central part of the claw. This area was incised and rotated clockwise, completely right musculoskeletal syndrome, leaving the right spine in the joint.

Remove the cortex and sponge layer of the right spine to create a V-shaped skeleton, cut the entire bone layer of the left spine, and lift the vertebrae to the right to complete the opening process. Drill holes on the left and right sacrums at the end of each chest, and then, drill holes on the left side of each spine, and used the titanium wire spine to drill the corresponding needle-shaped blade, squeeze the titanium wire and fix the growth of the thorns and separately from the blade (Fig. 2)

Outcome

At 3, 6, 12, 18, and 24 months after surgery, the patient's neurological function was examined and recorded. Functional measurement used a modified McCormick scale (a postoperative X-ray test) to assess the degree of cervical lordosis, lumbar lordosis, or scoliosis atrophy (Cobb angle > 10°). Front, back, left, and right flexion and visual analog scale (VAS; 0–10) 3, 6, 12, 18, and 24 months after surgery. Used feedback questionnaires and quantitative quality of life scales (expressed as a percentage of the total score) to assess the patient's quality of life.

The main result of this study was the appearance of progressive deformities of the spine (Fig. 2). The overall balance has not been assessed and was not the subject of this study. It was defined as a scoliosis or kyphosis curve that progresses at least 10° through ≥ 2 X-rays. Record the time when the progressive

deformity occurred. Symptoms of progressive deformation were also observed during the observation period. For progressive deformities, orthodontic equipment 2 would be used for conservative X-ray treatment; if the deformation continues, it would be thawed. This was a previous study[13].

Statistical analysis

Used the χ2 test or the exact Fisher test to express the determined variable as a percentage; usually, the distributed variable was expressed as the mean standard deviation and processed by independent t test or one-way analysis of variance (ANOVA). The Kaplan-Meier method was used to determine the relationship between postoperative deformation frequency and time, and the logarithmic test was used to compare the laminoplasty group and the posterior ligament preservation group. For statistical data, we used SAS version 9.3 (SAS 9.3, SAS Institute, Cary, NC). We used an exact P-value in the results and used a p-value less than 0.05 as statistically significant. The continuous variables data was represented by mean ± standard deviation (SD).

Results

Patient characteristic

In this study, 218 patients were included due to spinal canal tumors. Among them, 155 patients underwent laminoplasty, and 63 patients underwent laminoplasty with the posterior ligament complex preserved.

The average age was 42 ± 2.3 years. 34 children and 184 adults participated. There were 102 males, 152 spine types, and 80 nerve roots. Symptoms lasted for 6 months, with 125 cases were immobile. Our research also looked at previous treatments. The previous biopsy rate, resection, radiotherapy, and chemotherapy were 8.25%, 14.7%, 8.7%, and 5.50%, respectively. Other comparative patient data were shown in Table 1.

Table 1
Baseline date of pediatric and adult patients undergoing laminectomy VS. laminectomy retain posterior ligament complex for resction of intradural spinal tumors

Variable	All patients(n = 218),n(%)	Laminoplasy(n = 155),n(%)	Laminoplasy retain posterior ligament complex(n = 63),n(%)	P value
Mean age, y	42 ± 2.3	46 ± 3	41 ± 2	0.362
Pediatric (age < 18 y), n (%)	34(18)	23(17)	11(10)	0.388
Male, n (%)	102(46.8)	77(46.7)	45(71.4)	0.125
Median preoperative MMS	3(1–3)	2(1–2)	2(2–3)	0.625
Myelopathy, n (%)	152(69.7)	116(74.8)	46(73.0)	0.359
Radiculopathy, n (%)	80(36.7)	48(30.9)	32(50.7)	0.115
Duration of symptoms, mo	6(2.75)	7(4.51)	6(9.52)	0.852
Motor weakness, n (%)	125(57.3)	80(51.6)	45(71.4)	0.325
Intramedullary, n (%)	158(72.4)	105(67.7)	53(84.1)	0.152
Intradural-extramedullary, n (%)	115(52.7)	85(54.8)	30(47.6)	0.635
Median tumor spinal levels	3(1–2)	2(1–2)	2(1–2)	0.362
Abnormal preoperative alignment, n (%)	45(20.6)	31(20.0)	14(22.2)	0.122
Syrinx, n (%)	42(19.2)	30(19.3)	12(19.0)	0.082
Previous biopsy, n (%)	18(8.25)	12(7.75)	6(9.5)	0.362
Previous resection, n (%)	32(14.7)	21(13.5)	11(17.5)	0.369
Previous radiotherapy, n (%)	19(8.7)	15(9.7)	4(6.3)	0.075
Previous chemotherapy, n (%)	12(5.50)	8(5.16)	4(6.30)	0.521

Pathology included ependymoma in 72 (33%), low-grade astrocytoma in 24 (11%), hemangioblastoma in 25 (11%), ganglioglioma in 12 (5%), malignant astrocytoma in 3 (1%), metastasis in 2(0.9%), cavernoma

in 5(2%), medulloblastoma in 3 (1%), schwannoma in 26 (11%), meningioma in 25 (11%), lipoma in 8 (3%), neurofibroma in 7 (3%), and dermoid in 8 (3%).

Perioperative **results**

185 cases (84.8%) were completely resected. 33 cases (15.1%) were partially resected. 11 cases of wound infection (5.04%). In 16 cases (7.33%), the cerebrospinal fluid was lost through the incision. There were 2 cases (0.5%) of deep vein thrombosis and 3 cases (1%) of pulmonary embolism and the average length of hospital stay was 6 ± 2 days. Ninety-two patients (42.2%) were discharged and hospitalized. In the case of laminoplasty, in order to maintain the posterior ligament syndrome, the length and duration of hospital stay was significantly shorter than that of a single laminoplasty. This may indicate that maintaining the reverse link complex may help early recovery (Table 2).

Table 2
perioperative date of pediatric and adult patients undergoing laminectomy VS. laminectomy retain posterior ligament complex for resction of intradural spinal tumors

Variable	**All patients(n = 218),n(%)**	**Laminoplasy(n = 155),n(%)**	**Laminoplasy retain posterior ligament complex(n = 63),n(%)**	**P value**
> 3 Operative levels, n (%)	86(39.4)	56(36.1)	30(47.6)	0.632
Cervicothoracic decompression, n (%)	35(16.5)	23(14.8)	12(19.0)	0.125
Thoracolumbar decompression, n (%)	53(24.3)	35(22.5)	18(28.5)	0.321
Subtotal resection, n (%)	82(37.6)	63(40.6)	19(30.3)	0.621
Surgical site infection, n (%)	11(5.04)	8(5.16)	3(4.76)	0.215
Incisional CSF leak, n (%)	16(7.33)	14(9.03)	2(3.17)	0.325
Length of hospitalization, d	6 ± 2	8 ± 3	6 ± 2	**0.023**
Discharge to inpatient rehabilitation, n (%)	92(42.2)	75(48.4)	17(26.9)	**0.012**
Postoperative radiotherapy, n (%)	16(7.34)	12(7.74)	4(6.34)	0.625
Median MMS at last follow-up	2(1–3)	2(1–4)	3(2–4)	0.255
Last follow-up, mo	20.6 ± 2.6	21.6 ± 1.2	23.6 ± 3.6	0.361

Spine deformity, motor and quality of life

Thirty-one patients (12%) developed progressive image deformities an average of 20 months after surgery. Of these 31 patients, 7 had cervical lordosis and 3 had mild cervical kyphosis (Table 3). Three patients had progressive kyphosis, and 18 patients had a Cobb coronal angle (average change of 15°). The remaining patients were followed up for an average of 20 months. The majority of patients with radiographic progression (23, 74%) were asymptomatic, whereas 8 (25%) of these patients had associated mechanical neck or back pain. 6 (19%) subsequently underwent fusion (cervical lateral mass screw fixation, n = 3. anterior posterior cervical fusion, n = 2, and thoracic pedicle screw fusion, n = 1). At the last follow-up, median modified McCormick score was unchanged from the preoperative value: 3 (interquartile range, 2–4) vs 2 (interquartile range, 1–3).

Table 3
Comparison of postoperative rates of deformity in pediatric and adult patients undergoing laminectomy VS. laminectomy retain posterior ligament complex for resction of intradural spinal tumors at 24 months

Incidence of postoperative deformity	All patients(n = 218),n(%)	Laminoplasy(n = 155),n(%)	Laminoplasy retain posterior ligament complex(n = 63),n(%)	P value
Adult patients	13/184(7.06)	11/132(8.33)	2/52(3.84)	0.221
cervial cases	5/33(15.1)	4/30(13.3)	1/3(33.3)	0.092
Thoracolumber cases	8/141(5.67)	7/103(6.67)	1/38(2.63)	0.351
Pediatric patients	6/34(17.6)	2/23(8.69)	2/11(18.1)	0.512
cervial cases	3/10(30.0)	2/8(25.0)	1/2(50.0)	0.352
Thoracolumber cases	3/24(12.5)	2/15(13.3)	1/9(11.1)	0.125
Cord and C-function	85.36 ± 7.32	84.32 ± 6.25	85.66 ± 12.25	0.625
C-function	86.36 ± 10.23	88.62 ± 11.25	82.62 ± 11.25	0.255
QOL(%)	62.36 ± 12.62	60.25 ± 11.25	65.11 ± 6.25	0.251
VAS	2.33 ± 0.362	2.02 ± 0.62	1.25 ± 0.25	0.021

In the laminoplasty group, 8 patients (3%) developed progressive spinal cord malformations an average of 20 months after surgery, of which 2 (0.06%) were symptomatic. In the posterior ligament laminoplasty syndrome group, 3 patients (1%) developed progressive spinal deformity an average of 18 months after surgery, and 1 patient (0.04%) had symptoms. Over time, the laminoplasty group and the posterior ligament syndrome group showed similar changes in the risk of progressive deformity (relative risk 0.12; 95% confidence interval [CI] 0.43–1.25; p = 0.258, Fig. 3). This similarity occurred in adults (relative risk 0.24; 95% CI 0.21–2.1; Fig. 3) and children and adolescents (relative risk 0.52; 95% CI 0.31–2.8; Fig. 3). In group analysis, the absolute level of progressive deformity (25% vs. 20%), preoperative scoliosis or cervical/lumbar lordosis loss in patients under 18 years of age was similar to laminoplasty and the

maintenance of the posterior ligament complex (21). In addition, neither of these two methods showed spondylolisthesis. In addition to cases of the lumbar spine, ligament syndrome after laminoplasty also had an absolute frequency, similar to progressive deformities (15% vs. 14%).

We also analyzed the quality of life and long-term results of visual analogue scale (VAS) and found that maintaining the posterior ligament complex can relieve pain symptoms, but the difference in long-term quality of life became obvious after 24 months. In addition, we further analyzed the spinal flexion test and found no significant difference between the two groups. (Table 4)

Table 4
Comparison of postoperative rates of deformity in pediatric and adult patients undergoing laminectomy VS. laminectomy retain posterior ligament complex for resction of intradural spinal tumors at 24 months

Lumbar activity	Laminoplasy(n = 155),n(%)	Laminoplasy retain posterior ligament complex(n = 63),n(%)	P value
baseline			
Front	55.53 ± 2.61	52.61 ± 3.68	0.562
Back	9.36 ± 3.61	11.25 ± 2.36	0.225
Left flex	10.25 ± 2.36	11.25 ± 3.25	0.125
Right fles	9.36 ± 2.61	10.36 ± 3.62	0.263
3 month after surgery			
Front	56.25 ± 3.36	59.62 ± 6.32	0.352
Back	10.25 ± 3.62	13.62 ± 3.62	0.158
Left flex	12.36 ± 1.25	14.52 ± 3.62	0.114
Right fles	9.33 ± 3.61	10.25 ± 2.36	0.582
6 month after surgery			
Front	68.62 ± 6.36	71.52 ± 7.62	**0.025**
Back	13.52 ± 2.62	19.62 ± 6.32	0.125
Left flex	18.62 ± 3.62	22.62 ± 6.36	0.251
Right fles	15.62 ± 5.62	19.36 ± 5.61	**0.021**
12 month after surgery			
Front	70.52 ± 6.25	82.25 ± 2.36	**0.015**
Back	15.25 ± 6.25	20.61 ± 10.25	**0.045**
Left flex	19.25 ± 5.25	26.36 ± 3.62	**0.035**
Right fles	16.65 ± 3.25	21.22 ± 2.61	**0.085**
18 month after surgery			
Front	75.25 ± 5.61	83.62 ± 6.65	**0.011**
Back	16.25 ± 6.25	23.25 ± 6.25	**0.035**
Left flex	20.25 ± 6.33	26.35 ± 10.32	**0.025**
Right fles	21.25 ± 2.62	26.35 ± 5.61	**0.025**
24 month after surgery			

Lumbar activity	Laminoplasy(n = 155),n(%)	Laminoplasy retain posterior ligament complex(n = 63),n(%)	P value
Front	80.25 ± 10.25	88.62 ± 6.99	**0.001**
Back	18.36 ± 3.36	26.35 ± 5.66	**0.025**
Left flex	21.25 ± 6.25	28.66 ± 6.35	**0.012**
Right fles	22.36 ± 6.99	28.36 ± 10.25	**0.021**

Discussion

Spinal deformity and abnormal movement were common complications after interadural spinal tumor resection. In order to further improve patient complications, we studied the effect of laminoplasty on preserving the posterior ligament complex in patients with spinal deformity and sports after spinal surgery. Our research results show that whether it is children or adults, whether it is preoperative sagittal or coronal displacement, or cervical or thoracic laminoplasty, there were two surgical methods to treat the spinal canal. No statistical difference was found in the deformation of the extramedullary spine. But it needs to be emphasized that maintaining the posterior ligament can improve the patient's spinal mobility after long-term surgery and shorten the patient's hospital stay. This may be important for early recovery of patients after surgery.

The earliest surgical method of laminoplasty was modification of Kirita's technique[14].

Compared with laminectomy, laminoplasty can prevent complications such as postoperative vertebral instability, kyphosis, perineural adhesions, and delayed nerve injury [15] . Although long-term results indicate that cervical laminoplasty was safe and effective, it was still necessary to study the development of new and improved measures such as loss of lordosis[14]. Shiraishi et al. found that the exposure of the nipple plate without affecting the semicircular and separating muscles associated with the spine. Provide conservative exposure, allowing various operations on the back of the cervical spine. We found that the deep dilation and atrophy rate after C4 and C6 laminectomy was 13%, while the deep dilation and atrophy rate of traditional open laminectomy was 60%[16]. Yoshihisa et al. found that cervical laminoplasty using reserved deep extensors can improve spinal function and quality of life[17]. Our results also showed that maintaining the posterior ligament complex can reduce pain symptoms, but has no significant effect on quality of life. One possible reason is the short observation time.

Postoperative cervical sagittal deformity was a difficult problem for laminectomy to remove spinal tumors[18]. Compared with laminectomy to treat stenosis caused by degenerative spinal diseases, these deformities were more common after removal of intramedullary spinal cord injuries. Typical indications for surgery were progressive deformities, axial pain in the area, and neurological symptoms associated with the deformity. Surgical options include combined anterior, posterior, and anterior and posterior approaches[19]. Post-laminectomy deformities were more common in children with immature bones, but

they were also more common in young people (< 25 years of age) than in older people. The integrity of the posterior ligament complex also plays an important role in predicting spinal stability, future deformities, and progressive nerve damage [20]. Laminoplasty which mean that remove interadural spinal cord tumors has nothing to do with reducing the incidence of short-term progressive spinal deformities or improving neurological function[13]. However, the resection of intramedullary spinal cord tumors was associated with a reduction in the incidence of spinal deformities requiring progressive anastomosis in children undergoing bone plastic laminectomy, but does not affect long-term functional outcomes[21]. Similar results have been found in our results. It was very important to pay attention to the occurrence of spinal malformation in interadural tumor[22].

Although laminoplasty was a surgical method to maintain mobility, it often results in loss of mobility after surgery[23]. The loss of range of motion may be due to interlayer fusion between adjacent open layers, rupture of the posterior neck extensor muscles, and/or prolonged used of the collar after surgery[24]. Chen et al. found that the modified unilateral laminoplasty that preserves the posterior musculoskeletal complex can effectively treat cervical spondylotic myelopathy, restore nerve function, and retain cervical curvature and range of motion [25]. As the strength of the postoperative musculoskeletal complex increases, the loss of balance in the sagittal plane of the cervical spine increases[26]. Huang et al used a finite element analysis to investigate the biomechanical effects of the lumbar posterior complex on the adjacent segments after posterior lumbar interbody fusion (PLIF) surgeries Studies have shown that in PLIF surgery, the posterior complex involved acts as a posterior bundle, resulting in lower forces on the range of motion and proximal segment during flexion. Preserving the posterior complex during decompression can effectively prevent the adjacent segment degeneration (CIA) after PLIF[12]. Palem et al. found that the overall changes in range of motion were found to be relatively small, but corresponded to individual posterior bone complex lesions in stage I flexor stretch[27]. This was also consistent with the results of our study, which showed that retaining posterior ligaments had a significant effect on improved spinal activity.

Conclusion

The treatment of the posterior ligament complex during laminoplasty does not significantly affect spinal deformities, but significantly improves postoperative spinal activity, pain symptoms, and hospitalization. This has important clinical significance for the subsequent preservation of the post-ligand complex during spinal tumor laminoplasty.

Declarations

CRediT Authorship Statement

Conceptualization: XY, KL

Data curation: XY, KL

Formal analysis: XY, KL, YFJ, YBW, MYL

Funding acquisition: YFJ, YBW, MYL

Investigation: YFJ, YBW, MYL

Methodology: YFJ, YBW, MYL

Project administration: XY, KL, YFJ, YBW, MYL
Resources, Software: XY, KL, YFJ, YBW, MYL

Supervision and Validation: XY, KL, YFJ, YBW, MYL

Visualization: XY, KL, YFJ, YBW, MYL

Roles/Writing - original draft: XY, KL, YFJ, YBW, MYL, PL

Writing - review & editing: XY, KL, YFJ, YBW, MYL, PL

Acknowledgments

We would like to thank all participants and our hospital.

Funding

This research was no fund.

Conflicts of interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Figures

Figures 1-3 are not available with this version