Article published online: 2022-09-14

Original Article

Laminectomy Versus Laminoplasty in the Surgical Management of Long-Segment Intradural Spinal Tumors: Any Difference in Neurological Outcomes?

Abstract

Background: Previous comparative studies have shown that apart from lack of any significant difference in neurologic outcomes between laminoplasty and laminectomy following resection of intradural spinal tumours, spinal column issues such as postoperative deformities, malalignment, and adjacent level disease have also been clearly demonstrated to be quite similar for both techniques. However, there is no study yet that describes any difference in neurologic outcomes for long-segment intradural lesions as a rare subset of these lesions (in terms of number of spinal segments involved) following surgical management between these two techniques. **Materials and Methods:** This is a retrospective review of surgical treatment with either laminectomy or laminoplasty done for patients with long-segment intradural tumors at a tertiary health-care institution in India. **Results:** Out of over 167 patients surgically treated for intradural tumors during the study period, a total of 60 patients were included in the evaluation. The long-segment tumors were intramedullary in 22 (36.7%) patients and intradural-extramedullary in the remaining 38 (63.3%) patients. No patient in both cohorts had any revisional surgery after initial resection or any serious complications. The incidence of neurologic function remaining unchanged at the end of follow-up was similar between laminoplasty and laminectomy (12.5% vs. 11.1%). There was no significant correlation between the preoperative McCormick score and postoperative McCormick score ($P > 0.05$ at 95% degree of confidence; Spearman's rho = 0.028), suggesting that functional outcomes were not dependent on the initial neurologic status. Multivariate logistic regression analysis showed that : the two independent variables (Extent of surgery and Choice of procedure) were not significant predictors of the dependent variable (Functional outcome following surgery) (odds ratio = 3.836; $p = 0.071$). **Conclusion:** This retrospective evaluation demonstrates laminoplasty not to be more or less likely to have any better functional outcome or need for revision compared to laminectomy in the resection of long-segment intradural lesions. A quality randomized controlled study on a much larger scale will be required to validate this finding.

Keywords: *Long-segment intradural tumors, laminectomy, laminoplasty, neurological outcome*

Chiazor U.Onyia, Sajesh K. Menon[1]

Department of Surgery, Lagoon Hospitals, Lagos, Nigeria, [1]Division of Spine Surgery, Department of Neurosurgery, Amrita Institute of Medical Sciences and Research, Kochi, Kerala, India

Introduction

Surgical excision of midline ventral long segment intradural tumors can be quite formidable and can have potentially serious morbidity from spinal instability.[1,2] Various techniques has been widely accepted as a standard technique for treating these lesions.[2-4] Previous studies have clearly demonstrated no significant difference between laminectomy and laminoplasty in terms of postoperative structural complications after excision of intradural tumors such as deformities (kyphosis, scoliosis, or kyphoscoliosis), spinal instability requiring fusion or other forms of stabilization, as well as neurologic outcomes.[5-11] However, despite their relative rarity, there is often concern for unacceptable patient morbidity following surgical resection of long-segment intradural tumors as a specific subset among intradural tumors in general.[12-14]

Generally speaking, when comparing laminectomy to laminoplasty, neurologic outcome is typically not the metric of interest, since one would be dealing with mainly spinal column issues as already mentioned above. However, since it has previously been proven beyond any reasonable doubt that laminoplasty is neither associated with a decreased incidence of progressive spinal deformity nor improved

How to cite this article: Onyia CU, Menon SK. Laminectomy versus laminoplasty in the surgical management of long-segment intradural spinal tumors: Any difference in neurological outcomes?. Asian J Neurosurg 2018;13:1128-33.

Address for correspondence:
Dr. Chiazor U. Onyia, Department of Surgery, Lagoon Hospitals, Lagos, Nigeria.
E-mail: shalomazor@yahoo.com

Access this article online

Website: www.asianjns.org

DOI: 10.4103/ajns.AJNS_67_18

Quick Response Code:

neurological function when compared to laminectomy,[8,9] the objective of this retrospective study was to go a step further by determining if there is any relationship at all between the extent of resection of long-segment intradural spinal tumours and postoperative sequel after excision in terms of neurologic outcomes following laminectomy compared to laminoplasty.

Materials and Methods

Ethical considerations and clearance

The study was reviewed and approved by the Institutional Ethics Review Board at the Amrita Institute of Medical Sciences and Research, Kochi, Kerala, India.

Patient characteristics and criteria for selection

A retrospective review of databases of patients who underwent either laminectomy or laminoplasty for the excision of long-segment intradural tumors over a 14-year period between January 2000 and March 2014 was performed at the Department of Neurosurgery of Amrita Institute of Medical Sciences and Research, Kochi, Kerala, India. This department is a major neurosurgical referral center located in southwest of India serving both local and international patients. The senior author (SKM) was responsible for the clinical and surgical management of all patients under review. The selection criteria are summarized in Table 1. For this study, long-segment intradural tumors were defined as those spanning at least more than two spinal motion segments. The medical record identification numbers of these patients were retrieved by going through the operating theater records for the period under review for all who had either laminectomy or laminoplasty for various intradural tumors spanning more than two spinal motion levels. The clinical and radiologic reports of each patient were then retrieved from the hospital database system and the medical records were reviewed and recorded in two separate groups: Group A included those who had laminectomy, while Group B included those who had laminoplasty. Both procedures were performed in standard fashion by the same surgeon (SKM) and will not be discussed in detail in this article. Choice of which procedure to be performed in each case was simply based on surgeon's preference. Continuous intraoperative monitoring with sensory-evoked and motor-evoked potentials during surgery was used in all the cases.

Information was carefully extracted for each patient based on the following variables: patient's age and sex, the type of tumor, its histological features, its location and extent, technique used at surgery, pre- and post-operative imaging findings, and pre- and post-operative functional status according to Modified McCormick grading.

Functional evaluation

Measurement of functional status of each patient before and following surgery was defined according to the Modified McCormick grading system as follows:

- Grade 1: Neurologically intact, ambulates normally with minimal dysesthesia
- Grade 2: Mild motor or sensory deficit, maintains functional independence
- Grade 3: Moderate deficits, limitation of function, independent with external aid
- Grade 4: Severe deficits, limitation of function, dependent
- Grade 5: Paraplegia (or quadriplegia).

For all patients in both groups, the preoperative Modified McCormick score and the corresponding postoperative score, as well as the corresponding extent of surgery in each case, were documented for each patient. The postoperative records of the patients were carefully scrutinized for any evidence of recurrence of symptoms necessitating revision surgery.

Statistical analysis

Statistical analyses included bivariate analysis (Spearman's rho correlation, Kruskal–Wallis, and Mann–Whitney U-rank tests for nonparametric data) and multivariate analysis (multivariate logistic regression and Wilcoxon signed-rank test) using SPSS software for Windows (SPSS Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

Results

Out of a total of 121 patients who had laminectomy for excision of various intradural spinal tumors over the study period, 36 of them met the study selection criteria and constituted Group A [Table 2]. On the other hand, among a total of 46 patients who had laminoplasty for excision of various intradural spinal tumors over the period under review, 24 of them were included based on the study selection criteria. These constituted Group B [Table 2].

Hence, a total of sixty patients were evaluated. Of these, there were 37 (61.7%) males, while the remaining 23 (38.3%) were females, with a mean age of 40.6 + 13 years (age range of 12 years–74 years) [Table 2]. Four (6.7%) patients were pediatric

Table 1: Summary of selection criteria

Inclusion criteria	Exclusion criteria
Involvement of at least >2 motion segments	Incomplete patient clinical data
Surgery performed by same surgeon (SKM)	Patient with no follow-up/defaulting patients
Follow-up duration >3 months	Follow-up duration <3 months after surgery
Complete patient clinical data	
No spinal deformity	

Table 2: Comparison of demographic and clinical data of the patients treated for long-segment intradural tumor with laminectomy compared to laminoplasty

	All patients (*n*=60)	Group A-laminectomy (*n*=36)	Group B laminoplasty (*n*=24)	*P*
Age (years), mean±SD	40.6±13	42.4±14	38.0±12	0.221ɸ
Number of pediatric cases, i.e., <18 years, *n* (%)	4 (6.7)	2 (5.6)	2 (8.3)	0.232ɸ
Sex ratio (male: female)	37: 23	19:17	18:6	0.108*
Mode for spinal levels occupied by tumor (%)	Three levels (40.0)	Three levels (17.0)	Three levels (28.0)	**0.012ɸ**
Mode for number of levels operated (%)	Three levels (28.3)	Three levels (13.0)	Four levels (20.0)	**0.033ɸ**
Intramedullary, *n* (%)	22 (36.7)	4 (18.2)	18 (81.8%)	**0.000***
Intradural extramedullary, *n* (%)	38 (63.3)	32 (84.2)	6 (15.8%)	
Median preoperative modified McCormick score	2 (1-5)	2 (1-5)	2 (1-5)	0.244#
Median postoperative modified McCormick score	1 (1-5)	1 (1-4)	1.5 (1-5)	0.063#
Cervical, *n* (%)	13 (21.7)	6 (16.7)	7 (29.2)	
Segmental distribution of lesions resected, *n* (%)				
Cervicothoracic	13 (21.7)	8 (22.2)	5 (20.8)	
Thoracic	10 (16.7)	9 (25.0)	1 (4.2)	
Thoracolumbar	9 (15.0)	7 (19.4)	2 (8.3)	
Lumbar	7 (11.7)	3 (8.3)	4 (16.7)	
Lumbosacral	3 (5.0)	1 (2.8)	2 (8.3)	
Conus and cauda	5 (8.4)	2 (5.6)	3 (12.5)	
Histology of lesion resected, *n* (%)				
Arachnoid cyst	2 (3.3)	2 (5.6)	-	
Hamartoma	1 (1.7)	1 (2.8)	-	
Hemangioblastoma	1 (1.7)	1 (2.8)	-	
Meningioma	4 (6.6)	4 (11.2)	-	
Neurofibroma	5 (8.3)	5 (13.9)	-	
Schwannoma	13 (21.7)	11 (30.6)	2 (8.3)	
Astrocytoma	4 (6.7)	-	4 (16.7)	
Ependymoma I	8 (13.3)	2 (5.6)	6 (25.0)	
Ependymoma II	10 (16.7)	3 (8.3)	7 (29.2)	
Ependymoma III	1 (1.7)	1 (2.8)	-	
Ganglion-cell tumor/paraganglioma	3 (5.0)	1 (2.8)	2 (8.3)	
GBM	1 (1.7)	-	1 (4.2)	
TB granuloma	1 (1.7)	-	1 (4.2)	
Plasma cell granuloma	2 (3.3)	2 (5.6)	-	
Other inflammatory lesions (nonspecific)	1 (1.7)	1 (2.8)	-	
Lipoma	1 (1.7)	-	1 (4.2)	
Drop metastasis	1 (1.7)	1 (2.8)	-	
Not available	1 (1.7)	1 (2.8)	-	

*Fisher's exact test, #Kruskal–Wallis test, ɸIndependent sample's *t*-test, SD – Standard deviation; Boldface text=Statistically significant *P* value. GBM – Glioblastoma multiforme; TB – Tuberculosis

Table 3: Comparison of neurological outcomes postoperative for those treated with laminectomy compared to laminoplasty at the end of follow-up

	No improvement neurologically, *n* (%)	Neurologically improved, *n* (%)	Neurologically the same, *n* (%)	No preoperative neurologic deficits, *n* (%)
Laminectomy (*n*=36)	2 (5.6)	19 (52.8)	4 (11.1)	11 (30.6)
Laminoplasty (*n*=24)	7 (29.2)	6 (25.0)	3 (12.5)	8 (33.3)
Total (*n*=60)	9 (15.0)	25 (41.7)	7 (11.7)	19 (31.7)
P	1.000#	1.000#	0.022#	-

#Statistical comparisons done using Kruskal–Wallis test. Comparison excludes all those who presented with no neurologic deficits but had only pain (*n*=19)

(<18 years old), of which one had an intramedullary lesion (astrocytoma WHO I), while the remaining three had extramedullary tumors (two neurofibromas and one ependymoma WHO I). However, the age distribution in the entire cohort did not differ significantly from the expected normal distribution ($P = 0.691$; Shapiro–Wilk test). Furthermore, the baseline demographic data did not differ significantly between both groups of patients in terms of age ($P = 0.221$; independent samples *t*-test) as shown in Table 2. There was a male-to-female ratio of 1.6:1. The duration of follow-up following surgery ranged from 3 months to 30 months (average of 13.1 months) for the laminectomy group (Group A) and from 4 months to 46 months (average of 21.0 months) for the laminoplasty group. No serious surgical complication was noted for any patient in either of both groups.

Pathology was intramedullary in 22 (36.7%) and intradural-extramedullary in the remaining 38 (63.3%) patients [Table 2]. Among the patients in Group A, the most common histologic diagnosis was schwannoma (30.6%), closely followed by neurofibroma (13.9%), while the most common lesion among patients in Group B was ependymoma (54.2%). There was a fairly significant relationship of postoperative neurologic status (in terms of the postoperative McCormick score) with both age and gender ($P > 0.05$ at 95% degree of confidence; Spearman's rho correlation = 0.788 and 0.797, respectively). However, there was no significant correlation between the preoperative McCormick score and postoperative McCormick score ($P > 0.05$ at 95% degree of confidence; Spearman's rho = 0.028), suggesting that functional outcomes are not dependent on the initial neurologic status. The incidence of neurologic function remaining unchanged at the end of follow-up was similar between laminoplasty and laminectomy (12.5% vs. 11.1%). Table 3 shows comparison of neurological outcomes at the last follow-up evaluation between patients who had laminectomy and those who had laminoplasty.

To determine if there was any overall statistically significant improvement in terms of postoperative neurologic function compared to preoperative neurologic status for both groups, Wilcoxon signed rank test comparing McCormick preoperative scores with McCormick postoperative scores for each of the two groups revealed significant improvement functionally for the laminectomy group ($Z = -3.670$; $P = 0.000$), but no significant improvement for the laminoplasty group ($Z = -0.503$; $P = 0.615$). Finally, to assess for any significant impact of patient's age, patient's gender, extent of surgery, and the choice of procedure done on functional outcome (in terms of postoperative McCormick score at follow-up), multivariate logistic regression revealed none of all these factors to be a significant predictor of functional outcomes in these patients [Table 4]. Controlling for age, gender, and extent of surgery, patients who had laminectomy were neither more nor less likely to have any better functional outcome compared to those who had laminoplasty, though this was not statistically significant (odds ratio = 3.836; $P = 0.071$) as shown in Table 4.

Discussion

Although the numbers in the cohort for this review are not quite large, patients who had laminectomy were neither more nor less likely to have any better functional outcome compared to those who had laminoplasty following excision of these long-segment lesions. The incidence of neurologic function remaining unchanged at the end of follow-up was similar between laminoplasty and laminectomy (12.5% vs. 11.1%). However, statistical comparison of McCormick preoperative scores with McCormick postoperative scores revealed significant improvement functionally for the laminectomy group compared to the laminoplasty group. We suggest this interesting finding to be probably due to the fairly smaller patient numbers in the laminoplasty group compared to the laminectomy group. Larger patient numbers in a better planned prospective study would be required to confirm these findings.

Most of the few comparative studies involving these same techniques for intradural spinal tumors have been well documented in the literature but not specifically for the long-segment form of these lesions.[8,9,15] Most of the previous comparisons involving laminectomy for intradural spinal lesions were done with laminotomy. One such study focused on comparing the outcomes of excision of intradural

Table 4: Multivariate logistic regression model of comparing extent of resection with and without worse functional outcomes after undergoing laminectomy versus laminoplasty for long-segment intradural spinal tumors (*n*=41, due to exclusion of the 19 patients who had only pain and no neurologic deficits)

Parameter	df	β co-efficient	SEM	Wald	*P*	OR	95% CI for the OR	
							Lower	Upper
Gender/sex	1	−1.003	0.747	1.800	0.180	0.367	0.085	1.587
Age	1	0.025	0.029	0.742	0.389	1.025	0.969	1.084
Extent of surgery	1	−0.008	0.222	0.001	0.972	0.992	0.642	1.534
Laminectomy versus laminoplasty	1	1.344	0.744	3.265	0.071	3.836	0.892	16.488
Constant	1	−0.713	1.557	0.209	0.647	0.490	-	-

*$P<0.05$, significant factors relating to neurologic status following surgery for long-segment intradural extramedullary tumors. Multivariate logistic analysis shows Snell R Square to be 0.187 while the Negelkerke R Square was 0.254, meaning that between 18.7% and 25.4% of the variability in the dependent variable is explained by the model. OR – Odds ratio; df – Degree of freedom; CI – Confidence interval; SEM – Standard error of mean

meningioma with either laminotomy or laminectomy via the traditional midline approach with the minimally invasive option of unilateral hemilaminectomy.[16] Asazuma *et al*. studied postoperative changes following laminectomy, laminotomy, and hemilaminectomy in 51 patients, but that evaluation focused only on tumors in the cervical region of the spine and reviewed spinal tumors in general, and not intradural tumors in particular.[17] In a descriptive work by Ruggeri *et al.*, on the technique of laminotomy in forty patients over a period of 4 years, they acknowledged that a standardized procedure for the technique does not exist because of the various methods described in the literature and stated that laminotomy is not yet a standard approach to such pathologies of the spine despite their observation of satisfactory fusion of the osteo-ligamentous flap with the spine.[18] Compared with laminectomy previously carried out in another set of forty patients, their experience of postoperative kyphosis was far less than it was with the forty patients who had laminectomy.[18] Their work, however, included other pathologies of the spine apart from spine tumors.[18] Matsumoto *et al*. studied the outcomes of osteoplastic type of laminotomy as a technique for surgical management of spinal cord tumors in 21 patients but had no comparison with laminectomy or any other technique.[19] Furtado *et al*. similarly reported findings on children who underwent laminotomy and tumor excision for benign cervical intradural tumors.[20]

Our findings interestingly appear to be similar to those of previous comparative studies looking at outcomes between laminoplasty and laminectomy for the management of other problems.[7,10,11] Mahadewa *et al*. carried out a 3-year retrospective comparative study between bilateral laminoplasty and laminectomy with fusion as techniques of surgical decompression in the management of lumbar canal stenosis in 105 patients and observed that both were equally effective over a short period of follow-up.[7] Similarly, according to another study by Thomas *et al*., on radiographic comparison between laminectomy and laminoplasty for a smaller cohort of 26 patients with lumbar canal stenosis, laminoplasty had the same degree of postoperative listhesis as laminectomy.[10] Thome *et al*., in comparing both bilateral and unilateral laminotomy with laminectomy in 120 patients, found out that outcomes after unilateral laminotomy were quite comparable with that after laminectomy, but with bilateral laminotomy being more superior in outcomes to both unilateral laminotomy and laminectomy.[11]

Experience and literature on the subject of surgical considerations for intradural tumors spanning multiple spinal segments are scarce.[21] To the best of our knowledge, no studies on such objective comparisons on outcomes between both laminoplasty and laminectomy alone exist in the literature specifically for the management of long-segment intradural tumors. Surgical excision of midline ventral long-segment intradural tumors in particular can be quite formidable and can have potentially serious morbidity.[21] An appropriate surgical approach and strategy needs to be outlined to achieve a good outcome for operative treatment of such lesions.[21] It has been suggested that posterolateral approach is more suitable for such long-segment spinal tumors since a wider exposure would be required to achieve total control while removing the tumor.[21] Probably, as a result of how rare long-segment intradural tumors are, it has not been easy to organize a significantly large study population in order to objectively assess a surgical procedure that would be considered most suitable for treating these long-segment tumors.[1]

Limitations

Due to the retrospective nature of the study, choice of procedure for each case at the time of surgery was simply based on surgeon preference. Furthermore, the timeframe for the follow-up clinical evaluation after surgery was not uniform for all the patients. Available information was not consistent for all the sixty cases regarding whether gross total excision was achieved or not. There was no standard reporting of the Modified McCormick score for any of the patients at the time of their pre- and post-operative care. We attempted to circumvent this challenge by reading through the entire documented history and clinical examination notes to arrive at a score for each patient, both at the preoperative evaluation and the postsurgical assessment during follow-up. Furthermore, the number of patients in each of the two groups was also not equal.

Due to the sample sizes in the cohort not being large, we keep in mind that the correlation calculations with Spearman's rho may possibly have a considerably low power in detecting statistical differences where they probably existed. In spite of these drawbacks and concerns, we still believe that this review forms a basis for further evaluations on a much larger scale in order to confirm our findings.

Recommendation

More studies on outcomes following surgery for long-segment intradural tumors are required to inform clinical guidelines for surgical treatment of this patient group. Notwithstanding, the fact still remains that decision-making for choice of surgical procedure depends on other factors which must also be taken into consideration.

Conclusion

To the best of our knowledge from the available information in the literature, this review will be the first to study the neurological outcomes between laminectomy and laminoplasty for patients with long-segment intradural tumors. Similar to findings in other previous studies, laminoplasty is neither more nor less likely to give any better functional outcome compared to those who had laminectomy in the management of such long-segment lesions, based on evidence from this evaluation. Furthermore, the choice of procedure was not a significant predictor of functional outcomes in these patients. These are however subject to further investigation using prospective randomized studies with larger sample populations.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Ahn DK, Park HS, Choi DJ, Kim KS, Kim TW, Park SY, *et al.* The surgical treatment for spinal intradural extramedullary tumors. Clin Orthop Surg 2009;1:165-72.
2. Kim CH, Chung CK. Surgical outcome of a posterior approach for large ventral intradural extramedullary spinal cord tumors. Spine (Phila Pa 1976) 2011;36:E531-7.
3. Hossain MZ, Hoque M. Extramedullary spinal SOL – Outcome of surgery. Teach Assoc J 2009;22:5-9.
4. Sim JE, Noh SJ, Song YJ, Kim HD. Removal of intradural-extramedullary spinal cord tumors with unilateral limited laminectomy. J Korean Neurosurg Soc 2008;43:232-6.
5. Bruneau M, Lefranc F, Balériaux D, Brotchi J. Intradural extramedullary and intramedullary spinal cord tumors. Principles of Neurological Surgery. 3rd ed. Philadelphia: Elsevier, Saunders; 2012. p. 421-36.
6. Hersh DS, Iyer RR, Garzon-Muvdi T, Liu A, Jallo GI, Groves ML, *et al.* Instrumented fusion for spinal deformity after laminectomy or laminoplasty for resection of intramedullary spinal cord tumors in pediatric patients. Neurosurg Focus 2017;43:E12.
7. Mahadewa TG, Maliawan S, Raka Sudewi AA, Senapathi GA. A comparative study of bilateral laminotomy and laminectomy with fusion for lumbar stenosis. Neurol Asia 2010;15:153-8.
8. McGirt MJ, Chaichana KL, Atiba A, Bydon A, Witham TF, Yao KC, *et al.* Incidence of spinal deformity after resection of intramedullary spinal cord tumors in children who underwent laminectomy compared with laminoplasty. J Neurosurg Pediatr 2008;1:57-62.
9. McGirt MJ, Garcés-Ambrossi GL, Parker SL, Sciubba DM, Bydon A, Wolinksy JP, *et al.* Short-term progressive spinal deformity following laminoplasty versus laminectomy for resection of intradural spinal tumors: Analysis of 238 patients. Neurosurgery 2010;66:1005-12.
10. Thomas NW, Rea GL, Pikul BK, Mervis LJ, Irsik R, McGregor JM, *et al.* Quantitative outcome and radiographic comparisons between laminectomy and laminotomy in the treatment of acquired lumbar stenosis. Neurosurgery 1997;41:567-74.
11. Thomé C, Zevgaridis D, Leheta O, Bäzner H, Pöckler-Schöniger C, Wöhrle J, *et al.* Outcome after less-invasive decompression of lumbar spinal stenosis: A randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy. J Neurosurg Spine 2005;3:129-41.
12. Iida Y, Kataoka O, Sho T, Sumi M, Hirose T, Bessho Y, *et al.* Postoperative lumbar spinal instability occurring or progressing secondary to laminectomy. Spine (Phila Pa 1976) 1990;15:1186-9.
13. Naganawa T, Miyamoto K, Hosoe H, Suzuki N, Shimizu K. Hemilaminectomy for removal of extramedullary or extradural spinal cord tumors: Medium to long-term clinical outcomes. Yonsei Med J 2011;52:121-9.
14. Sun CX, Meng XL, Xie SN, Yu Y, Yang HJ, Wu B, *et al.* Unilateral hemilaminectomy for patients with intradural extramedullary tumors. J Zhejiang Univ Sci B 2011;12:575-81.
15. Canbay S, Hasturk AE, Basmaci M, Erten F, Harman F. Management of thoracic and lumbar schwannomas using a unilateral approach without instability: An analysis of 15 cases. Asian Spine J 2012;6:43-9.
16. Iacoangeli M, Gladi M, Di Rienzo A, Dobran M, Alvaro L, Nocchi N, *et al.* Minimally invasive surgery for benign intradural extramedullary spinal meningiomas: Experience of a single institution in a cohort of elderly patients and review of the literature. Clin Interv Aging 2012;7:557-64.
17. Asazuma T, Nakamura M, Matsumoto M, Chibo K, Toyama Y. Postoperative changes of spinal curvature and range of motion in adult patients with cervical spinal cord tumors: Analysis of 51 cases and review of the literature. J Spinal Disord Tech 2004;17:178-82.
18. Ruggeri A, Pichierri A, Marotta N, Tarantino R, Delfini R. Laminotomy in adults: Technique and results. Eur Spine J 2012;21:364-72.
19. Matsumoto Y, Harimaya K, Doi T, Maeda T, Iwamoto Y. Outcome of osteoplastic laminotomy for excision of spinal cord tumours. J Orthop Surg (Hong Kong) 2009;17:275-9.
20. Furtado SV, Murthy GK, Hegde AS. Cervical spine instability following resection of benign intradural extramedullary tumours in children. Pediatr Neurosurg 2011;47:38-44.
21. Mahore A, Muzumdar D, Chagla A, Goel A. Pure ventral midline long segment schwannoma of the cervicodorsal spine: A case report. Turk Neurosurg 2009;19:302-5.