Menoufia Medical Journal

PRINT ISSN: 1110-2098 - ONLINE ISSN: 2314-6788

journal hompage: www.menoufia-med-j.com

Volume 35 | Issue 4 Article 53

3-4-2023

Outcome predictors in the surgical management of intradural spinal tumors

Adel M. Hanafy
Menoufia University

Ahmed G. Azzab
Menoufia University

Ahmed G. El Naggar
Menoufia University

Essam G. Saleh
Menoufia University

Hossam A. Elnoamany
Menoufia University

Recommended Citation

Hanafy, Adel M.; Azzab, Ahmed G.; El Naggar, Ahmed G.; Saleh, Essam G.; Elnoamany, Hossam A.; Habeb, Hossam A.; Hegazy, Ibrahim M.; and El Tabl, Mohamed A. (2023) "Outcome predictors in the surgical management of intradural spinal tumors," *Menoufia Medical Journal*: Vol. 35: Iss. 4, Article 53.
DOI: https://doi.org/10.4103/mmj.mmj_184_22

Outcome predictors in the surgical management of intradural spinal tumors

Ibrahim M. Hegazy[a], Essam G. Saleh[b], Ahmed G. Azzab[b], Ahmed G. El Naggar[b], Mohamed A. El Tabl[b], Adel M. Hanafy[b], Hossam A. Elnoamany[b], Hossam A. Habeb[b]

[a]Military Medical Academy, Mansheya El-Bakry, Heliopolis, Cairo Governorate, Egypt, [b]Department of Neurosurgery, Faculty of Medicine, Menoufia University, Menoufia, Egypt

Correspondence to Ibrahim M. Hegazy, MD, Delengat, Behira, Egypt
Postal code: 22511;
Tel: +20 122 150 4011;
e-mail: dr_hemoo@yahoo.com

Received 30 May 2022
Revised 20 July 2022
Accepted 24 July 2022
Published 04 March 2023

Menoufia Medical Journal 2022, 35:1949–1954

Objective

To evaluate the different factors affecting the surgical outcome of intradural spinal tumors.

Background

Among the intradural spinal tumors, meningiomas, ependymomas, astrocytomas, and nerve sheath tumors are the most common. Early surgical intervention with the use of technical adjunctives and postoperative adjuvant therapy has improved the outcome.

Patients and methods

A prospective study was done on 30 consecutive patients with an age group ranging from 20 to 60 years. All patients underwent surgery for intradural spinal tumors at Menoufia University and Alexandria Armed Forces Hospital. Data were collected regarding histopathological diagnosis, clinical presentation, tumor location, operative data, and postoperative complications. A functional outcome was assessed using the modified McCormick Scale (MMS).

Results

There were 16 (53.3%) patients with extramedullary tumors and 14 (46.7%) patients with intramedullary tumors. Guided tissue regeneration (GTR) was achieved in 21 (70%) patients, mostly meningioma and ependymoma. Extramedullary locations are more likely to achieve GTR and are associated with better outcomes than those with intramedullary locations. The mean preoperative MMS (2.70 ± 0.88) showed marked improvement compared with the mean 2.20 ± 1.42, 2.0 ± 1.51, and 1.93 ± 1.51 immediately postoperatively, 6-month, and 1-year follow-up, respectively. The complication rate was 33.3% (10 patients), and cerebrospinal fluid leak was the most common complication.

Conclusion

The use of adjunctive (cavitron ultrasonic aspirator, IOM), the extramedullary location, low preoperative MMS, GTR, and low tumor grade were associated with better postoperative outcomes.

Keywords:
complications, functional outcome, intradural, spinal tumors

Menoufia Med J 35:1949–1954

1110-2098

Introduction

Intradural spinal tumors are rare and account for 5–15% of all adult spinal tumors and 2–4% of primary central nervous system tumors. They remain an important entity in the differential diagnosis for patients presenting with back pain, sensorimotor deficits, autonomic dysfunction, and radicular pain [1].

Based on their anatomical location with respect to the cord, these tumors are classified as being either intramedullary (~20–30% of the cases) or extramedullary (70–80%). The most common histological findings for intramedullary neoplasms are ependymomas and astrocytomas, whereas the most common intradural-extramedullary neoplasms are meningiomas and nerve sheath tumors [2,3].

Since the first successful resection of a spinal cord tumor by Mr Victor Horsley in 1887, remarkable technical advances have been achieved in spinal tumor surgery. Advancements in neuroimaging, neuromonitoring, surgical techniques, equipment, and adjuvant therapy improved the postoperative outcome of these challenging lesions [4].

Surgical removal is the treatment of choice, aiming at complete resection with preservation of neurological function. Therefore, identification of outcome predictors is essential. Many studies have established that functional outcome after surgery has been correlated strongly with the timing of surgery, preoperative neurological status, anatomical location, tumor histology, and extent of surgical resection [5,6].

This study evaluates the prognostic factors and functional outcome of patients with intradural spinal tumors who have undergone surgical removal.

Patients and methods

The study was conducted on 30 patients with spinal intradural tumors, who were treated surgically at the Neurosurgery Department, Faculty of Medicine, Menoufia University and Alexandria Armed Forces Hospital during the period between March 2020 and March 2021. Ethical approval of Menoufia University and written informed consent from each patient were obtained.

Both sexes with age groups ranging from 20 to 60 years with primary spinal intradural tumors from the upper cervical to the cauda equina were included, while patients with metastatic lesions and tumor-like conditions were excluded.

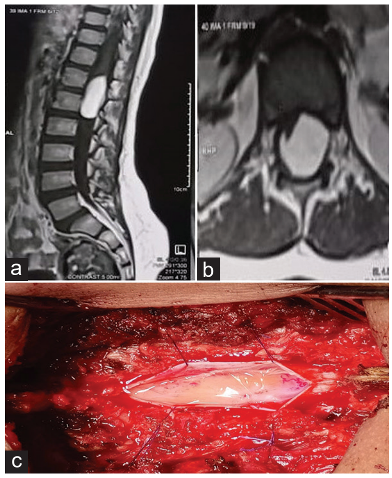
Data were collected regarding clinical presentation obtained during the preoperative stage and postoperative follow-up, radiological evaluation, operative technique, histopathological diagnosis, and postoperative complications. Postoperative magnetic resonance imaging was performed for all patients to determine the extent of tumor resection. Functional outcome was assessed using the modified McCormick Scale (MMS; grades I–V) [7].

Under general anesthesia, all patients underwent the procedure in prone position. After fluoroscopic confirmation of the correct spinal level, a midline linear skin incision was made, followed by muscle splitting. Then laminectomy was performed at the level of interest, ensuring that we had adequate exposure of the tumor. After extradural hemostasis, the dura was opened with a midline incision and retracted with sutures.

For cases of extramedullary tumors, a central debulking of the tumor was done with the aid of a cavitron ultrasonic aspirator (CUSA). Then dissection of the lesion was performed from the spinal cord and dura. When a tumor was attached to a nerve fiber, a nerve stimulator was used to identify the type of nerve branch. The motor branch was preserved through careful dissection, while the sensory branch can be sacrificed (Fig. 1). Sectioning of the dentate ligaments might further release the cord to improve anterior control.

In cases of intramedullary tumors, a myelotomy over the posterior median sulcus was performed, centered on the lesion. Myelotomy should respect the vasculature in general and should be extended in length to the poles of the tumors for full visualization and control. We stayed within the tumor limits, and central debulking was performed with the use of an ultrasonic aspirator. After central debulking, peripheral dissection of the tumor from the spinal cord tracts was carried out under the guidance of electrophysiological monitoring whenever feasible.

Figure 1



Female patient, 21 years old, presented with low back pain, bilateral sciatica, and unsteadiness. (a and b) Unenhanced T1 sagittal and axial images reveals hyperintense lobulated intradural mass opposite D12–L1. (c) Pathological and surgical evaluation showed this mass to be intradural lipoma.

After proper hemostasis and irrigation with normal saline, the dura was closed in a watertight manner or dural graft with fascia lata, to reduce the chance of postoperative myelopathy related to cord tethering at the level of surgery.

After surgery, patients were assessed for postoperative complications, clinical outcome, and adjuvant therapy.

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package, version 20.0. (IBM Corp., Armonk, New York, USA). Qualitative data were described using number and percent. The Kolmogorov–Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, SD, median, and interquartile range. Significance of the obtained results was judged at the 5% level. The used tests were: Friedman test for abnormally distributed quantitative variables, to compare between more than two periods or stages and postoperative hoc test (Dunn's) for pairwise comparisons.

Results

Thirty patients were included in the study, with 13 men and 17 women. The mean age was 41.73 ± 12.75, ranging from 21 to 60 years old. As regards tumor location, 13 (43.3%) tumors were cervical, 13 (43.3%) dorsal, and four (13.3%) lumbar. There were 16 (53.3%) patients with extramedullary tumors, and meningioma was the most frequent in nine (30%) patients, followed by schwannoma in four (13.3%) patients. Regarding intramedullary tumors, 14 (46.7%) patients had the most frequent ependymoma in nine (30%) patients, followed by astrocytoma in five (16.7%) patients.

The duration of symptoms ranged from 3 to 24 months (mean, 9.7 ± 35.34 months). The most common presenting symptoms were pain (n = 30, 100%), followed by sensory changes (n = 24, 80%), then motor weakness (n = 23, 76.7%), and autonomic dysfunction (n = 7, 23.3%) (Table 1).

The preoperative MMS of the 30 patients was: 16 (53.3%) patients with grade II, eight (26.7%) patients with grade III, five (16.7%) patients with grade IV, and one (3.3%) patient with grade V. The mean preoperative MMS was 2.70 ± 0.88 (range, 2–5).

Total resection was achieved in 21 (70%) patients, mostly meningioma and ependymoma, and nine (30%) patients underwent subtotal resection, mostly astrocytoma, as GTR cannot be achieved in all cases (five cases) of astrocytoma. An ultrasonic aspirator was used in 20 (66.7%) patients, while intraoperative monitoring was performed in 10 (33.3%) cases. Postoperative adjuvant therapy was implemented for 11 (36.6%) cases with intramedullary tumors where total resection was not achieved or cerebrospinal fluid (CSF) showed dissemination of the tumor cells.

In our study, the complication rate was 33.3% (10 patients). Five (16.7%) cases had postoperative deterioration of neurological function. Four (13.3%) cases developed CSF leaks that responded to bed rest and conservative treatment. Three (10%) cases showed tumor recurrence. Finally, one case had postoperative superficial wound infection.

In our study, the functional outcome showed marked improvement from mean preoperative MMS 2.70 ± 0.88 to 2.20 ± 1.42, 2.0 ± 1.51, and 1.93 ± 1.51 immediately postoperatively, 6-month, and 1-year follow-up, respectively (P < 0.05) (Table 2).

The use of technical adjuncts (CUSA, IOM) has a significant association with good postoperative outcome (P < 0.005). Also, the extramedullary location, low preoperative MMS, GTR, and early surgery with

Table 1 Data analysis for patients with intramedullary tumors (*n*=14)

Age/sex	Clinical presentation	Duration of symptoms (months)	Location	Pathology	Preoperative MMS	Postoperative MMS	F/U 6 months MMS	F/U 1 year MMS	Extent of resection	IOM	CAUSA	Complications	Adjuvant therapy
30/F	Pain, motor, sensory	12	Cervical	Ependymoma 2	2	2	2	2	TR	No	Yes	No	No
38/F	Pain, sensory	5	Dorsal	Ependymoma 1	2	1	1	1	TR	No	Yes	No	Yes
51/M	Pain, motor, sensory	3	Cervical	Astrocytoma 1	4	3	3	2	STR	Yes	Yes	No	Yes
40/F	Pain, motor. sensory	11	Dorsal	Astrocytoma 3	4	5	5	5	STR	No	No	Recurrence, motor weakness	Yes
12/F	Pain, motor, sensory	12	Cervical	Astrocytoma 2	3	3	3	3	STR	No	No	No	No
48/M	Pain, motor, sensory	4	Cervical	Ependymoma 2	3	2	1	1	TR	Yes	Yes	No	No
44/M	Pain, sensory	8	Cervical	Ependymoma 2	2	2	2	1	TR	No	Yes	No	Yes
21/M	Pain, motor, sensory	12	Dorsal	Ependymoma3	2	3	3	3	STR	No	No	Motor weakness	Yes
22/F	Pain, motor, sensory, autonomic	13	Cervical	Astrocytoma 4	4	5	5	5	STR	No	Yes	Recurrence, motor weakness	Yes
35/M	Pain, sensory	5	Cervical	Ependymoma 2	2	1	1	1	TR	Yes	Yes	No	Yes
48/M	Pain, sensory	9	Cervical	Ependymoma2	2	2	1	1	TR	Yes	Yes	No	Yes
58/M	Pain, motor, sensory	8	Cervical	Ependymoma2	3	2	1	1	TR	Yes	Yes	No	Yes
58/M	Pain, motor, sensory, autonomic	13	Dorsal	Astrocytoma 3	3	4	4	5	STR	No	No	Recurrence, motor weakness	Yes
24/M	Pain, motor	8	Dorsal	Ependymoma2	3	2	1	1	TR	Yes	Yes	No	Yes

F, female; F/U, follow-up; M, male; MMS, modified McCormick scale score; STR, subtotal resection; TR, total resection.

Table 2 Data analysis for patients with extramedullary tumors (*n*=16)

Age/sex	Clinical presentation	Duration of symptoms (months)	Location	Pathology	Preoperative MMS	Postoperative MMS	F/U 6 months MMS	F/U 1 year MMS	Extent of resection	IOM	CAUSA	Complications	Adjuvant therapy
22/F	Pain, motor, sensory, autonomic	9	Dorsal	Teratoma	2	1	1	1	TR	No	Yes	No	No
56/F	Pain, motor, sensory	9	Cervical	Meningioma	2	1	1	1	TR	Yes	Yes	No	No
42/M	Pain, motor, sensory, autonomic	10	Dorsal	Meningioma	3	2	1	1	TR	No	Yes	CSF leak	No
31/F	Pain, motor, sensory, autonomic	14	Dorsal	Meningioma	4	5	5	5	TR	No	No	Weakness	No
37/F	Pain, motor, sensory	9	Lumbar	Schwannoma	2	1	1	1	TR	No	No	CSF leak	No
41/F	Pain, motor	8	Dorsal	Meningioma	2	1	1	1	TR	No	yes	No	No
54/F	Pain, motor, sensory, autonomic	20	Dorsal	Meningioma	4	4	4	4	TR	No	No	Wound infection	No
56/F	Pain, motor	7	Dorsal	Meningioma	3	2	1	1	TR	Yes	No	No	No
54/F	Pain, motor, sensory	5	Cervical	Meningioma	2	1	1	1	TR	No	Yes	No	No
51/F	Pain, motor	9	Dorsal	Meningioma	2	1	1	1	TR	No	Yes	No	No
46/F	Pain, motor	24	Dorsal	Meningioma	4	4	4	4	TR	No	Yes	No	No
48/F	Pain, motor	7	Cervical	Schwannoma	2	1	1	1	STR	Yes	Yes	No	No
60/M	Pain, motor, sensory, autonomic	24	Cervical	Schwannoma	3	2	2	1	TR	No	Yes	No	No
52/M	Pain, sensory	3	Lumbar	Schwannoma	2	1	1	1	TR	No	No	CSF leak	No
21/F	Pain, sensory	5	Lumbar	Lipoma	2	1	1	1	STR	Yes	Yes	No	No
43/M	Pain, sensory	6	Lumbar	Epidermoid	2	1	1	1	STR	No	No	CSF leak	No

CSF, cerebrospinal fluid; F, female; F/U, follow-up; M, male; MMS, modified McCormick scale score; STR, subtotal resection; TR, total resection.

duration of symptoms of less than 10 months were associated with better postoperative outcome.

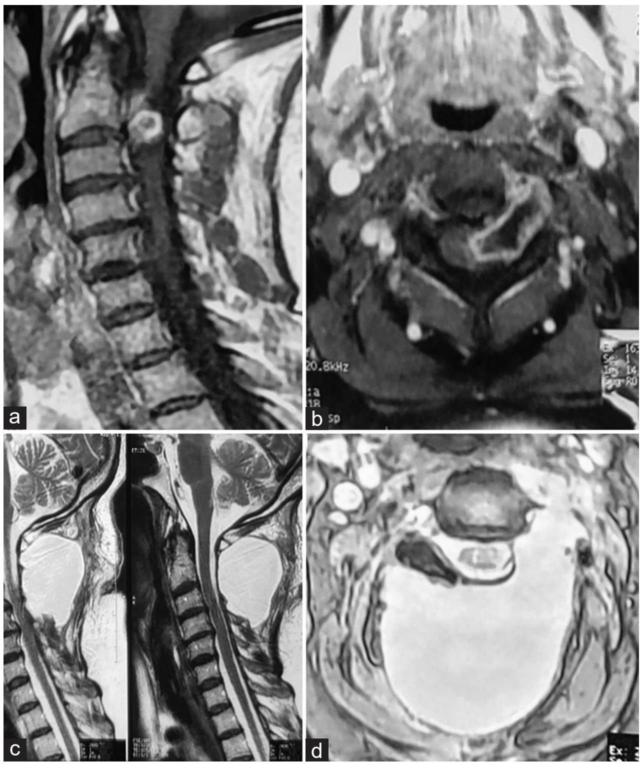
Tumor grade is another important prognosticator for postoperative outcome. We find that low-grade tumors (ependymoma, meningioma, and schwannoma) have a statistically significant association with better postoperative outcome, whereas high-grade tumors (astrocytoma, high-grade ependymoma) have a significant association with poor long-term outcome, as the cases showed marked deterioration from mean preoperative MMS (3.25 ± 0.96) to mean MMS (4.50 ± 1.0) at 1-year follow-up (Figs. 2 and 3).

Discussion

Now, it is widely accepted that surgery is the primary treatment for spinal cord tumors and gross total resection alone may control disease progression [8]. In our study, we analyzed the outcome predictors after surgery in 30 patients with intradural spinal tumors who had been operated on in the last 2 years.

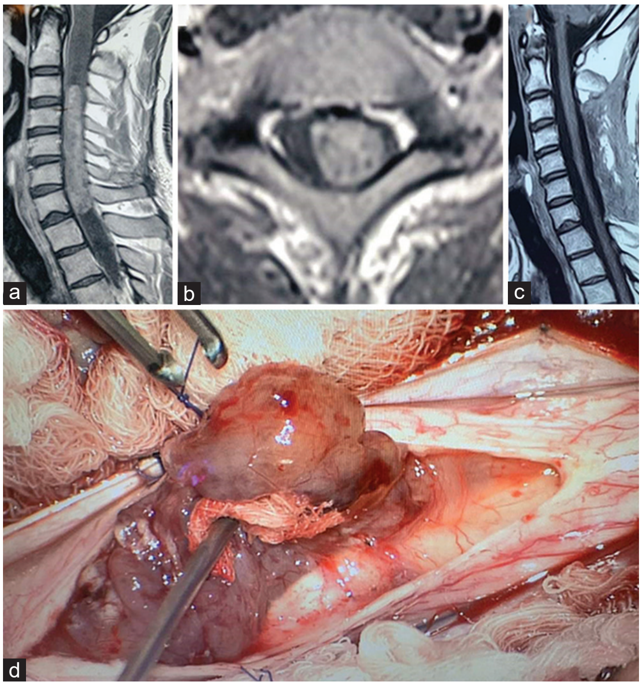
The MMS was used to evaluate preoperative clinical status, postoperative clinical outcome, and follow-up

Figure 2



A female patient, 48 years old, presented with neck pain, left brachialgia, and heaviness while walking. (a and b) Preoperative MRI sagittal and axial T1WI with contrast reveal a C2–C3 schwannoma traversing the Lt-C2–C3 intervertebral foramen. (c and d) Sagittal and axial T2WI postoperative MRI demonstrating tumor resection and postoperative pseudomeningocele.

Figure 3



A female patient, 30 years old, presented with dull aching neck pain, bilateral brachialgia, and unsteadiness. (a and b) Preoperative MRI sagittal and axial T1WI with contrast reveal a C3–C7 ependymoma. (c) Sagittal T1WI postoperative MRI showing tumor resection and syrinx resolution. (d) Intraoperative view showing tumor resection.

after discharge due to its simplicity and widespread use [9,10].

The clinical presentation of spinal intradural tumors is determined by cord compression and their location. They include pain, motor, sensory, and autonomic dysfunction [11,12].

In our study, pain was the most common presenting symptom, while autonomic dysfunction was the least frequent which was also noted in Nambiar and Kavar [13]. Regarding sensory-motor affection, 24 (80%) cases had sensory disturbance and 23 (76.7%) cases had motor dysfunction. Jenkinson *et al*. [14] and Nambiar and Kavar [13] reported a lower percentage of sensory-motor affection (50% sensory and 51% motor involvement).

We report a mean duration of symptoms of 9.73 ± 5.34 months ranging from 3 to 24 months, which is significantly shorter than that of Jenkinson *et al*. [14] (17 months) for Human embryonic stem cell-derived mesenchymal stem cells (EMSC) and 20 months for IMSCT. Manzano *et al*. [15] found a mean duration of 25.3 months for IMSCT and El-Mahdy *et al*. [16] reported a mean duration of 30 months for EMSC. This variation was attributed to the advancement and availability of imaging techniques and diagnostic tools that have shortened the duration of symptoms by aiding earlier diagnosis.

Gross total resection was achieved in 70% of our cases, and tumors with extramedullary locations are more likely to achieve gross total resection than those with intramedullary locations. We attribute this to the fact that meningioma and schwannoma are the commonest EMSC and always amenable to GTR due to the presence of the dissection plane, while ependymoma and astrocytoma are the commonest IMSCT and not always amenable to GTR, which was also reported by Chang *et al*. [17].

Our study showed that the use of adjunctive tools (CUSA, IONM [intraoperative neurophysiological monitoring]) and advanced microsurgical techniques has maximized the extent of tumor resection with lower morbidity, which has a significant association with good postoperative functional outcome ($P < 0.001$). Our results are consistent with Nambiar and Kavar [13] and Ng *et al*. [18], which showed that GTR was a good prognostic factor for surgical outcome. This is because complete resection of the tumor is associated with lower incidence of recurrence and repeated surgery.

We found that patients with good preoperative status and (MMS ≤3) were a significant prognostic factor for positive postoperative outcome ($P = 0.011$), which was also noted by Setzer *et al*. [19] and Johnston [20]. We agree with many authors that short duration of symptoms and early surgery as well as lower tumor grade are associated with good postoperative functional outcome [13,14,21,22].

After 1 year of follow-up, we found that sex and age did not have a significant effect on the functional outcome. Cofano *et al*. [23] reported that there was no registered association between sex, age, and clinical outcome. We also found no significant association between adjuvant therapy and postoperative or follow-up outcomes. The role of adjuvant therapy in spinal cord tumors remains controversial, and there is no sufficient data available for proper assessment of such a treatment modality [13].

The pattern of complications after surgery in this study is nearly equal to that of many other authors [16]. CSF leak is the most common complication, while infection is the least frequent. We reported a 10% recurrence rate, which is similar to the 10.4% recurrence rate reported in Jenkinson *et al*. [14]. The incidence of recurrence may be underestimated due to the absence of long-term follow-up, serial imaging, and small sample size. Also, zero mortality in our series may be attributed to the previous causes.

Conclusions

IDSCT are rare neoplasms and represent a surgical challenge. They can be extramedullary or intramedullary in location. Functional outcome is influenced by tumor histology, tumor location, and preoperative clinical status. The use of technical adjuncts and advanced microsurgical techniques aimed at GTR with low morbidity is the cornerstone of management. Subtotal resection and adjuvant therapy are valid options if GTR cannot be achieved.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Chamberlain MC, Tredway TL. Adult primary intradural spinal cord tumors: a review. Curr Neurol Neurosci Rep 2011; **11**:320–328.

2 Engelhard HH, Villano JL, Porter KR, Stewart AK, Barua M, Barker FG, *et al.* Clinical presentation, histology, and treatment in 430 patients with primary tumors of the spinal cord, spinal meninges, or cauda equina. J Neurosurg Spine 2010; **13**:67–77.

3 Schellinger KA, Propp JM, Villano JL, McCarthy BJ. Descriptive epidemiology of primary spinal cord tumors. J Neurooncol 2008; **87**:173–179.

4 Safaee M, Oh MC, Mummaneni PV, Weinstein PR, Ames CP, Chou D, *et al.* Surgical outcomes in spinal cord ependymomas and the importance of extent of resection in children and young adults. J Neurosurg Pediatr 2014; **13**:393–399.

5 Kucia EJ, Maughan PH, Kakarla UK, Bambakidis NC, Spetzler RF. Surgical technique and outcomes in the treatment of spinal cord ependymomas: part II: myxopapillary ependymoma. Neurosurgery 2011; **68**:90–94.

6 Garcés-Ambrossi GL, McGirt MJ, Mehta VA, Sciubba DM, Witham TF, Bydon A, *et al.* Factors associated with progression-free survival and long-term neurological outcome after resection of intramedullary spinal cord tumors: analysis of 101 consecutive cases. J Neurosurg Spine 2009; **11**:591–599.

7 McCormick PC, Torres R, Post KD, Stein BM. Intramedullary ependymoma of the spinal cord. J Neurosurg 1990; **72**:523–532.

8 Stein BM. Surgery of intramedullary lesions and escap- able pitfalls. In: Villers JC. editor *Some pitfalls and problems in neurosurgery, progress in neurological surgery*. Basle: Karger; 1990; 131–153.

9 Soon WC, Fisher B, Chowdhury YA, Hodson J, Fashola E, Egbuji O, *et al.* Factors influencing surgical outcomes for intradural spinal tumours: a single-centre retrospective cohort study. Cureus 2022; **14**:e21815.

10 Matsuyama Y, Sakai Y, Katayama Y, Imagama S, Ito Z, Wakao N, *et al.* Surgical results of intramedullary spinal cord tumor with spinal cord monitoring to guide extent of resection. J Neurosurg Spine 2009; **10**:404–413.

11 Ropper AE, Ropper AH. Acute Spinal Cord Compression. N Engl J Med 2017; **376**:1358-1369. doi: 10.1056/NEJMra1516539. PMID: 28379788.

12 Raco A, Esposito V, Lenzi J, Piccirilli M, Delfini R, Cantore G. Long-term follow-up of intramedullary spinal cord tumors: a series of 202 cases. Neurosurgery 2005; **56**:972–981.

13 Nambiar M, Kavar B. Clinical presentation and outcome of patients with intradural spinal cord tumours. J Clin Neurosci 2012; **19**:262–266.

14 Jenkinson MD, Simpson C, Nicholas RS, Miles J, Findlay GF, Pigott TJ. Outcome predictors and complications in the management of intradural spinal tumours. Eur Spine J 2006; **15**:203–210.

15 Manzano G, Green BA, Vanni S, Levi AD. Contemporary management of adult intramedullary spinal tumors-pathology and neurological outcomes related to surgical resection. Spinal Cord 2008; **46**:540–546.

16 El-Mahdy W, Kane PJ, Powell MP, Crockard HA. Spinal intradural tumours: part I – extramedullary. Br J Neurosurg 1999; **13**:550–557.

17 Chang UK, Choe WJ, Chung SK, Chung CK, Kim HJ. Surgical outcome and prognostic factors of spinal intramedullary ependymomas in adults. J Neurooncol 2002; **57**:133–139.

18 Ng Z, Ng S, Nga V, Teo K, Lwin S, Ning C, *et al.* Intradural spinal tumors – review of postoperative outcomes comparing intramedullary and extramedullary tumors from a single institution's experience. World Neurosurg 2018; **109**:e229–e232.

19 Setzer M, Vatter H, Marquardt G, Seifert V, Vrionis FD. Management of spinal meningiomas: surgical results and a review of the literature. Neurosurg Focus 2007; **23**:E14.

20 Johnston RA. The management of acute spinal cord compression. J Neurol Neurosurg Psychiatry 1993; **56**:1046–1054.

21 Woodworth GF, Chaichana KL, McGirt MJ, Sciubba DM, Jallo GI, Gokaslan Z, *et al.* Predictors of ambulatory function after surgical resection of intramedullary spinal cord tumors. Neurosurgery 2007; **61**:99–105.

22 Klekamp J. Spinal ependymomas. Part 1: intramedullary ependymomas. Neurosurg Focus 2015; **39**:E6.

23 Cofano F, Giambra C, Costa P, Zeppa P, Bianconi A, Mammi M, *et al.* Management of extramedullary intradural spinal tumors: the impact of clinical status, intraoperative neurophysiological monitoring and surgical approach on outcomes in a 12-year double-center experience. Front Neurol 2020; **11**:1683.