

# Minimally Invasive Hemilaminectomy Approach in Cases of Intradural-Extramedullary Spinal Tumors: Local Experience

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## ABSTRACT

**Background Data:** Intradural-extramedullary (IDEM) tumors represent two-thirds of spinal cord tumors. As IDEM tumors are mostly benign, advocated approaches for surgical excision of these lesions should aim for total excision of the lesion with avoiding unnecessary disruption of spinal stability.

**Study design:** This is a retrospective case series.

**Purpose:** To assess the feasibility and advantages of a minimally invasive hemilaminectomy approach for excising IDEM spinal tumors.

**Patients and Methods:** This study was conducted in our institution to review retrospectively cases of IDEM spinal tumors that underwent a minimally invasive hemilaminectomy approach from January 2016 to January 2019. Twenty-six patients who presented with twenty-seven tumors fulfilled our criteria and were included in this study. The history of all patients was taken and they were subjected to clinical examination and preoperative MRI with contrast. Frankel scale was used to assess the neurological status of the affected limbs and Visual Analogue Scale (VAS) for the evaluation of associated radicular pain. Regular follow-up visits were arranged for our cases one month after surgery and then every three months for at least 6 months.

**Results:** Twenty-six patients with 27 tumors were included in this study, 15 females (57.7%) and 11 males (42.3%). The mean age of patients was  $42.3 \pm 12.8$  years. This study included 15 schwannomas (55.6%), 4 neurofibromas (14.8%), and 8 meningiomas (29.6%). Gross total excision was achieved in 26 tumors (96%). Early mobilization and short hospital stay ( $1.38 \pm 1.09$ ) days were reported in all these cases. Complications reported in this study included one case of wound infection, one patient developed a CSF leak, and one patient experienced a mild deterioration of motor power.

**Conclusion:** This study suggests that a minimally invasive hemilaminectomy approach offers an adequate, safe, and convenient corridor for the total excision of IDEM tumors. However, good patient selection, accurate preoperative and intraoperative tumor localization, and meticulous microsurgical resection are mandatory. (2020ESJ208)

**Keywords:** Hemilaminectomy, Approach, Schwannoma, Neurofibroma, Intradural extramedullary, tumors.

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## INTRODUCTION

In 1888, Sir Victor Horsley succeeded for the first time in excising an IDEM tumor which was located in the thoracic region. This dated more than forty years before the invention of myelography, and unsurprisingly, the diagnosis of this case was delayed until the patient became paraplegic before being operated on via an extensive laminectomy with wound complication till full recovery after 1 year.<sup>6</sup>

Recently, the field of spinal oncology witnessed outstanding advancements in both spinal imaging and surgical techniques. This has led to a dramatic improvement in managing spinal tumors in terms of early diagnosis, precise preoperative and intraoperative localization, minimally invasive approaches, neurophysiological monitoring, fast recovery, and good overall outcome.<sup>14</sup>

The hemilaminectomy technique was first introduced in 1910 by Taylor<sup>16</sup>; then, it was popularized in 1983 by Eggert et al.<sup>4</sup> and in 1989 by Chiou et al.<sup>3</sup> Several biomechanical reports proved that a minimally invasive hemilaminectomy approach keeps the stability of the spine and decreases alterations of segmental motion after surgery.<sup>10</sup>

Although the use of the hemilaminectomy approach has become more popular among spine surgeons, traditional full laminectomy is still a common practice for surgical excision of spinal tumors and has stood the test of time, despite causing massive tissue damage, blood loss, and prolonged hospital stays, especially when multiple levels are included. Many clinical reports emphasized the fact that laminectomy could lead to postoperative complications such as instability, deformity, epidural adhesion, and progressive myelopathy.<sup>18</sup>

This study was designed to assess the feasibility, safety, and efficacy of the minimally invasive hemilaminectomy approach in the surgical excision of IDEM spinal tumors.

## PATIENTS AND METHODS

This retrospective study was conducted in the Neurosurgery Department, Mansoura University Hospitals, to report the cases of IDEM spinal tumors excised by the minimally invasive hemilaminectomy approach from January 2016 to January 2019. Analysis of our hospital records and imaging database was conducted. Screening of all medical records was done utilizing the electronic hospital database and details of patients with a documented clinical diagnosis of IDEM were retrieved. The imaging database was then screened to identify those patients who satisfied the eligibility criteria. Demographic details such as age, sex, and duration of symptoms were retrieved from the database.

Twenty-six patients who presented with 27 tumors fulfilled our criteria and were included in this study. The study was approved by the local institutional review board (IRB), with strict adherence to patient confidentiality. All patients signed preoperative informed consent.

Inclusion criteria were as follows: patients with IDEM tumors, available preoperative and postoperative clinical and radiological data, age ranging from 20 to 65 years, MRI-confirmed nonsyndromic IDEM tumors, and normal spinal alignment with adequate stability. Exclusion criteria were as follows: extensive tumors spanning more than three spinal levels, previously operated cases with recurrent lesions, patients with insufficient clinical and radiological follow-up data, cases with an unstable spine, cases with other pathologies, neglected cases with marked irreversible neurological deficits, and patients with follow-up periods less than six months.

A detailed history was taken including onset, progression, and duration of patients' complaints and associated symptoms suggesting motor, sensory, or sphincteric dysfunctions. Pain was evaluated according to the location, extensions, quality, and intensity, in addition to aggravating and alleviating factors. Pain intensity was estimated

in a subjective self-reported fashion using the 0-10 Visual Analogue Scale (VAS) applied for cases presenting with radicular pain. Past and family history was taken for the exclusion of associated neurofibromatosis and previous surgeries for similar tumors. A thorough general examination was conducted in each case to exclude signs suggesting associated syndromes or asymptomatic lesions elsewhere. Full neurological examination was then performed to document preoperative status including motor and sensory systems. The overall spinal cord function was assessed using the Frankel grade classification and was applied for all patients.

Preoperative diagnosis was fulfilled in all cases using spinal MRI with intravenous contrast. Spinal X-ray was performed for preoperative confirmation of adequate spinal stability, whereas spinal CT of the involved segment was performed in selected cases when the study of the local osseous anatomy was required.

### **Surgical Procedure**

Surgery was done under general anesthesia. Patients were positioned in a prone position with pillows below the chest and pelvis with the head fixed in a 3-point rigid cranial stabilization system in case of tumors affecting the cervical region. Intraoperative fluoroscopy was used to identify the exact tumor level. A posterior midline skin incision was made followed by unilateral subperiosteal muscle stripping; then hemilaminectomy was performed for one to three levels according to the extent of the tumor (Figure 1). In some cases, the base of the spinous process was drilled to give extra space in stenotic levels. The ligamentum flavum was then removed and the dura was opened. Microsurgical total excision of the tumor was targeted in all cases, assisted with and confirmed by intraoperative ultrasonography (Figure 2). In cases of meningioma, the dural attachment of the tumor was coagulated using bipolar diathermy or maximally excised and repaired using a graft from the dorsal fascia. After watertight closure of the dura was ensured, the wound was closed in layers anatomically over a drain. In four cases, there were

large extraforaminal parts in the cervical region, which necessitated an additional lateral approach to remove them as shown in Figures 2 and 3.

### **Postoperative Care**

All resected tumors were sent for histopathological examination to confirm the diagnosis. All patients were subjected to postoperative spinal MRI with contrast to detect any residual tumor or postoperative complications. A physiotherapeutic program was applied for all patients presenting with motor deficits during the preoperative preparation and as postoperative rehabilitation. Regular outpatient follow-up visits were arranged one month after surgery and then every three months. In each visit, both residual and new pain VAS scores and Frankel grade for spinal cord function were evaluated during clinical assessment for all patients. The postoperative spinal stability was evaluated using plain dynamic radiographs in a standing position.

### **Statistical Analysis**

The datasets are represented as measures of central tendency and variability for scale variables and as numbers and proportions for categorical variables. For central tendency, mean was used for normally distributed data, whereas median was used when data were not normally distributed. Similarly, variability was represented by standard deviation or minimum and maximum based on normal or non-normal distribution, respectively. Normality of data was tested using the Shapiro–Wilk test. Moreover, Wilcoxon’s signed-rank test was applied for statistical data analysis.

## RESULTS

Twenty-seven tumors in 26 patients were evaluated in this study. The mean age of the included cases was  $42.3 \pm 12.8$  (range, 20–65) years. We included 15 females (57.7%) and 11 males (42.3%). The mean duration of symptoms was  $13.8 \pm 7.6$  months. Fifteen tumors (55.6%) were on the right side of the spinal canal, whereas 12 tumors (44.4%) were on the left side (Table 1).

This study included 15 schwannomas (55.6%), 4 neurofibromas (14.8%), and 8 meningiomas (29.6%). Ten tumors (37%) were in the cervical region, with 6 (60%) being schwannomas. Eleven tumors (40.7%) were in the dorsal region, with six (54.5%) being meningiomas (including one patient with 2 meningiomas). Six tumors (22.3%) were in the lumbar region, with 6 (66.7%) being schwannomas. Overall, in terms of gender, 8 women (53.3%) had schwannomas and 5 (62.5%) had meningiomas (Table 2).

The mean operative time was  $121.5 \pm 20.9$  (range, 85–160) minutes. The mean blood loss was  $325 \pm 150$  (range, 175–475) ml. with only one case needing blood transfusion (one unit of 250 ml of packed RBCs). In this study, in total, we performed 46 hemilaminectomies with a mean of  $1.74 \pm 0.59$  (range, 1–3) lamina. Hemilaminectomy for one level was conducted for 10 tumors (37%), two levels for 15 tumors (55.6%), and three levels for two tumors (7.4%) (Table 1).

Early mobilization was instructed to all patients and this was feasible. The mean hospital stay was  $1.38 \pm 1.09$  (range, 1–5) days; however, only patient no. 3 who had neurologic deterioration of his motor power from Frankel D preoperatively to Frankel C postoperatively was hospitalized for four days.

All patients included in this study showed clinical improvement postoperatively except for one case (patient no. 3) that deteriorated and then showed improvement on his motor power assessment and enhanced myelopathic features on follow-up visits with medical treatment and physiotherapy.

The mean VAS score of radicular pain patients (N = 11) was reduced from  $5 \pm 0.73$  (range, 4–6) preoperatively to  $1.63 \pm 0.48$  (range, 1–2) postoperatively. According to the Frankel scale, preoperatively 12 patients were grade E, 8 grade D, 6 grade C, and 0 grades B and A, whereas, at the last follow-up, 21 patients were grade E, 4 were grade D, 1 was grade C, and 0 were grades B and A.

Gross total excision was achieved in 25 patients (96%) including the one with double-level meningiomas (patient no. 22), and this was confirmed by postoperative MRI which was done routinely one month after surgery. In patient no. 11, we could excise about 80% of the tumor because of marked adhesiveness of the tumor to the extraforaminal portion of the exiting nerve root.

Complications in this study were reported in 3 patients including the following. One patient developed wound infection (patient no. 24) which improved on conservative medical treatment after 5 days of hospital stay. Another patient (patient no. 25) had a CSF leak five days postoperatively while he was at home; we readmitted him again and a lumbar drain was inserted for three days and then he was discharged after CSF control on the fourth day of readmission. A third case (patient no. 3) experienced a mild deterioration of his motor power from Frankel grade D to Frankel grade C postoperatively; however, he was discharged on the fourth postoperative day and showed improvement on conservative medical measures and physiotherapy on regular follow-up visits.

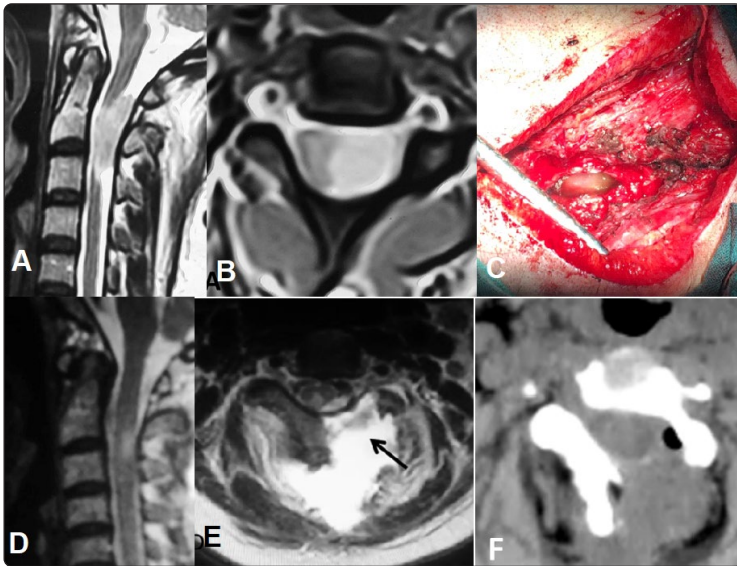


**Table 1.** Summary of data of patients (N = 26) in this study.

No.	Age	Sex	Level	Side	Location	Presentation	Preop VAS	Preop Frankel	Hemilaminectomy levels	Op time	Pathology	Postop VAS	Postop Frankel
1	35	F	C4	R	Dumbbell	Radiculopathy	5	E	1	90	Schwannoma	1	E
2	20	F	D8	L	IDEM	Myelopathy		D	2	110	Schwannoma		E
3	32	M	D10-11	L	IDEM	Myelopathy		D	2	135	Meningioma		C
4	44	M	D8	R	IDEM	Myelopathy/ Brown squared		D	1	105	Schwannoma		D
5	50	M	D7-8	L	IDEM	Hemihypesthesia		E	3	140	Meningioma		E
6	37	M	L3-4	R	IDEM	Radiculopathy	4	E	2	125	Schwannoma	1	E
7	46	F	C3-4	R	Dumbbell	Neck mass		E	1	145	Neurofibroma		E
8	38	F	C1-2	L	IDEM	Motor weakness		C	2	160	Meningioma		E
9	25	F	D11-12	L	IDEM	Myelopathy		C	2	110	Schwannoma		D
10	28	M	C3	L	Dumbbell	Neck mass		E	2	90	Schwannoma		E
11	22	F	C4-5	L	IDEM	Radiculopathy	4	E	2	145	Neurofibroma	2	E
12	27	F	L2-3	R	IDEM	Cauda equina		C	2	150	Meningioma		D
13	50	M	C2	L	Dumbbell	Neck mass		E	1	135	Neurofibroma		E
14	30	F	L2	R	IDEM	Radiculopathy	5	D	1	120	Schwannoma	2	E
15	64	F	C5	R	Dumbbell	Radiculopathy	6	E	2	85	Schwannoma	2	E
16	55	F	L4	L	IDEM	Radiculopathy	5	D	1	115	Neurofibroma	1	E
17	60	F	D5	R	IDEM	Myelopathy		D	2	120	Meningioma		E
18	45	M	C2-3	L	IDEM	Neck pain		E	2	110	Schwannoma		E
19	40	M	L1-2	R	IDEM	Radiculopathy	4	D	1	90	Schwannoma	1	E
20	37	M	L3	R	IDEM	Radiculopathy	6	D	1	100	Schwannoma	2	E
21	46	F	C6-7	R	IDEM	Radiculopathy	5	E	2	110	Schwannoma	2	E
22	50	F	D5&D11	R&R	IDEM	Myelopathy		C	2&1	135 90	Meningioma		D
23	56	F	D1-2	R	IDEM	Radiculopathy	5	C	2	130	Schwannoma	2	E
24	57	F	C7-D1	L	IDEM	Radiculopathy	6	E	1	120	Schwannoma	2	E
25	65	M	D9-10	R	IDEM	Hemihypesthesia		E	3	150	Schwannoma		E
26	43	M	L1-2	L	IDEM	Cauda equina		C	2	135	Meningioma		E
Total	42.3±12.8						5±0.73		1.74±0.59	121.5±20.9		1.63±0.48	

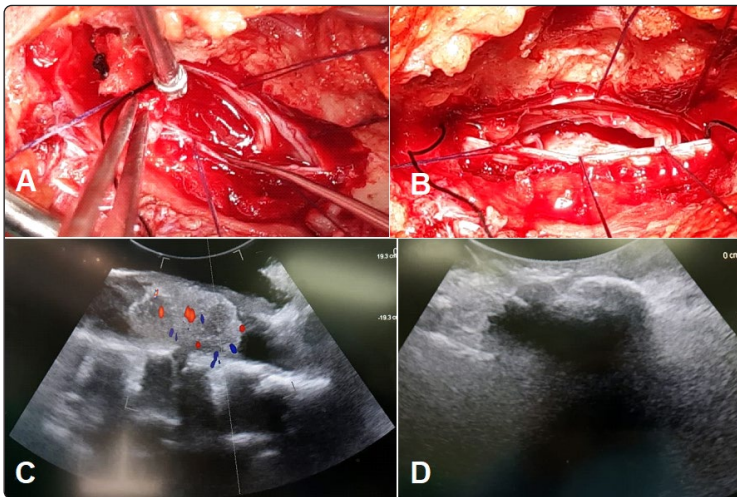
**Table 2.** Tumors distribution according to site and pathology.

Parameters	Schwannoma	Neurofibroma	Meningioma	Total
Cervical	6	3	1	10 (37%)
Dorsal	5	0	6	11 (40.7%)
Lumbar	4	1	1	6 (22.3%)
Total	15 (55.6%)	4 (14.8%)	8 (29.6%)	27



**Figure 1.**

A 46-year-old female patient complaining of C2 meningioma. (A) T2-WI MRI axial cut showing massive cord compression by the tumor. (B) T2-WI MRI sagittal cut showing the craniocaudal extent of the tumor beyond C2 & C3 spinous processes. (C) Intraoperative photo showing the surgical corridor and total excision of the mass with preservation of the right side musculature and fascial attachment. (D) Three-day postoperative MRI of the patient showing the total excision of the lesion with cord reexpansion. (E) Postoperative sagittal T2-WI MRI showing decompression of the canal with preservation of all spinous processes. (F) Postoperative CT scan with a bony window showing the extent of bony resection and preservation of C2 & C3 spinous processes.



**Figure 2.**

(A) Intraoperative photo showing tumor removal through a hemilaminectomy approach. (B) Intraoperative photo after tumor removal. (C) Intraoperative ultrasonography showing the tumor and its vascularity. (D) Intraoperative ultrasonography after tumor removal



**Figure 3.**

A 58-year-old female patient complaining of D5 meningiomas. (A) Preoperative T2-WI MRI sagittal view showing the presence of double intradural lesions. (B) Postoperative CT scan showing the corridor of surgical procedure with extent of bony resection after total excision of the lesion through minimally invasive unilateral routes with preservation of all spinous processes.

## DISCUSSION

Intradural-extramedullary (IDEM) tumors account for more than 70% of spinal cord tumors. It is well known that schwannomas and neurofibromas have a higher incidence in the cervical and lumbar regions, while meningiomas are more common in the dorsal region<sup>11</sup>, similar to the results of our study. Here, we had ten tumors occupying the cervical region: 6 (60%) schwannomas, 3 (30%) neurofibromas, and 1 (10%) meningioma. In the dorsal region, there were eleven tumors: 6 (54.5%) meningiomas and 5 (45.5%) schwannomas, whereas, in the lumbar region, schwannomas represented 66.7% of all tumors.

Many reports suggested that meningiomas represent 25%–46% of all primary intraspinal tumors and spinal meningiomas are only 7.5%–12.5% of all meningiomas as they are mostly found in the brain. Spinal meningiomas are more commonly located in the dorsal region and they are more common in females, mostly owing to female hormones.<sup>15</sup> These results are in agreement with our findings where meningiomas represented 29.6% of the tumors. Our study included 8 meningiomas, with 6 (75%) being in the dorsal region and 5 (62.5%) in female patients.

Although there are many technical explanations for the term “minimally invasive,” gross total excision of these lesions with minimal complications is still the main goal. Minimally invasive surgery for intradural tumors offers many advantages such as limited tissue destruction, minimal bleeding, better patient recovery, and reducing the risk of instability which occurs in multiple laminectomies.<sup>13</sup> Some authors prefer to do muscle splitting using the tubular retractor system to reach the involved lamina.<sup>12</sup> Other surgeons used unilateral subperiosteal muscle stripping to approach these tumors. In this technique, an adequate amount of bone in the trajectory of the tumors can be removed, which may necessitate excision of parts of the adjacent laminae above

and below to achieve the dural exposure which enables total tumor excision.<sup>17</sup>

These results and concepts are supported by our study. We used unilateral subperiosteal muscle stripping and expanded our corridor by drilling the base of the spinous process and sometimes by taking out a part of the upper and lower laminae. In our patients, short hospital stay and early recovery were observed, and almost all cases but one improved their presenting symptoms.

Elsobky et al.<sup>5</sup>, in their series about the combined approach for spinal schwannomas with large extraspinal extension, concluded that the intraspinal could be removed easily and totally through a minimally invasive hemilaminectomy with facet preservation and this will not interfere with spine stability.

Other reports assumed that gross total excision rates for IDEM tumors are higher than those for intramedullary tumors and the recorded ranges were 80% to 99%. Patients with marked neurological deficits preoperatively showed remarkable improvement after tumor excision and physiotherapeutic programs. Tumors that occupy cervical and lumbar regions were noticed to show a better prognosis than those occupying the dorsal region.<sup>8</sup> These results are similar to ours as we achieved gross total excision assisted by intraoperative ultrasonography in 96% of patients. Marked improvement was observed in patients with preoperative neurological deficits after gross total excision and rehabilitation programs. The only case which was deteriorated postoperatively was a meningioma in the dorsal region.

Many reports about intradural-extramedullary tumors reported significant pain improvement after surgery. Ahn et al.<sup>1</sup> documented that the mean VAS score was decreased in their patients from 8 before surgery to 1.2 after surgery, whereas Ahsan et al.<sup>2</sup> reported a reduction of the mean VAS score from 7.67 preoperatively to 1.14 postoperatively. Consistent with previous studies, in our series, the mean VAS score was reduced from  $5 \pm 0.73$  (range, 4–6) preoperatively to  $1.63 \pm 0.48$  (range, 1–2) postoperatively.



Reviewing the literature, we concluded that despite using different scales in each study of intradural-extramedullary tumors as measuring tools to evaluate the pre- and postoperative neurological status, all of them showed remarkable neurological improvement after surgical excision of the tumor. Konovalov et al.<sup>9</sup> reported that 50% of patients moved to a higher functional class of McCormick scale after laminectomy and resection of the tumor. Ahsan et al.<sup>2</sup> and Ahn et al.<sup>1</sup> reported that the mean Nurick's grade has improved from three preoperatively to one postoperatively. Similarly, Gu et al.<sup>7</sup> revealed that 93% of their patients had improved Frankel grade 1 preoperatively to grade 1.6 postoperatively, whereas 7% of patients had no change in their grade after surgery. Consistent also with the previous studies, in our series, there was an improvement of the Frankel grade in our patients at least one grade up, while intact patients remained intact at the last follow-up.

This study included 6 cases occupying transitional zones in the vertebral column: two in the cervicodorsal region and 4 in the thoracolumbar region. During surgery on these areas, stability is the main concern. This approach allows for less bony removal and minimal tissue destruction. The spinous processes and interspinous ligaments are not disrupted. The facets, the laminae, and the paraspinal muscles of the other side are not interrupted. All these factors will keep the stability of the spine and decrease alterations of segmental motion after surgery especially in transitional zones.

Despite the large number of IDEM cases, this study was limited by the inability to conduct extended long-term follow-up for some patients who have experienced improvement and stopped regular follow-up at our outpatient clinics. Moreover, minimally invasive surgeries were not performed in many cases because of some factors such as large tumor size, presence of marked adhesion due to previous surgeries, and rapid marked neurological deterioration which necessitates performing traditional wide decompression aiming for enhancing neural recovery.

## CONCLUSION

This study suggests that the minimally invasive hemilaminectomy approach offers an adequate, safe, and convenient corridor for the total excision of IDEM tumors. However, good patient selection, accurate preoperative and intraoperative tumor localization, and meticulous microsurgical resection are mandatory.

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## الملخص العربي

**النهج الجراحي المحدود لاستئصال أورام العمود الفقري داخل الام الجافية وخارج الحبل الشوكي**  
**البيانات الخلفية:** تمثل أورام داخل الجافية خارج النخاع ثلثي أورام النخاع الشوكي. كما نعلم أن هذه الأورام حميدة في الغالب، فإن الإزالة الكاملة تعني علاج المرضى.  
**تصميم الدراسة:** هذه دراسة حالة سريرية مستقبلية.

**الغرض:** تم تصميم هذه الدراسة لتقييم جدوى ومزايا نهج طفيفة التوغل لاستئصال أورام العمود الفقري.

**المرضى والطرق:** جريت هذه الدراسة الاستباقية في قسم جراحة المخ والأعصاب ، مستشفى جامعة المنصورة من 2016 إلى 2019 على ستة وعشرين مريضاً تم تقديمهم مع سبعة وعشرون أوراماً داخل الام الجافية خارج النخاع. تم تقييم جميع المرضى بأخذ التاريخ ، والفحص السريري والتصوير بالرنين المغناطيسي قبل الجراحة على النقيض. تم استخدام مقياس MRC معدل لتقييم قوة تحرك للأطراف المصابة، وتم استخدام مقياس vas لتقييم الحالات المصحوبه بالام طرفيه، وتم استخدام مقياس FRANKEL لتقييم الحالات المصحوبه باعتلال لوظائف النخاع الشوكي. خضعت جميع الحالات لعملية استئصال جراحي عن طريق الجراحة طفيفة التوغل ، وتم ترتيب زيارات متابعة منتظمة لحالاتنا بعد شهر واحد من الجراحة ثم كل ثلاثة أشهر لمدة ثمانية عشر شهراً على الأقل..

**النتائج:** تم تضمين 27 ورماً في 26 مريضاً في هذه الدراسة. كان متوسط عمر الحالات المشمولة  $12.8 \pm 42.3$  سنة (المدى 20-65). أدرجنا 15 أنثى (57.7%) و 11 ذكور (42.3%). اشتملت هذه الدراسة على 15 ورم شوان (55.6%) و 4 أورام ليفية عصبية (14.8%) و 8 أورام سحائية (29.6%). تم تحقيق إجمالي الاستئصال الإجمالي في 26 ورماً (96%) من الحالات المشمولة في هذه الدراسة. كان متوسط وقت الجراحة  $20.9 \pm 121.5$  ساعة. وتم ازالة الصفائح العظمية للمستويات المصابة بمتوسط  $0.59 \pm 1.74$  صفيحة. وكان مقدار تحسن الحالات بمقياس FRANKEL بالمتوسط هو ارتفاع من الدرجة الرابعة الي الدرجة الخامسة، كما كان مقدار التحسن علي 11 مريض بشكوى رئيسيه للآلام طرفيه هي انخفاض لمستوي الالام علي مقياس vas من  $0.73 \pm 5$  قبل الجراحة الي  $0.48 \pm 1.63$  لما بعد الجراحة.

**الخلاصة:** على الرغم من أن هذا المنهج الجراحي هو منهج طفيف التوغل ، إلا أنه يوفر ممراً مناسباً وآمناً ومريحاً للاستئصال التام لهذه الاورام.