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**ORIGINAL ARTICLE**

# Unilateral Hemilaminotomy for Intradural Extramedullary Spinal Tumors: Safety, Efficacy, and Neurological Outcomes

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## Abstract

**Introduction and Objectives:** Intradural extramedullary (IDEM) spinal tumors constitute the most common group of intraspinal tumors and frequently present with progressive neurological deficits due to spinal cord or nerve root compression. Conventional laminectomy, though widely used, is associated with significant postoperative morbidity and spinal instability. With advancements in minimally invasive spine surgery, unilateral hemilaminotomy has emerged as an alternative approach aimed at preserving spinal stability while achieving adequate tumor excision. **Materials and Methods:** This hospital-based longitudinal observational study was conducted in a tertiary care neurosurgical center between January 2014 and December 2018. A total of 30 patients with IDEM tumors who underwent surgical excision using unilateral hemilaminotomy were included. Ethical approval was obtained, and written informed consent was secured from all participants. Preoperative evaluation included detailed neurological assessment using Nurick's grading and magnetic resonance imaging for tumor localization. **Results:** The study population had a mean age of 51 years with equal gender distribution. Thoracic spine was the most commonly involved region. Gross total tumor excision was achieved in all cases without conversion to conventional laminectomy. There was a statistically significant improvement in neurological status, with mean Nurick grade improving from 2.63 preoperatively to 0.30 postoperatively ($p < 0.0001$). Schwannomas were the most common histopathological diagnosis, followed by meningiomas. **Conclusion:** Minimally invasive unilateral hemilaminotomy is a safe and effective surgical approach for IDEM tumors, providing excellent neurological outcomes with minimal morbidity while preserving spinal stability. This technique represents a reliable and durable alternative to conventional laminectomy.

**Key words:** Intradural extramedullary tumor, Hemilaminotomy, Spinal tumors, Minimally invasive spine surgery, Neurological outcome

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## Graphical Abstract

**Unilateral Hemilaminotomy for Intradural Extramedullary Spinal Tumors: Safety, Efficacy, and Neurological Outcomes**

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**Background**
Intradural extramedullary (IDEM) spinal tumors constitute the most common group of intraspinal tumors and frequently present with progressive neurological deficits due to spinal cord or nerve root compression. Conventional laminectomy, though widely used, is associated with significant postoperative morbidity and spinal instability. With advancements in minimally invasive spine surgery, unilateral hemilaminotomy has emerged as an alternative approach aimed at preserving spinal stability while achieving adequate tumor excision.

**Methods**
This hospital-based longitudinal observational study was conducted in a tertiary care neurosurgical center between January 2014 and December 2018. A total of 30 patients with IDEM tumors who underwent surgical excision using unilateral hemilaminotomy were included. Ethical approval was obtained, and written informed consent was secured from all participants. Preoperative evaluation included detailed neurological assessment using Nurick's grading and magnetic resonance imaging for tumor localization.

**Baseline demographic and tumor characteristics of patients with IDEM tumors**

| Parameter | Sub classification | F | % |
|---|---|---|---|
| Age Group | 21-30 | 2 | 6.66 |
| | 31-40 | 6 | 20 |
| | 41-50 | 6 | 20 |
| | 51-60 | 8 | 26.67 |
| | 61-70 | 5 | 16.67 |
| | 71-80 | 3 | 10 |
| Sex | Male | 15 | 50 |
| | Female | 15 | 50 |
| Location of IDEM tumour | Cervical | 8 | 26.67 |
| | Thoracic | 18 | 60 |
| | Thoracolumbar | 1 | 3.33 |
| | Lumbar | 3 | 10 |

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**Conclusions** Minimally invasive unilateral hemilaminotomy is a safe and effective surgical approach for IDEM tumors, providing excellent neurological outcomes with minimal morbidity while preserving spinal stability. This technique represents a reliable and durable alternative to conventional laminectomy.

## Introduction

Spinal tumors constitute approximately 15% of all central nervous system tumors and are classified anatomically as extradural or intradural lesions. Intradural tumors are further subdivided into intramedullary and extramedullary tumors based on their relationship to the spinal cord. Among these, intradural extramedullary (IDEM) tumors represent the most common type of intraspinal tumors [1].

Nerve sheath tumors and meningiomas account for the majority of IDEM tumors. Among nerve sheath tumors, schwannomas are more frequently encountered than neurofibromas and typically arise from the dorsal nerve roots, whereas neurofibromas are more often associated with ventral roots and may present with a dumbbell configuration [2,3]. IDEM tumors are generally slow-growing lesions and often present with progressive spinal cord compression, leading to neurological deficits that may worsen over time if left untreated.

Surgical excision remains the treatment of choice for IDEM tumors, with the primary objectives being complete tumor removal, adequate decompression of the spinal cord and nerve roots, and histopathological diagnosis [4]. Traditionally, laminectomy has been the standard surgical approach for the excision of IDEM tumors because it provides wide exposure and is familiar to most surgeons. However, conventional laminectomy is associated with several drawbacks, including extensive muscle dissection, increased blood loss, prolonged hospital stay, epidural scarring, postoperative axial pain, and a significant risk of postoperative spinal instability and kyphotic deformity, which may ultimately result in progressive myelopathy [5-10,35-37,43,46,47].

To overcome these limitations, alternative surgical techniques such as laminotomy and laminoplasty have been developed. Although laminoplasty aims to

preserve posterior spinal elements, studies have shown that it does not completely eliminate the risk of postoperative spinal instability and may be technically demanding, time-consuming, and associated with a higher risk of dural injury, particularly in elderly patients [9-14,38-40]. These approaches also require bilateral stripping of posterior musculoligamentous structures, which play a crucial role in maintaining spinal stability.

With advances in microsurgical techniques and a growing emphasis on minimally invasive spine surgery, unilateral hemilaminotomy has gained attention as an effective alternative for the management of IDEM tumors. Biomechanical studies have demonstrated that hemilaminotomy preserves the structural integrity of the spine by maintaining posterior stabilizing elements [12,15-22,32-34]. Clinical studies have further shown that this approach is associated with shorter operative time, reduced intraoperative blood loss, fewer postoperative complications, shorter hospital stay, and better preservation of spinal stability when compared with conventional laminectomy.

In this study, we analyze the clinical and neurological outcomes of patients with spinal IDEM tumors treated using a minimally invasive unilateral hemilaminotomy approach and evaluate the efficacy and safety of this technique in achieving adequate tumor excision while preserving spinal stability.

## Materials and Methods

This hospital-based longitudinal observational study was conducted in the Department of Neurosurgery at a tertiary care referral centre in South India. Prior to initiation of the study, approval was obtained from the Institutional Ethics Committee and the concerned university authorities. All procedures were carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. Eligible patients and their immediate relatives were approached during the preoperative period, and the nature of the study, surgical procedure, potential benefits, possible risks, and follow-up requirements were explained in detail in their vernacular language. Written informed consent was obtained from both the patient and a responsible attendant before inclusion in the study. Participation was entirely voluntary, and confidentiality of patient data was strictly maintained throughout the study.

Patients diagnosed with intradural extramedullary (IDEM) spinal tumors who underwent surgical excision by unilateral hemilaminotomy were included in the study. Patients who were medically unfit for surgery, unwilling to undergo surgical intervention, had a history of previous spinal surgery, or were operated for recurrent tumors were excluded. A total of 30 patients fulfilling the inclusion criteria were enrolled. Demographic details, clinical presentation, neurological status, comorbid conditions, imaging findings, intraoperative observations, histopathological diagnosis, postoperative complications, and follow-up details were recorded using a structured proforma.

All patients underwent detailed preoperative clinical and neurological evaluation. Neurological status was assessed using Nurick's grading system at admission and during follow-up. Magnetic resonance imaging of the spine was performed in all cases to determine the level, size, side, and extent of the tumor. Histopathological classification of tumors was carried out according to World Health

Organization criteria. Preoperative preparation included routine laboratory investigations, anesthetic evaluation, and administration of prophylactic antibiotics. Intraoperative electrophysiological monitoring, including somatosensory evoked potentials, motor evoked potentials, and free-run electromyography, was employed in all cases to enhance surgical safety and preserve functional neural structures.

All patients were operated in the prone position under general anesthesia. After appropriate positioning and padding of pressure points, a midline skin incision was made over the involved spinal level. Unilateral subperiosteal dissection of paraspinal muscles was performed on the side of the tumor. A unilateral hemilaminotomy was carried out using a high-speed drill and Kerrison rongeurs, preserving the contralateral lamina, spinous process, and posterior ligamentous structures. Partial facetectomy, undercutting of the spinous process base, or limited contralateral laminar undercutting was performed when necessary to improve exposure, without compromising spinal stability. After achieving meticulous hemostasis, the dura was opened paramedially and dural hitch sutures were applied. The arachnoid membrane was carefully opened, and the tumor was internally decompressed using ultrasonic aspirators or tumor biopsy forceps, followed by piecemeal excision. In cases of schwannoma, the involved nerve root was coagulated and divided when found to be nonfunctional, while in meningiomas, the dural attachment was excised as far as possible or coagulated when complete excision was not feasible. After complete tumor removal, watertight dural closure was performed using continuous prolene sutures. An epidural suction drain was placed, and the wound was closed in layers. Patients were mobilized on the first or second postoperative day.

Postoperatively, patients were monitored for neurological status and surgical complications such as cerebrospinal fluid leak, wound infection, pseudomeningocele formation, or new neurological deficits. Follow-up evaluations were performed at regular intervals, with a minimum follow-up period of six months. At follow-up, neurological status was reassessed using Nurick's grading system, and radiological evaluation including computed tomography, dynamic X-rays, and magnetic resonance imaging was performed to assess spinal stability, alignment, and presence of residual or recurrent tumor.

Statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS) version 16.0 for Windows. Descriptive statistics were used to summarize demographic and clinical variables, expressed as frequencies, percentages, means, and standard deviations. Preoperative and postoperative neurological outcomes were compared using paired t-test. A p-value of less than 0.05 was considered statistically significant.

**Results**

The study population comprised 30 patients with intradural extramedullary (IDEM) tumors, with an equal gender distribution (50% males and 50% females). The mean age of the patients was 51 years, with the majority of cases observed in the fifth and sixth decades of life, particularly in the 51–60 year age group (26.67%). Thoracic spine was the most common location of IDEM tumors, accounting for

60% of cases, followed by cervical (26.67%), lumbar (10%), and thoracolumbar (3.33%) regions, indicating a clear predominance of thoracic involvement in the study cohort (Table 1).

Table 1. Baseline demographic and tumor characteristics of patients with IDEM tumors

| Parameter | Sub classification | F | % |
|---|---|---|---|
| Age Group | 21-30 | 2 | 6.66 |
| | 31-40 | 6 | 20 |
| | 41-50 | 6 | 20 |
| | 51-60 | 8 | 26.67 |
| | 61-70 | 5 | 16.67 |
| | 71-80 | 3 | 10 |
| Sex | Male | 15 | 50 |
| | Female | 15 | 50 |
| Location of IDEM tumour | Cervical | 8 | 26.67 |
| | Thoracic | 18 | 60 |
| | Thoracolumbar | 1 | 3.33 |
| | Lumbar | 3 | 10 |

Preoperatively, the majority of patients presented with moderate to severe neurological impairment, with 46.66% of patients classified as Nurick grade 3 or 4, reflecting significant functional limitation. Postoperatively, there was a marked improvement in neurological status, with all patients improving to either Nurick grade 0 (70%) or grade 1 (30%) at six months follow-up, and none having higher grades. Clinically, motor weakness (66.68%) and sensory disturbances (63.33%) were the most common presenting symptoms, followed by local pain (60%), sphincter dysfunction (26.68%), and radicular pain (20%), highlighting the varied but predominantly motor-sensory presentation of IDEM tumors (Table 2).

Table 2. Clinical presentation and neurological status of study participants

| Parameter | Sub classification | F | % |
|---|---|---|---|
| Preoperative Nurick grading. | 0 | 5 | 16.68 |
| | 1 | 4 | 13.33 |
| | 2 | 3 | 10 |
| | 3 | 7 | 23.33 |
| | 4 | 7 | 23.33 |
| | 5 | 4 | 13.33 |
| Postoperative Nurick grading | 0 | 21 | 70 |
| | 1 | 9 | 30 |
| Clinical features | Radicular pain | 6 | 20 |
| | Local pain | 18 | 60 |
| | Motor weakness | 20 | 66.68 |
| | Sensory disturbance | 19 | 63.33 |
| | Sphincter dysfunction | 8 | 26.68 |

There was a statistically significant improvement in neurological status following unilateral hemilaminotomy, as reflected by a substantial reduction in the mean Nurick grade from 2.63 ± 1.69 preoperatively to 0.30 ± 0.46 postoperatively. This improvement was highly significant ($p < 0.0001$), demonstrating the effectiveness of the surgical approach in achieving meaningful functional recovery among patients with IDEM tumors (Table 3).

Table 3. Comparison of Mean Pre and post operative Nurick grade

| Nurick grade | Mean | SD | P-value |
|---|---|---|---|
| Preoperative | 2.63 | 1.69 | <0.0001 |
| Postoperative | 0.3 | 0.46 | |

*Paired t test

Histopathological analysis revealed schwannomas as the most common IDEM tumor, constituting 56.67% of cases, followed by meningiomas in 40% of patients, while neurofibromas were rare (3.33%). This distribution underscores the predominance of nerve sheath tumors among IDEM lesions and is consistent with the commonly reported pathological profile of intradural extramedullary spinal tumors (Table 4).

Table 4. Histopathological distribution of IDEM tumors

| Histopathology of tumors | Number of patients | Percentage |
|---|---|---|
| Schwannomas | 17 | 56.67 |
| Meningiomas | 12 | 40 |
| Neurofibromas | 1 | 03.33 |

**Discussion**

Conventional laminectomy has long been the standard surgical approach for the excision of intradural extramedullary (IDEM) spinal tumors because it provides wide exposure and is familiar to most neurosurgeons. However, long-term follow-up studies have demonstrated that extensive removal of posterior spinal elements during laminectomy is associated with several complications, including postoperative spinal instability, kyphotic deformity, epidural fibrosis, persistent axial pain, and progressive neurological deterioration [5,9,36,37,43,46,47]. These drawbacks have prompted the development of alternative surgical techniques aimed at minimizing tissue trauma while maintaining adequate exposure for complete tumor excision.

In the present study, unilateral hemilaminotomy provided sufficient exposure for complete excision of IDEM tumors in all patients without the need for conversion to conventional laminectomy. This approach preserved the contralateral musculoligamentous structures and posterior bony elements, thereby maintaining spinal stability. Biomechanical and clinical studies have previously demonstrated that unilateral approaches reduce disruption of posterior tension bands

and significantly lower the risk of postoperative instability when compared to bilateral laminectomy [12,21]. The absence of spinal deformity or instability in our patients during follow-up further supports these findings.

The demographic profile of patients in this study showed a mean age of 51 years, with most patients presenting in the fifth and sixth decades of life, which is comparable with several published series [4,16,27,29,30]. Thoracic spine was the most commonly involved region, followed by cervical and lumbar regions, consistent with earlier reports indicating thoracic predominance of IDEM tumors, particularly meningiomas and nerve sheath tumors [4,12,16,29,31]. The equal gender distribution observed in our study aligns with reports showing variable sex predilection depending on tumor type and study population [12,26,29].

Clinically, most patients presented with motor weakness, sensory disturbances, and pain, reflecting progressive spinal cord compression due to the slow-growing nature of IDEM tumors [45,46]. Preoperatively, a significant proportion of patients had moderate to severe neurological impairment as assessed by Nurick grading, indicating delayed presentation. Following surgery, all patients demonstrated significant neurological improvement, with a marked reduction in mean Nurick grade, which was statistically significant. Similar favorable neurological outcomes following hemilaminotomy have been reported by several authors, who observed substantial improvement in functional status with minimal morbidity [12,21].

Gross total resection was achieved in all cases in this study. Schwannomas constituted the most common histopathological diagnosis, followed by meningiomas, with neurofibromas being rare, a distribution consistent with previously reported large series of IDEM tumors [4,12,16,25,29,31]. In meningioma cases, Simpson grade II excision was achieved, and no recurrence was observed during follow-up, supporting earlier observations that coagulation of the dural attachment provides satisfactory tumor control [47].

The mean operative time in our study was comparable with other published series using hemilaminotomy and minimally invasive approaches [4,29]. The incidence of postoperative complications was low, with only one patient developing cerebrospinal fluid leak, which resolved spontaneously. No patient developed wound infection, pseudomeningocele, new neurological deficit, spinal instability, or deformity. These findings are in agreement with earlier studies reporting lower complication rates, reduced blood loss, and faster recovery with unilateral hemilaminotomy compared to conventional laminectomy [12,26,25,27,29-31].

During a mean follow-up period of 35 months, none of the patients demonstrated radiological evidence of spinal instability, deformity, residual tumor, or recurrence. Similar long-term outcomes have been reported by multiple authors, further reinforcing the durability and safety of the hemilaminotomy approach for IDEM tumors [26,29-31]. The preservation of posterior spinal elements appears to play a crucial role in maintaining sagittal alignment and preventing late complications.

Despite these favorable outcomes, the present study has certain limitations, including a relatively small sample size and the absence of a control group undergoing

conventional laminectomy. Additionally, comorbidities were not included in outcome assessment. Nevertheless, the consistent neurological improvement, low complication rate, and preservation of spinal stability observed in this study support the growing body of evidence favoring unilateral hemilaminotomy as a safe and effective minimally invasive approach for the management of IDEM tumors.

## Conclusion

Minimally invasive unilateral hemilaminotomy is a safe and effective surgical technique for the management of intradural extramedullary spinal tumors. This approach allows complete tumor excision with significant neurological improvement while preserving posterior spinal elements and maintaining spinal stability. The procedure is associated with minimal surgical morbidity, low complication rates, and early postoperative mobilization. Adequate exposure can be achieved without the need for extensive bone removal or conversion to conventional laminectomy. The absence of postoperative spinal deformity or tumor recurrence during follow-up further supports the durability of this technique. Unilateral hemilaminotomy should be considered a preferred minimally invasive option for IDEM tumors across different spinal levels.

## Statements and Declarations

### Conflicts of interest

The authors declare that they do not have conflict of interest.

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