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Primary Intradural Extramedullary Spinal Tumors in the Elderly: Beyond Chronological Age

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Abstract

Purpose

To determine whether chronological age influences functional outcome after surgery for primary intradural extramedullary (IDEM) spinal tumors, and which preoperative factors predict an unfavorable result.

Methods

Retrospective single-center study of 103 consecutive patients operated on for an IDEM tumor (2016–2025). The primary outcome was functional independence (modified Rankin Scale, mRS 0–2) at last follow-up. Patients aged 70 years or older (n = 26) were compared with younger patients (n = 77), and seven prespecified factors were tested by univariable Firth penalized logistic regression for an unfavorable outcome (mRS 3–5).

Results

Median age was 58 years; schwannoma (51.5%) and meningioma (45.6%) predominated. Complete excision was achieved in 82.5% and complications occurred in 10.7%; all 6 recurrences (6.0%) followed partial excision. Over a median follow-up of 24 months, independence rose from 68.9% to 89.1%. Elderly patients presented with worse baseline status (mRS 3–5: 57.7% vs. 22.1%, p = 0.001) and more meningiomas (80.8% vs. 33.8%, p < 0.001), yet achieved equivalent complete excision (76.9% vs. 84.4%, p = 0.384), complication (7.7% vs. 11.7%, p = 0.726) and independence rates (88.0% vs. 89.5%, p = 1.000). No deaths occurred. Only the mRS at diagnosis (OR 3.58 per point, 95% CI 2.02–7.40) and myelomalacia (OR 4.86, 95% CI 1.28–26.52) were associated with an unfavorable outcome; age 70 years or older was not (OR 1.25, 95% CI 0.29–4.48).

Conclusions

Chronological age alone should not preclude surgery for IDEM tumors. Baseline function and preoperative cord signal change, not age, set the ceiling of recovery.

Introduction

The number of individuals aged 60 years or older is projected to exceed 2.1 billion by 2050 [38], and elderly patients are expected to represent a meaningful proportion of neurosurgical admissions within the decades to come. [22, 31] Defining reliable surgical candidacy criteria for this population has become one of the most pressing challenges in the field. Primary intradural extramedullary spinal tumors (IDEM tumors) [1], essentially meningiomas and nerve sheath tumors, are rare but may cause progressive

myelopathy, gait dysfunction, and sphincteric impairment that are potentially irreversible if decompression is delayed. Elderly patients are disproportionately affected, with a predominance of spinal meningiomas that carries specific technical challenges including greater calcification and cord adhesion. [13, 29] Historically, advanced age has been associated with higher perioperative risk and reduced recovery potential, driving a conservative surgical bias. [15, 23] We therefore aimed to determine whether chronological age influences functional outcome in the surgical management of IDEM tumors and to explore preoperative factors associated with recovery.

Material and Methods

Study design and patient selection

This was a retrospective, single-center cohort study conducted at Gui de Chauliac Hospital, Montpellier University Medical Center, France. All consecutive patients who underwent surgery for an IDEM tumor between January 2016 and December 2025 were screened for inclusion. Patients were eligible if they had a histologically confirmed IDEM tumor and had undergone open surgical resection as the primary treatment modality. Patients with intramedullary tumors, metastatic spinal disease, extradural primary tumors, recurrent tumors previously operated upon at another institution, or incomplete medical records were excluded. Intramedullary tumors were excluded a priori because their patient profile, resectability, functional risk, and prognosis differ substantially from those of extramedullary lesions. [36] The study was conducted in accordance with the Declaration of Helsinki. Institutional review board approval was obtained (IRB00011687), and the requirement for individual informed consent was waived given the retrospective observational nature of the study.

Outcome measures and definitions

The primary outcome was functional independence at last follow-up, defined as a modified Rankin Scale (mRS) score of 0–2. Secondary outcomes included the proportion of patients improving by at least one mRS grade, normalization of gait and of bladder dysfunction (an Aminoff-Logue score of 0 at last follow-up among patients impaired preoperatively), the perioperative complication rate, and the tumor recurrence rate. Spinal cord-specific disability was assessed using the Aminoff-Logue scale, which separately grades gait dysfunction (0–5, where 0 = normal and 5 = unable to walk) and bladder dysfunction (0–3, where 0 = normal and 3 = catheter-dependent). [3] This scale has previously been applied to primary intradural spinal tumors. [11] All functional assessments were performed at the preoperative visit and at the last available outpatient follow-up appointment by the operating neurosurgeon. Preoperative comorbidity was graded using the American Society of Anesthesiologists (ASA) physical status classification, retrieved from the pre-anesthetic evaluation records. Complete excision was defined as the absence of residual tumor on the first postoperative contrast-enhanced magnetic resonance imaging (MRI), together with the surgeon's intraoperative assessment as

documented in the operative report. Myelomalacia was defined as an intramedullary T2-weighted hyperintensity of the spinal cord at the level of compression on the preoperative MRI.

Surgical technique

The operative approach was determined by tumor location, spinal level, and relationship to the cord and nerve roots, with complete tumor excision as the primary surgical objective. A standard posterior midline approach was used in all cases, with laminectomy or hemilaminectomy over a number of levels determined by preoperative MRI planning. Anterior or anterolateral tumor implantation was uncommon in this series; when present, it was managed through the same posterior approach extended by facetectomy, providing lateral exposure of the ventral dura without requiring a dedicated anterior or anterolateral corridor. Dural closure was systematically reinforced with a collagen sponge sealant and fibrin glue to minimize the risk of postoperative cerebrospinal fluid leak. Preoperative spinal angiography to identify the artery of Adamkiewicz was not performed in this series. Intraoperative neurophysiological monitoring was not routinely employed during the study period, reflecting institutional practice at the time.

Age stratification

For the age-stratified analysis, patients were divided into two groups based on age at surgery: elderly patients, defined as those aged 70 years or older at the time of surgery (n = 26), and younger patients, defined as those aged under 70 years (n = 77). The threshold of 70 years was selected a priori based on prior literature in spinal tumor surgery, in which this cut-off has been used to define the elderly population. [17]

Statistical analysis

Continuous variables are reported as mean ± SD or median (IQR) and were compared between groups with parametric or non-parametric tests as appropriate; categorical variables were compared with the chi-square or Fisher's exact test. Factors associated with an unfavorable functional outcome (mRS 3–5) at last follow-up were explored in the overall cohort using Firth penalized logistic regression [10, 12] on seven prespecified, clinically selected factors (age ≥70 years, delay from symptom onset to surgery, complete excision, ASA score, mRS at diagnosis, myelomalacia on MRI, and thoracic location), given the limited number of unfavorable outcomes (n = 11). Odds ratios (OR) with 95% confidence intervals are reported, an OR greater than 1 indicating a factor associated with a worse outcome; this analysis was regarded as exploratory and no correction for multiple comparisons was applied. A two-sided significance threshold of $\alpha = 0.05$ was used. Analyses were performed with GraphPad Prism version 10.0 (GraphPad Software, Boston, Massachusetts, USA) and R version 4.5 (R Foundation for Statistical Computing).

Results

Demographics and tumor characteristics

A total of 103 patients with primary intradural extramedullary spinal tumors were included. Patient demographics, tumor characteristics, and presenting features are summarized in Table 1. Briefly, the median age was 58 years (IQR 46–70) with a female predominance (73/103, 70.9%). Schwannoma (53/103, 51.5%) and meningioma (47/103, 45.6%) were the most frequent tumor types (Figures 1,2), and the thoracic spine was the predominant location (61/103, 59.2%). All meningiomas were WHO grade I. Most patients had a low burden of comorbidity (ASA grade 1 or 2: 88/103, 85.4%). The median delay from symptom onset to diagnosis was 6 months (mean 10.7 months), while treatment was initiated rapidly once the diagnosis was established (median 1 month); the median delay from symptom onset to surgery was 7 months (IQR 4–16). The most common presenting features were sensory disturbances (72/103, 69.9%), radicular pain (61/103, 59.2%), and motor weakness (46/103, 44.7%). At baseline, 32 patients (31.1%) were functionally dependent (mRS 3–5), gait dysfunction was present in 61 patients (59.2%), and bladder dysfunction in 24 patients (23.3%).

Surgical outcome

All patients underwent open surgery. Complete excision was achieved in 85/103 patients (82.5%) and partial excision in 18/103 (17.5%), with a median intraoperative blood loss of 300 mL (IQR 200–400) and a median hospital stay of 7 days (IQR 5–9). Extent of resection was unrelated to age ≥70 years (23.5% of complete vs. 33.3% of partial excisions, $p = 0.384$) or to tumor histology ($p = 0.081$; meningiomas 6/47, 12.8% vs. schwannomas 10/53, 18.9%). Partial excision was less frequent for thoracic than for cervical or lumbosacral tumors (6/61, 9.8% vs. 12/42, 28.6%; $p = 0.014$), although the four spinal regions did not differ overall ($p = 0.112$). Perioperative complications occurred in 11/103 patients (10.7%), including CSF leak, wound infection, nerve root injury, postoperative hematoma, and meningocele requiring reoperation. Tumor recurrence was recorded in 6/100 patients (6.0%), exclusively among patients with previous partial excision (6/16, 37.5%; 2 schwannomas, 2 meningiomas, 1 neurofibroma, 1 epidermoid cyst). Patients with complete excision did not show recurrence during the time frame of our study.

Functional outcome

At last follow-up (median 24 months), functional independence (mRS 0–2) had increased from 71/103 (68.9%) at baseline to 90/101 (89.1%), and 75/101 patients (74.3%) improved by at least one mRS grade (functional data missing in 2 patients). Among patients with baseline gait dysfunction, 30/60 (50.0%) normalized to grade 0 postoperatively and only 9/60 (15.0%) retained moderate-to-severe dysfunction (grades 3–5). Among those with baseline bladder dysfunction, 21/24 patients (87.5%) normalized completely to grade 0. No deaths were recorded during follow-up.

Age-stratified comparison

Twenty-six patients (25.2%) were aged 70 years or older. The age-stratified comparison is presented in Table 2. Elderly patients differed significantly from younger patients in tumor histology — meningioma dominated in the elderly (21/26, 80.8%) while schwannoma predominated in younger patients (49/77, 63.6%; both $p < 0.001$) — and presented with significantly worse baseline functional status (mRS 3–5: 57.7% vs. 22.1%, $p = 0.001$) and a higher ASA score (median 2 in both groups, Mann-Whitney $p = 0.044$; ASA ≥3: 26.9% vs. 10.4%, $p = 0.054$). Despite this, all surgical and postoperative outcomes were equivalent between groups, including the complete excision rate (20/26, 76.9% vs. 65/77, 84.4%; $p = 0.384$), the complication rate (2/26, 7.7% vs. 9/77, 11.7%; $p = 0.726$), postoperative functional independence at last follow-up (mRS 0–2: 22/25, 88.0% vs. 68/76, 89.5%; $p = 1.000$), and gait normalization (13/22, 59.1% vs. 17/38, 44.7%; $p = 0.422$).

Factors associated with an unfavorable outcome

At last follow-up, 90/101 patients were functionally independent (mRS 0–2) and 11 were dependent. In the univariable Firth penalized logistic regression on seven prespecified factors (Table 3, Figure 3), two factors were associated with an unfavorable outcome: the mRS at diagnosis (OR 3.58 per point, 95% CI 2.02–7.40, $p < 0.001$) and myelomalacia on preoperative MRI (OR 4.86, 95% CI 1.28–26.52, $p = 0.019$; present in 9/11 dependent versus 39/89 independent patients). Age ≥70 years was not associated with outcome (OR 1.25, 95% CI 0.29–4.48, $p = 0.743$), nor were the delay from symptom onset to surgery (OR 1.02 per month, 95% CI 0.98–1.05, $p = 0.323$), complete excision (OR 0.50, 95% CI 0.13–2.21, $p = 0.334$), ASA score (OR 0.65 per point, 95% CI 0.24–1.55, $p = 0.350$), or thoracic location (OR 1.17, 95% CI 0.35–4.39, $p = 0.805$). Within the elderly subgroup, functional independence was achieved in 11/11 (100%) of elderly patients with a preoperative mRS of 0–2, 8/8 (100%) with mRS 3, and 3/6 (50%) with mRS 4–5.

Discussion

The present series of 103 consecutive patients with IDEM tumors demonstrates that surgical resection achieves consistent and meaningful functional improvement across all age groups. Functional independence (mRS 0–2) increased from 68.9% at baseline to 89.1% at last follow-up, accompanied by high rates of bladder and gait recovery. The central finding of the study is that advanced age was not associated with postoperative outcome: elderly patients aged 70 years or older, despite presenting with significantly worse baseline neurological status, higher ASA scores, and a distinct histological profile dominated by meningioma, achieved surgical and functional results statistically equivalent to those of younger patients across all measured endpoints. In the overall cohort, two factors, baseline functional status and myelomalacia on preoperative MRI, but not chronological age, were associated with an unfavorable outcome in our exploratory analysis.

Outcomes in the overall cohort

Our series confirms the favorable outcome of IDEM tumors following complete surgical excision. Complete resection was achieved in 82.5% of patients, consistent with published rates for mixed intradural tumors. [21, 26] Perioperative complications occurred in 10.7% of patients; most were minor and managed conservatively, in line with published series of intradural extramedullary tumors. [13] The observation that recurrence was exclusively confined to patients with partial excision, with zero recurrences among the patients who underwent complete resection during the study period, underscores the oncological importance of achieving radical removal. [30, 33] However, this objective must be weighed against the potential harm of extensive resection in the elderly. Functional outcomes were equally encouraging: independence increased by nearly 20 percentage points and 74.3% of patients improved by at least one mRS grade. Bladder dysfunction proved particularly amenable to surgical correction (87.5% normalized), while gait improvement was less complete though still substantial (50.0% normalized, approximately one in seven left with moderate-to-severe impairment). These figures support an active approach to resection in patients presenting with progressive neurological deficits.

Age and surgical outcome: an age-stratified analysis

A frequently cited concern in the surgical management of elderly patients with spinal tumors is the perceived increased risk of perioperative complications and reduced capacity for neurological recovery. [7] Our data argue against this assumption. In the age-stratified comparison, elderly patients aged 70 years or older showed no significant difference from younger patients in complete excision rate, complication rate, postoperative functional independence, or gait normalization. Notably, no deaths were recorded in either group.

The apparent paradox of equivalent outcomes despite worse baseline status in the elderly group warrants attention. Elderly patients in this series presented with significantly higher rates of preoperative functional dependency and a histological profile dominated by meningioma. They also showed significantly higher ASA scores, although most remained ASA 1–2, indicating moderate rather than severe comorbidity in the operated population. Their clinical presentation aligned with tumor biology, as meningiomas usually present with a noisy clinical picture but with high rates of functional recovery. [20, 27–28] Moreover, the distribution of tumor locations did not differ significantly between groups, although thoracic tumors, classically associated with less favorable gait recovery, were proportionally more frequent in the elderly. The equivalence of outcomes may therefore reflect a genuine age-independent capacity for neurological recovery following decompression, although residual confounding by tumor topography and unmeasured selection cannot be excluded.

Histological profile and surgical implications in elderly patients

The predominance of meningioma in the elderly subgroup (80.8%) compared with schwannoma in younger patients (63.6%) reflects the well-established epidemiological shift in spinal tumor histology with advancing age. [16] Consistent with the benign nature typically reported for spinal meningiomas, all meningiomas in our series were WHO grade I; these tumors arise from dural attachments at thoracic

levels, where their resection, including coagulation or excision of the dural base, is associated with favorable outcome and low recurrence rates when complete excision is achieved. [9] The equivalence of complete excision rates between elderly and younger patients, despite the technical challenges sometimes attributed to calcified or adherent meningiomas in older individuals, attests to the surgical feasibility of radical resection in this population. Although complete excision was not significantly associated with functional outcome in our small exploratory analysis, the equivalence of resection rates between age groups supports maintaining complete removal as the technical objective irrespective of age, whenever anatomically safe. [17, 37]

Predictors of an unfavorable outcome

To explore determinants of outcome, we performed a Firth penalized logistic regression analysis [10, 12] in the overall cohort, restricted to seven prespecified, clinically relevant factors in order to limit multiple testing given the small number of unfavorable outcomes (n = 11). Two factors were associated with an unfavorable outcome: the mRS at diagnosis and myelomalacia on preoperative MRI, whereas age ≥ 70 years was not.

Diagnostic delay

The delay from symptom onset to surgery was not significantly associated with the risk of an unfavorable outcome (OR 1.02 per month, 95% CI 0.98–1.05, p = 0.323), although the direction of the estimate is consistent with the pathophysiology of compressive myelopathy, in which prolonged mechanical compression of the spinal cord results in progressive demyelination, axonal injury, and ultimately irreversible gliosis. [5–6, 14, 24] In the degenerative cervical myelopathy literature, symptom duration prior to surgery is a recognized independent predictor of neurological outcome [8]; our study may simply have lacked the power to demonstrate such an association. Prompt neuroimaging and referral of patients with progressive myelopathy nonetheless remain clinically sound objectives.

Complete surgical excision

Complete surgical excision was not significantly associated with outcome (OR 0.50 for an unfavorable result, 95% CI 0.13–2.21, p = 0.334), and the confidence interval remains wide given the number of events. An apparent benefit of complete resection in previous series may also partly reflect favorable tumor topography — posteriorly located, well-demarcated lesions — rather than an independent effect of the extent of resection. [2, 19, 21]

The oncological rationale for complete resection is nonetheless reinforced by the recurrence data from our full cohort: all 6 recurrences occurred exclusively in patients with partial excision, with zero recurrences in the completely resected group during the study period. In elderly patients, where reoperation carries additional risk and functional reserve may be more limited, the importance of achieving complete removal must be weighed against the preservation of quality of life, considering the often benign nature and indolent course of the disease. These findings support a surgical strategy that prioritizes complete resection as the primary objective when anatomically safe and argue against a

conservative or debulking-only approach based on patient age alone. In our cohort, incomplete resections are likely to have resulted from technical constraints: ventral tumor location, adhesion to the spinal cord, or involvement of functional nerve roots, rather than from an age-based strategy. Consistent with this, the extent of resection varied with spinal level but not with age or histology, partial excision being about three times less frequent for thoracic than for cervical or lumbosacral tumors; the anatomical relationship of the tumor to the surrounding neural structures, rather than the patient's age, appears to determine the achievable surgical goal, and may drive part of the association between residual tumor and outcome reported in the literature.

Baseline functional status and incidental tumors

The mRS at diagnosis was the factor most strongly associated with outcome, each additional point multiplying the odds of an unfavorable result by 3.58 (95% CI 2.02–7.40). This is consistent with the general principle that better preserved preoperative function predicts better postoperative recovery, and reinforces the argument for operating before irreversible disability sets in. It was not, however, the only predictor: myelomalacia on preoperative MRI — defined here as intramedullary T2 hyperintensity at the level of maximal compression — was also associated with outcome, patients with cord signal change being nearly five times more likely to be dependent at last follow-up (OR 4.86, 95% CI 1.28–26.52). This is consistent with previous reports associating preoperative myelomalacia with worse outcome after spinal meningioma surgery [35], and supports the view that intrinsic cord damage, rather than age, sets the ceiling of recovery. Neither ASA grade nor tumor topography was associated with outcome; these questions warrant prospective investigation in larger cohorts.

Among the 24 patients presenting with spasticity at diagnosis, baseline disability was more severe (median mRS 3) than in the non-spastic group (median mRS 2). Despite this, spastic patients reached the same median mRS at last follow-up (1) as non-spastic patients, with a similar proportion achieving improvement and no cases of clinical worsening.

Importantly, a poor baseline mRS should not be read as an absolute contraindication in the elderly: every elderly patient presenting with an mRS of 0–3 regained independence, as did half of those presenting with an mRS of 4–5. Advanced preoperative disability should not in itself be used as a criterion for surgical exclusion in this population.

Incidentally discovered tumors deserve a separate comment. Four tumors in our series (3.9%), all meningiomas, were incidental findings, including 2 in patients aged 70 years or older. In asymptomatic patients, particularly the very elderly, we believe that initial clinical and radiological surveillance with serial MRI is a reasonable first-line strategy, with surgery reserved for clinical progression or documented radiological growth. This attitude is supported by natural-history data for spinal schwannomas, which show slow or absent growth in a substantial proportion of cases. [4] Surveillance nevertheless requires an active commitment to operate on progression. In patients over 80 years of age with few or no symptoms, the anticipated benefit of resection should be weighed particularly carefully against the indolent natural history of these tumors.

Clinical implications

Taken together, these findings support a paradigm in which age alone is insufficient justification for conservative management of IDEM tumors. The decision to operate should be guided by functional status, comorbidity, and the anticipated risk-benefit profile of the procedure rather than chronological age. In our exploratory analysis, baseline functional status and myelomalacia on MRI were associated with outcome; diagnostic delay and extent of resection nonetheless remain clinically actionable targets, and both the literature and the direction of our estimates argue for prompt neuroimaging and specialist referral in elderly patients with progressive myelopathy.

The low complication rate (7.7%), the absence of perioperative mortality, and the high rate of functional improvement in elderly patients in this series suggest that contemporary spinal tumor surgery, performed in an experienced center with modern perioperative protocols, can be offered to elderly patients with an acceptable safety profile. These results are consistent with a growing body of evidence in spinal oncology indicating that physiological age, frailty assessment, and functional status are more relevant determinants of operative risk than chronological age. [7, 18] Nonetheless, stratification by chronological age is an imperfect surrogate for physiologic robustness: most individuals over 85 years do not meet the definition of frailty. [32] As demonstrated by Pazniokas et al. [25] in a systematic review of over 100,000 neurosurgical cases, frailty, defined as decreased physiological reserve independent of age, predicted postoperative complications and mortality across neurosurgical subspecialties. The equivalence of outcomes observed in our elderly cohort may therefore partly reflect the physiological robustness of a surgically selected population rather than a true age-independence of outcome across all elderly patients with IDEM tumors. The ASA distribution of our operated elderly patients (predominantly grades 1–2, with 26.9% grade ≥ 3) argues against an extreme degree of selection, but the number of elderly patients denied surgery over the study period is unknown. Prospective incorporation of a validated frailty instrument, such as the modified Frailty Index [34], into preoperative assessment would more precisely identify which elderly patients are most likely to benefit from surgery and represents a priority for future work in this field.

Limitations

Several limitations should be acknowledged. The retrospective single-center design carries a selection bias: patients not referred or judged unsuitable for surgery were not captured, so our findings apply to operated patients and cannot be generalized to all elderly patients harboring an IDEM tumor. With only 11 unfavorable outcomes, the regression was restricted to prespecified factors assessed one at a time, precluding multivariable adjustment; residual confounding therefore cannot be excluded, although the worse baseline status of elderly patients would bias against them rather than explain their equivalent outcomes. The median follow-up of 24 months may underestimate late recurrence, and no standardized frailty assessment was available. Finally, the Aminoff-Logue scale was preferred to the McCormick scale because it grades gait and sphincter recovery separately, at the cost of direct comparability with published series.

Conclusion

Surgery for IDEM tumors achieved equivalent functional outcomes in elderly and younger patients in our cohort. Age itself did not determine postoperative recovery, and even markedly impaired elderly patients retained meaningful recovery potential: advanced preoperative disability should not in itself preclude surgical intervention. In our exploratory analysis, baseline functional status and preoperative myelomalacia — but not chronological age — were both associated with an unfavorable outcome, and the respective roles of diagnostic delay, extent of resection, comorbidity, and tumor topography require confirmation in larger, ideally multicenter, prospective cohorts incorporating a validated frailty assessment. In the meantime, these findings support considering active surgical management of symptomatic IDEM tumors in elderly patients on the basis of functional status and comorbidity rather than chronological age, while asymptomatic incidental tumors may reasonably be managed with initial clinical and radiological surveillance.

Declarations

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Review Board (IRB00011687).

Consent to participate

This is a retrospective observational study. The Institutional Review Board waived the requirement for individual informed consent given the retrospective, non-interventional nature of the study.

Clinical trial number

Not applicable.

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Author Contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by LR and VN. The first draft of the manuscript was written by LR and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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None

Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information available upon request.

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Tables

Table 1 Cohort characteristics and presenting features (n = 103)

	Value
Demographics	
Age — mean ± SD (range), years	57.2 ± 16.7 (23–89)
Female sex	73 (70.9%)
Symptom onset → diagnosis — median (IQR), months	6 (3–12)
Diagnosis → treatment — median (IQR), months	1 (0–2)
Symptom onset → surgery — median (IQR), months	7 (4–16)
Follow-up — median (IQR), months	24 (6–48)
ASA grade 1 or 2	88 (85.4%)
Tumor type	
Schwannoma	53 (51.5%)
Meningioma	47 (45.6%)
Other (neurofibroma, epidermoid cyst)	3 (2.9%)
Spinal level	
Thoracic	61 (59.2%)
Lumbar	21 (20.4%)
Cervical	18 (17.5%)
Sacral	3 (2.9%)
Presenting features	
Sensory symptoms	72 (69.9%)
Radicular pain	61 (59.2%)
Cord signal change (intramedullary T2-weighted hyperintensity) on MRI	49/101 (48.5%)
Motor weakness	46 (44.7%)
Back pain	40 (38.8%)
Spasticity	24 (23.3%)
Incidental finding	4 (3.9%)
Baseline disability	
mRS 3–5 (dependent)	32 (31.1%)
Gait dysfunction (Aminoff-Logue > 0)	61 (59.2%)

	Value
Bladder dysfunction (Aminoff-Logue > 0)	24 (23.3%)

Values are n (%) or n/N (%) — N shown when data were missing — or median (IQR) unless otherwise stated. ASA American Society of Anesthesiologists physical status classification, IQR interquartile range, mRS modified Rankin Scale, SD standard deviation.

Table 2 Age-stratified comparison for surgically treated primary intradural extramedullary spinal tumors

	≥70 yrs (n = 26)	<70 yrs (n = 77)	p-value
Demographics & tumor			
Age — median (IQR)	78 (74–80)	53 (43–61)	—
Female	22/26 (84.6%)	51/77 (66.2%)	0.086
ASA score — median (IQR)	2 (1–3)	2 (1–2)	0.044*
ASA ≥ 3	7/26 (26.9%)	8/77 (10.4%)	0.054
Meningioma	21/26 (80.8%)	26/77 (33.8%)	<0.001*
Schwannoma	4/26 (15.4%)	49/77 (63.6%)	<0.001*
Other (neurofibroma, epidermoid cyst)	1/26 (3.8%)	2/77 (2.6%)	1.000
Location			
Thoracic location	21/26 (80.8%)	40/77 (51.9%)	0.068□
Lumbar location	3/26 (11.5%)	18/77 (23.4%)	—
Cervical location	2/26 (7.7%)	16/77 (20.8%)	—
Sacral location	0/26 (0.0%)	3/77 (3.9%)	—
Baseline disability			
mRS 0–2	11/26 (42.3%)	60/77 (77.9%)	0.001*
mRS 3–5	15/26 (57.7%)	17/77 (22.1%)	0.001*
Surgical and postoperative outcomes			
Complete excision	20/26 (76.9%)	65/77 (84.4%)	0.384
Perioperative complication	2/26 (7.7%)	9/77 (11.7%)	0.726
mRS 0–2 at last follow-up	22/25 (88.0%)	68/76 (89.5%)	1.000
mRS improved ≥ 1 grade	20/25 (80.0%)	55/76 (72.4%)	0.600
Overall improved	24/26 (92.3%)	68/77 (88.3%)	0.726
AL-Gait grade normalized to 0	13/22 (59.1%)	17/38 (44.7%)	0.422
AL-Bladder grade normalized to 0	3/4 (75.0%)	18/20 (90.0%)	0.437

Values are n/N (%) or median (IQR). AL Aminoff-Logue, ASA American Society of Anesthesiologists physical status classification, IQR interquartile range, mRS modified Rankin Scale. AL grade normalized to 0: among patients with an abnormal grade at baseline. Asterisk denotes p < 0.05. □ Overall 4-category location test (thoracic vs. lumbar vs. cervical vs. sacral).

Table 3 Univariable analysis of factors associated with an unfavorable functional outcome (mRS 3–5) at last follow-up in the overall cohort (n = 101)

	Independent (n = 90)	Dependent (n = 11)	OR (95% CI)	p-value
Age ≥70 years	22/90 (24.4%)	3/11 (27.3%)	1.25 (0.29–4.48)	0.743
Delay onset → surgery, months	7 (5–15)	10 (4–18)	1.02 (0.98–1.05)	0.323
Complete excision	75/90 (83.3%)	8/11 (72.7%)	0.50 (0.13–2.21)	0.334
ASA score (per point)	2 (1–2)	1 (1–2)	0.65 (0.24–1.55)	0.350
mRS at diagnosis (per point)	2 (1–2)	4 (4–5)	3.58 (2.02–7.40)	<0.001*
Myelomalacia on MRI	39/89 (43.8%)	9/11 (81.8%)	4.86 (1.28–26.52)	0.019*
Thoracic location	53/90 (58.9%)	7/11 (63.6%)	1.17 (0.35–4.39)	0.805

Values are median (IQR) for continuous and ordinal variables and n/N (%) for binary variables. Independent: mRS 0–2 at last follow-up; Dependent: mRS 3–5. Odds ratios are for an unfavorable outcome (mRS 3–5), so that OR > 1 indicates a factor associated with a worse outcome; they derive from univariable Firth penalized logistic regression on seven prespecified factors (profile-likelihood 95% CI; penalized likelihood-ratio p-values). CI confidence interval, IQR interquartile range, mRS modified Rankin Scale, OR odds ratio. Asterisk denotes p < 0.05.

Figures



Figure 1

Lumbar MRI in a 75-year-old woman with right L5 radicular pain and paresthesia. **(A)** Preoperative sagittal T2-weighted image (T2WI): ovoid IDEM lesion of the cauda equina behind the L5 vertebral body. **(B)**Preoperative sagittal T1-weighted image after gadolinium (T1WIGd): intense homogeneous enhancement. **(C)** Preoperative axial T2WI: the lesion fills most of the canal and displaces the nerve roots. **(D)** Preoperative axial T1WIGd: avid enhancement, no dural tail. **(E)** Postoperative sagittal T2WI:

complete resection through a unilateral laminectomy, free thecal sac. **(F)**Postoperative axial T2WI: restored canal with normal CSF signal, no residual tumor. Diagnosis: L5 root schwannoma; uneventful course with complete resolution of pain and paresthesia, no neurological deficit

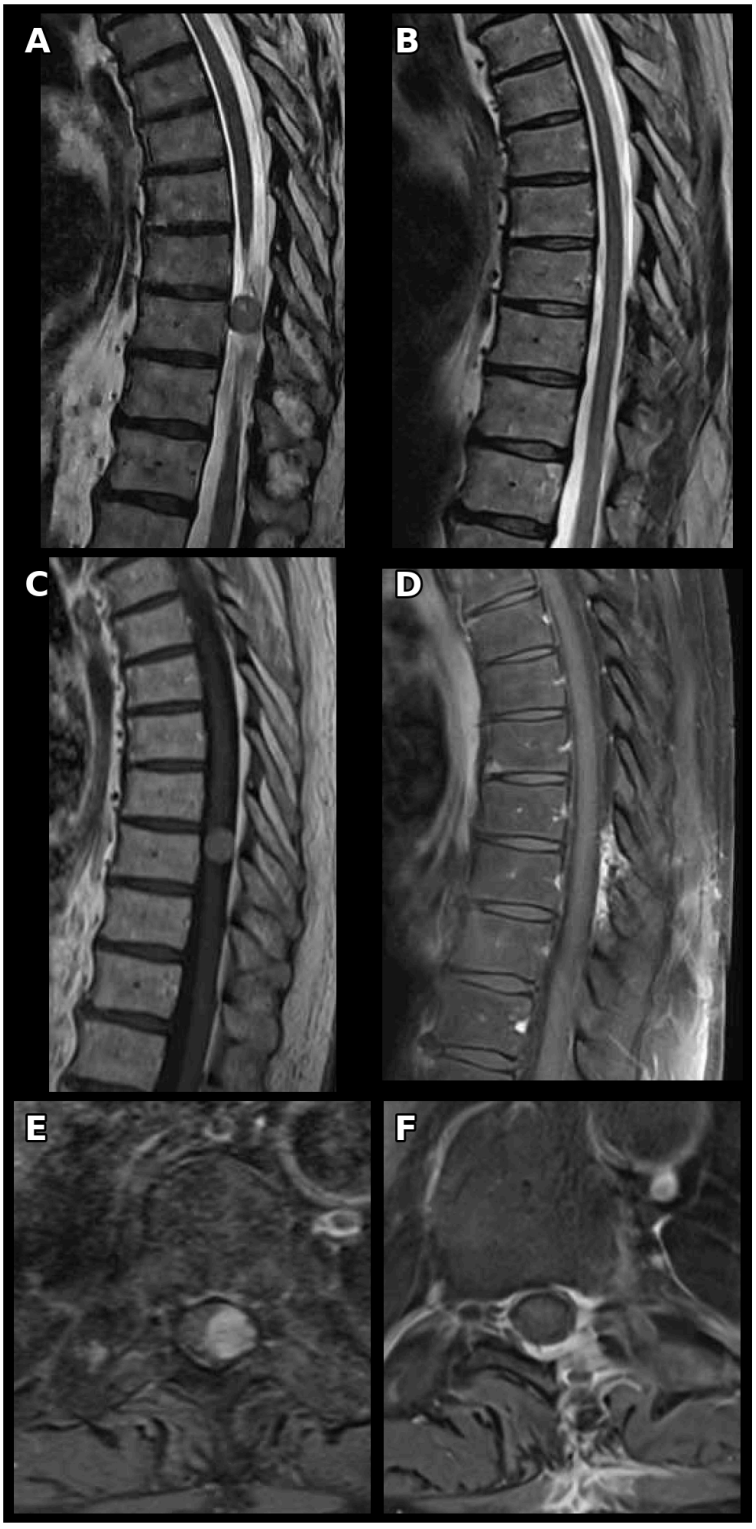


Figure 2

Thoracic MRI in a 71-year-old woman with progressive claudication, gait instability and a pyramidal syndrome. **(A)** Preoperative sagittal T2-weighted image (T2WI): rounded IDEM lesion at T8–T9 displacing the cord. **(B)**Postoperative sagittal T2WI: cord in normal position, no intramedullary hyperintensity. **(C)** Preoperative sagittal T1-weighted image after gadolinium (T1WIGd): homogeneous enhancement with a broad dural base. **(D)**Postoperative sagittal T1WIGd: no residual enhancement. **(E)** Preoperative axial T1WIGd: enhancing mass compressing the cord. **(F)** Postoperative axial T1WIGd: complete removal through a unilateral laminectomy, posterior elements preserved. WHO grade I meningioma; complete recovery at three months

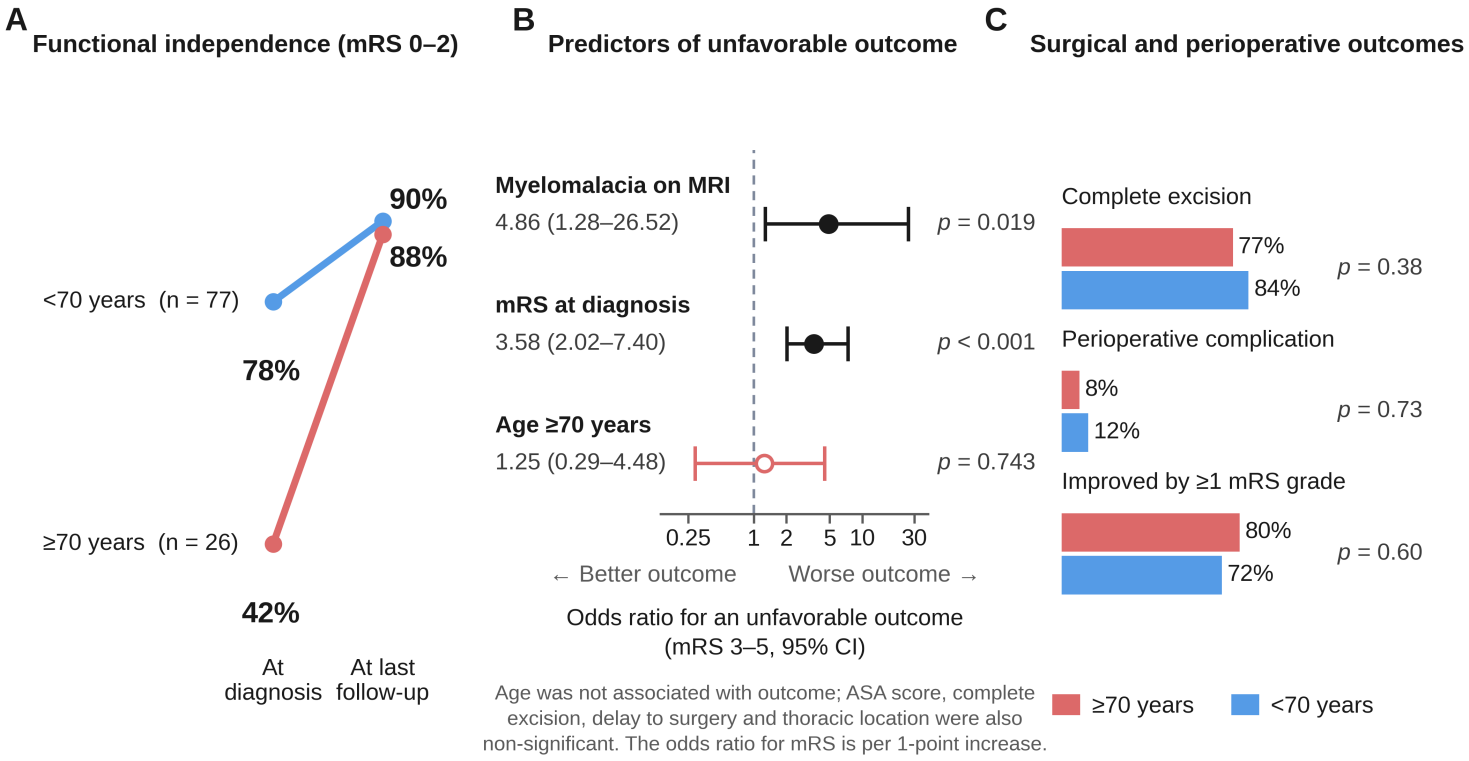


Figure 3

Functional outcome, its determinants, and surgical results by age group. **(A)** Proportion of patients functionally independent (mRS 0–2) at diagnosis and at last follow-up, in patients aged 70 years or older and in younger patients. (B) Univariable Firth penalized logistic regression for an unfavorable functional outcome (mRS 3–5) at last follow-up; an odds ratio greater than 1 indicates a factor associated with a worse outcome, and bars are 95% confidence intervals. **(C)** Surgical and postoperative outcomes in the two age groups. Complete results are reported in Tables 2 and 3