Intradural Spinal Tumors

Extramedullary & Intramedullary Tumors — Diagnosis, Classification & Surgical Treatment

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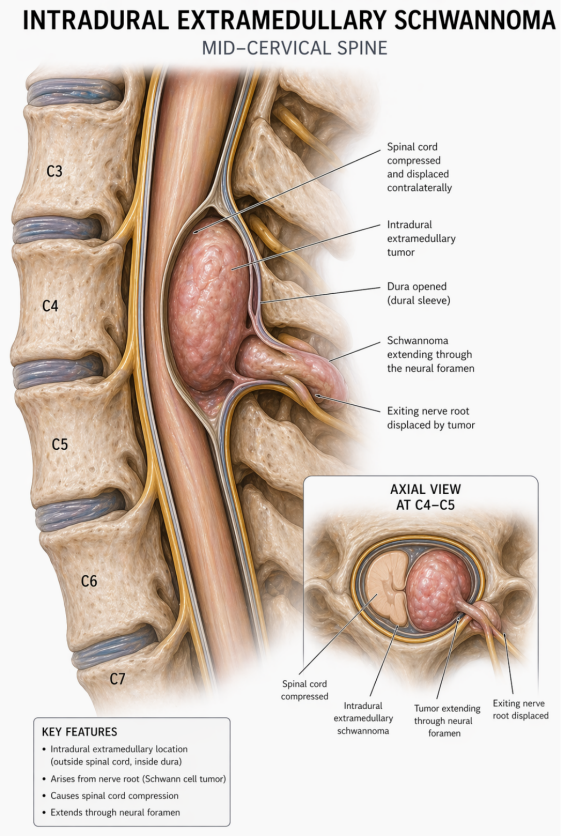
Intradural spinal tumors are growths that arise within the dural sac — the tough membrane that encloses the spinal cord and its nerve roots. Although far less common than brain tumors, they are among the most surgically rewarding spinal conditions to treat: the majority are benign, grow slowly, and can be cured with complete surgical resection — often with dramatic recovery of neurological function when treated before irreversible cord injury occurs.

The critical first distinction in any intradural tumor is its relationship to the spinal cord: is it **outside** the cord (extramedullary) or **within** the cord itself (intramedullary)? This single anatomical classification determines the tumor type, the surgical approach, the degree of resectability, and the expected outcome.

1. Classification of Intradural Spinal Tumors

Location	Definition	Common Tumor Types	% of Intradural Tumors	Typical Behavior
Intradural Extramedullary	Inside the dura; outside the spinal cord	Schwannoma, meningioma, neurofibroma, paraganglioma, nerve sheath myxoma	**~65–70%**	Usually benign; displace cord; highly curable with resection
Intradural Intramedullary	Inside the dura; within the spinal cord substance itself	Ependymoma, astrocytoma, hemangioblastoma, cavernous malformation	**~25–30%**	Variable; arise from cord tissue; resection more challenging; outcomes depend on grade
Extradural (for reference)	Outside the dura; within the spinal canal	Metastases, lymphoma, epidural lipomatosis, chordoma	Most common overall	Often malignant; metastatic; systemic treatment usually required alongside surgery

2. Intradural Extramedullary Tumors



Intradural extramedullary schwannoma at C4-C5. The tumor arises from the nerve sheath of the exiting nerve root, expands within the dura, displaces the spinal cord contralaterally, and may extend through the foramen ("dumbbell" configuration). Axial view confirms cord compression.

What Are Extramedullary Tumors?

Intradural extramedullary (IDEM) tumors grow inside the dural sac but *outside* the spinal cord. They compress and displace the cord and nerve roots from without, rather than invading cord tissue. Because they are separated from the cord by a surgical plane, complete resection is usually achievable and the outcomes are excellent.

Schwannoma

The most common intradural spinal tumor, accounting for approximately 30% of all primary spinal tumors. Schwannomas arise from the Schwann cells of the myelin sheath that surrounds peripheral nerve axons — most commonly from a dorsal sensory nerve root. They are nearly always benign (WHO Grade I) and grow slowly.

- **Origin:** A single fascicle of the nerve root; the remaining fascicles are displaced around the tumor capsule and can be preserved at surgery
- **Capsule:** Schwannomas have a well-defined fibrous capsule that creates a clear dissection plane from surrounding structures — greatly facilitating complete surgical removal
- **Dumbbell configuration:** Up to 30% extend through the neural foramen both inside and outside the spinal canal, creating an hourglass or "dumbbell" shape visible on MRI and as shown in the illustration
- **Imaging:** On MRI, schwannomas appear as well-circumscribed, oval masses that enhance vividly and homogeneously with gadolinium. Cystic change is common in larger tumors.
- **Spinal level:** May occur at any level — cervical, thoracic, or lumbar. Most are solitary. Multiple schwannomas suggest schwannomatosis or neurofibromatosis type 2 (NF2).
- **Cure rate:** Gross total resection is curative in the vast majority of cases. Recurrence is rare after complete removal.

Schwannoma vs. Neurofibroma — Key Distinctions

Feature	Schwannoma	Neurofibroma
Cell of origin	Schwann cells only; other nerve elements displaced around tumor	Mixed — Schwann cells, perineural cells, and fibroblasts intimately mixed with axons
Capsule	**Well-encapsulated — clear surgical plane**	**Unencapsulated — nerve fascicles run through tumor; no clean plane**
Nerve root sacrifice	**Usually spared — remaining fascicles dissected off capsule**	**Usually requires sacrifice of the affected fascicle(s) — nerve function at risk**

Resectability	**Gross total resection usually achieved**	**Complete resection more difficult; subtotal resection accepted to preserve function**
Malignant potential	Very rarely malignant (<1%)	~5–10% malignant transformation (MPNST) especially in NF1
Association	Sporadic; or NF2 / schwannomatosis (bilateral / multiple)	Sporadic (isolated); or neurofibromatosis type 1 (NF1) — café-au-lait spots, multiple lesions
MRI appearance	Vivid homogeneous enhancement; may have cystic areas; eccentric to nerve	"Target sign" on T2 (central low signal, peripheral high signal); fusiform along nerve axis

Meningioma

The second most common intradural spinal tumor (~25%). Meningiomas arise from the arachnoid cap cells of the meninges — the membrane lining the dural sac — rather than from the nerve roots. They are most common in the thoracic spine (~80%) and overwhelmingly affect women (4:1 female predominance), typically in the fifth to seventh decades. They have a characteristic broad base of attachment to the dura ("dural tail" on MRI), are almost always benign (WHO Grade I), and are highly curable with en-bloc resection including the dural attachment. Unlike schwannomas, there is no nerve root of origin to preserve — the tumor simply grows from the dural wall and compresses the cord from one side.

3. Intradural Intramedullary Tumors

Intramedullary tumors arise from cells *within* the spinal cord itself. Because they are embedded in functioning neural tissue, they present the greatest surgical challenge of all spinal tumors — resection must be balanced against the risk of neurological injury to the surrounding cord. Intraoperative neuromonitoring (MEPs, SSEPs, and D-wave recording) is essential in all intramedullary tumor surgery.

Ependymoma

The most common intramedullary tumor in adults (~60% of intramedullary tumors). Ependymomas arise from the ependymal cells lining the central canal of the spinal cord. They are typically well-circumscribed, have a clear surgical plane from surrounding cord tissue, and are almost always benign (WHO Grade II). The **myxopapillary ependymoma** is a distinct low-grade variant that occurs at the conus medullaris and filum terminale — technically extramedullary at that location and highly curable with resection.

- Most common at cervical and cervicothoracic levels
- On MRI: centrally located in the cord, enhancing, often with cap sign (hemosiderin caps at upper and lower poles from prior microhemorrhage)
- Gross total resection is the goal and is achievable in the majority — associated with excellent long-term outcomes and low recurrence
- Incompletely resected or high-grade ependymomas may require adjuvant radiation therapy

Hemangioblastoma

Highly vascular, benign tumors arising from stromal cells — accounting for approximately 5% of intramedullary tumors. May be solitary or multiple (in the context of **von Hippel-Lindau (VHL) disease**, an autosomal dominant syndrome). Hemangioblastomas are often associated with a large syrinx that extends far above and below the small tumor nodule. Pre-operative embolization may be considered for highly vascular lesions to reduce intraoperative blood loss.

Astrocytoma

The second most common intramedullary tumor (~30%), and the most common in children. Unlike ependymomas, spinal astrocytomas are often poorly circumscribed, infiltrating the cord without a clear surgical plane. Most are low-grade (WHO Grade I–II, pilocytic or diffuse astrocytoma), but high-grade variants (Grade III–IV) occur and carry a poor prognosis.

- Most common in the cervical and thoracic cord
- On MRI: expansile cord lesion, often with patchy enhancement and ill-defined borders — in contrast to the sharp margins of ependymoma
- Surgery aims for maximal safe resection without worsening neurological function. Gross total resection is often not achievable for infiltrating tumors; biopsy or partial resection followed by radiation and/or chemotherapy is the standard approach for high-grade lesions
- Low-grade spinal astrocytomas in children may be managed with observation after subtotal resection if neurologically stable

Cavernous Malformation

Clusters of abnormally enlarged blood-filled vascular spaces within the cord. Technically vascular malformations rather than tumors, but they present in a similar fashion — with episodic neurological deterioration from repeated microhemorrhages. Cavernous malformations do not enhance with gadolinium but have a characteristic "popcorn" appearance on gradient echo MRI from hemosiderin deposition. Surgery is considered after the second clinical hemorrhage, when the risk of further bleeding outweighs the surgical risk.

4. Symptoms & Diagnosis

Symptoms

Intradural tumors grow slowly, and symptoms may be present for months to years before diagnosis. The pattern of symptoms depends on the spinal level, whether the tumor is extramedullary or intramedullary, and which neural structures are compressed:

- **Pain** — the most common initial symptom. Extramedullary tumors often cause radicular pain (sharp, shooting pain in a nerve root distribution) from nerve root compression. Intramedullary tumors may cause a diffuse, poorly localized central pain.
- **Myelopathy** — progressive spinal cord dysfunction: hand clumsiness, grip weakness, gait imbalance, spasticity, and hyperreflexia. The pace may be slow and insidious over years.
- **Sensory disturbance** — numbness, tingling, or a "band-like" sensation at the level of the tumor. Intramedullary tumors classically produce "dissociated" sensory loss — loss of pain and temperature with preserved light touch and proprioception (from central cord involvement of the crossing spinothalamic fibers).
- **Weakness** — upper motor neuron pattern (spasticity, increased reflexes, Babinski sign) below the lesion; lower motor neuron pattern (flaccidity, atrophy, fasciculations) at the level of the lesion.
- **Bladder and bowel dysfunction** — urinary urgency, retention, or incontinence; indicates significant cord involvement.
- **Scoliosis** — in children and young adults, an intramedullary tumor or associated syrinx may manifest as progressive scoliosis before other neurological symptoms appear.

Diagnosis

- **MRI with and without gadolinium contrast** — the gold standard. Gadolinium enhancement defines the tumor precisely, distinguishes it from surrounding edema, and characterizes its relationship to the cord. Full spine MRI is obtained to screen for additional lesions in patients with suspected NF1, NF2, schwannomatosis, or VHL.
- **CT scan** — used to assess bony involvement, neural foraminal widening in dumbbell tumors, and spinal column stability.
- **CT myelogram** — when MRI is contraindicated (cardiac pacemaker, certain metallic implants), contrast injected into the CSF outlines the tumor as a filling defect within the dural sac.
- **Angiography / embolization** — for highly vascular tumors (hemangioblastoma) or dumbbell schwannomas with a large foraminal component, pre-operative selective angiography and tumor embolization may reduce intraoperative blood loss.
- **Genetic testing** — in patients with multiple tumors or family history of NF1, NF2, schwannomatosis, or VHL, genetic counseling and testing guides surveillance of additional lesions.

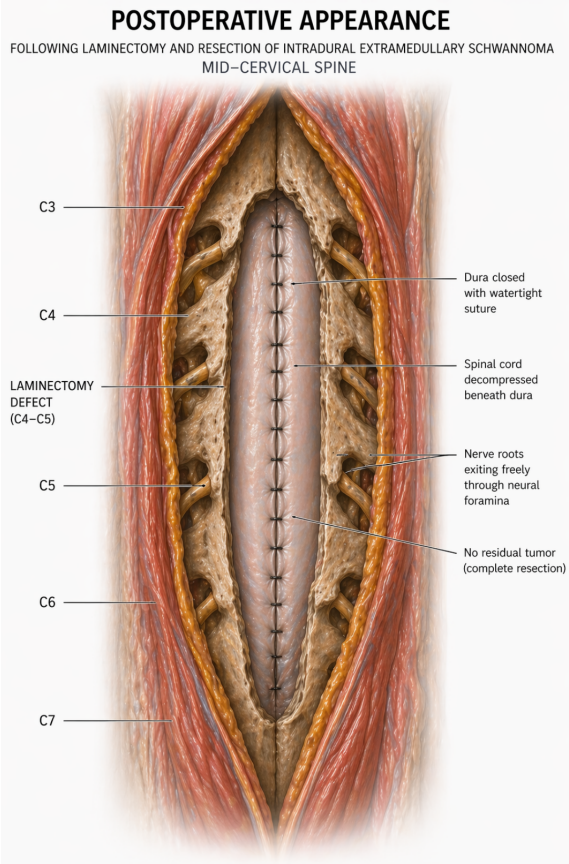
Key MRI Characteristics by Tumor Type

- **Schwannoma:** Eccentric to cord; vivid enhancement; T2-bright; possible cysts; dumbbell extension
- **Meningioma:** Broad dural base; homogeneous enhancement; "dural tail" sign; no cord invasion
- **Ependymoma:** Central in cord; hemosiderin cap sign; well-defined margins; strong enhancement
- **Astrocytoma:** Expansile cord; ill-defined margins; patchy or no enhancement
- **Hemangioblastoma:** Small enhancing nodule with large associated syrinx; flow voids from vessels

5. Surgical Treatment — The Osteoplastic Laminoplasty Approach

Dr. Caridi's Preferred Technique: Motion-Preserving Osteoplastic Laminoplasty

For the surgical treatment of intradural tumors, Dr. Caridi routinely performs an **osteoplastic laminoplasty** rather than a standard laminectomy. This technique preserves the posterior bony elements of the spine — protecting long-term spinal stability, preventing post-laminectomy kyphosis, and maintaining full spinal motion at the operated levels without the need for fusion.



Postoperative field after intradural schwannoma resection: dura closed with a watertight suture, spinal cord fully decompressed, nerve roots exiting freely, and no residual tumor. In Dr. Caridi's osteoplastic laminoplasty, the laminar bone flap removed to gain this exposure is replaced and secured at closure — eliminating the permanent laminectomy defect and preserving posterior spinal architecture.

Standard Laminectomy vs. Osteoplastic Laminoplasty

In a **standard laminectomy**, the laminae (the bony arches forming the posterior roof of the spinal canal) are removed and discarded to gain access to the intradural tumor. While this provides excellent exposure, the permanent removal of posterior bone elements can lead to spinal instability, post-laminectomy kyphosis (particularly in the cervical spine), and — in younger patients — progressive deformity requiring later fusion surgery.

In Dr. Caridi's **osteoplastic laminoplasty**, the laminae are carefully removed as a single intact bone flap using a high-speed drill and fine osteotomes. The bone flap is set aside, preserved in antibiotic-irrigated saline, and — after the tumor is completely resected and the dura is closed with a watertight running suture — the bone flap is **replaced anatomically and secured** with small titanium miniplates or sutures. The posterior elements are reconstructed as if the surgery never required their removal.

Advantages of the Laminoplasty Approach

- **Spinal stability is preserved:** The posterior tension band — laminae, facet joints, and ligaments — remains intact after bone replacement, maintaining the mechanical integrity of the spine
- **Motion is preserved:** No fusion is required. The patient retains full range of motion at the operated levels — a critical advantage, particularly for multilevel cervical procedures
- **Post-laminectomy kyphosis is prevented:** In the cervical spine especially, laminectomy without fusion causes progressive kyphosis in up to 20% of patients. Laminoplasty eliminates this risk entirely
- **Equivalent tumor exposure:** The osteoplastic technique provides identical surgical exposure to standard laminectomy — there is no compromise in the ability to perform complete tumor resection
- **Better cosmesis and wound healing:** Replacement of the bone flap fills the posterior defect, providing better soft tissue support and reducing the risk of wound breakdown

The Operation — Step by Step

- **Positioning & neuromonitoring:** The patient is placed prone on a Jackson table with the head secured in a Mayfield clamp (cervical and upper thoracic cases) or in neutral position (thoracic and lumbar). Baseline MEPs, SSEPs, and free-running EMG are established before any surgical manipulation.
- **Exposure:** A midline posterior incision is made over the affected levels. Paraspinal muscles are dissected subperiosteally from the spinous processes and laminae and retracted laterally — preserving muscular attachments as much as possible.
- **Osteoplastic laminoplasty:** Using a high-speed drill and Kerrison rongeurs, bilateral troughs are created at the junction of the laminae and facet joints. The laminae and attached spinous processes are carefully lifted off as a single unit — the "laminoplasty flap" — and set aside in antibiotic solution. The facet joints and facet capsules are scrupulously preserved.
- **Dural opening & tumor resection:** The dura is opened in the midline with microscissors under microscope magnification. Dural tack-up sutures retract the dura laterally. For extramedullary tumors, the tumor capsule is identified and sharply dissected from the cord and nerve roots. For intramedullary tumors, the dorsal midline sulcus is used to enter the cord (myelotomy), and the tumor is dissected from surrounding cord tissue using microsurgical techniques under continuous neuromonitoring guidance.
- **Dural closure:** The dura is closed in a watertight fashion with a running 4-0 or 5-0 non-absorbable suture. A Valsalva maneuver confirms the watertight seal. A dural sealant may be applied.
- **Laminoplasty flap replacement:** The bone flap is replaced anatomically in its original position and secured with small titanium miniplates and screws. Bone wax and local bone graft are used to encourage incorporation of the replaced flap. The paraspinal muscles and fascia are meticulously reapproximated.

6. Risks & Complications

Intradural tumor surgery is performed with the highest standards of microsurgical technique and continuous intraoperative neuromonitoring. Despite this, risks exist and must be clearly understood:

- **Neurological injury — spinal cord or nerve root:** The most significant risk. Extramedullary tumor resection carries a low risk of cord injury when a clear surgical plane exists. Intramedullary tumor resection carries a higher risk, as the tumor is embedded in functioning cord tissue. Neuromonitoring changes prompt immediate modification of the surgical approach.
- **Temporary neurological worsening:** Post-operative swelling of the spinal cord after tumor removal — even with no direct cord injury — can cause temporary worsening of pre-existing deficits. Intravenous steroids (dexamethasone) are used peri-operatively to minimize cord edema. Most temporary deficits improve over days to weeks.
- **CSF leak:** Despite watertight dural closure, CSF leakage through the incision can occur in 3–5% of cases. Most resolve with bed rest and wound care; persistent leaks may require lumbar drain placement or surgical re-exploration.
- **Nerve root sacrifice (schwannoma/neurofibroma):** When the tumor arises from a sensory nerve root, that root is often sacrificed to achieve complete resection. In the lumbar spine this may cause predictable sensory loss in a dermatomal distribution; motor function is rarely affected if only one root is sacrificed.
- **Incomplete resection:** For infiltrating intramedullary tumors (astrocytoma) or extensively adherent extramedullary tumors, gross total resection may not be safely achievable. Subtotal resection preserves neurological function and may be followed by radiation or observation depending on tumor grade and histology.
- **Infection:** Surgical site infection occurs in approximately 1–3% of cases. Deep infections involving the dura or spinal cord are rare but serious, requiring surgical debridement and prolonged antibiotic therapy.
- **Epidural hematoma:** Post-operative bleeding into the laminoplasty bed can compress the spinal cord and requires emergency re-exploration. Close neurological monitoring in the immediate post-operative period allows early detection.
- **Laminoplasty flap resorption:** In rare cases, the replaced bone flap may not fully incorporate and may be gradually resorbed — though this is uncommon and rarely clinically significant.
- **Tumor recurrence:** After gross total resection of benign extramedullary tumors (schwannoma, meningioma), recurrence is uncommon (<5% at 10 years). Annual or biennial MRI surveillance is recommended, particularly for patients with NF1, NF2, or schwannomatosis.

7. Recovery After Intradural Tumor Resection

Hospital Stay 2–4 days	Close neurological monitoring in the first 24–48 hours. Physical and occupational therapy assessment begins day 1. Head-of-bed positioning maintained at 30° to reduce CSF pressure on the closure. Steroid taper for cord edema. Most patients are ambulatory before discharge.
Weeks 1–4 Home Recovery	Activity restriction to protect the dural repair. No heavy lifting, straining, or Valsalva-type exertion. No submerging in water until the wound is fully healed. A soft cervical collar may be worn for comfort in cervical cases. Wound check at 10–14 days.
Weeks 4–8 Rehabilitation	Outpatient physical therapy for gait training, balance, strengthening, and fine motor rehabilitation as needed. Activity gradually expanded. Many patients experience continued improvement in neurological symptoms as cord swelling resolves. X-rays confirm laminoplasty flap position.
Months 2–6 Full Recovery	Most patients achieve their full neurological recovery by 3–6 months. MRI at 3 months confirms complete tumor resection. Return to work and full activity as cleared by Dr. Caridi. Annual or biennial surveillance MRI recommended for all patients.
Long-Term Surveillance	Outcomes after gross total resection of benign intradural tumors are excellent — the majority of patients experience lasting relief of pain, stabilization of myelopathy, and return to full activity. The motion-preserving osteoplastic laminoplasty avoids the long-term complications of post-laminectomy kyphosis and eliminates the need for future fusion surgery.

8. When to Seek Evaluation

Seek Evaluation With Dr. Caridi If You Experience Any of the Following:

- Progressive weakness, numbness, or tingling in the arms, hands, legs, or feet
- Difficulty with fine motor tasks — buttoning, writing, typing — or a new clumsiness of the hands
- Gait imbalance, unsteadiness, or a tendency to fall — signs of cervical or thoracic cord compression
- Bladder or bowel dysfunction — urgency, retention, or incontinence
- New or worsening back or neck pain, particularly if associated with a radicular component (pain radiating into the arm or leg)
- A known intradural tumor (schwannoma, meningioma, ependymoma) with new or worsening symptoms, or enlargement on surveillance imaging
- Diagnosis of NF1, NF2, schwannomatosis, or Von Hippel-Lindau disease — spinal surveillance imaging is recommended even in the absence of symptoms
- Any sudden new neurological deficit — seek emergency evaluation immediately

When an intradural spinal tumor is found, timing matters. Surgery performed before permanent cord injury has occurred — when neurological deficits are still mild and reversible — yields dramatically better outcomes than surgery performed after prolonged cord compression. Dr. Caridi will guide you through the diagnosis, recommend the optimal timing of surgery, and perform the resection using the osteoplastic laminoplasty technique to give you the best possible neurological outcome while protecting your spinal stability for life.