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www.bsmi.uz
https://newdaymedicine.com
E: ndmuz@mail.ru
Тел: +99890 8061882

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IMPROVING SURGICAL DECISION-MAKING IN PATIENTS WITH EXTRADURAL TUMORS OF THE SPINE

Khushbokov Ibrohim Sayfullayevich e-mail: ibrohimxushboqov.95@gmail.com
Djumanov Kamoliddin Nuriddinovich e-mail: djumanovkamoliddin@gmail.com
Ibragimov Akobir Ismoilovich e-mail: akobiribragimov@gmail.com

Republican Specialized Scientific and Practical Center of Neurosurgery, Tashkent, Uzbekistan.
Tashkent city, Mirzo Ulugbek district, Humoyun st 40a-house E-mail: admin@neuro.uz
Tel: +998 (71) 264-96-10

✓ ***Resume***

Extradural spinal tumors are growths located outside the dura mater, most commonly found in the epidural space or within the vertebral bones. They differ from intradural tumors, which develop inside the dural sac. The vast majority of extradural spinal tumors are metastatic, arising from hematogenous spread of primary cancers such as those of the breast, lung, prostate, kidney, thyroid, as well as melanoma, lymphoma, myeloma, and various gastrointestinal malignancies. These tumors frequently cause pain, vertebral collapse, spinal instability, or neurological symptoms due to compression of nerve roots or the spinal cord.

Primary extradural tumors are comparatively rare and may be either benign or malignant, with their clinical behavior and outcomes largely dependent on histological type. The histological characteristics of a tumor are crucial in guiding management, as they offer important prognostic insights and influence treatment decisions. Stratifying tumors by their aggressiveness—from indolent to rapidly progressive—helps predict postoperative survival and determines the extent of surgery and the need for additional therapies.

Certain hypervascular metastases, including those from renal cell carcinoma, thyroid cancer, hepatocellular carcinoma, melanoma, and some giant cell tumors, carry an elevated risk of significant bleeding during surgery. Preoperative embolization can be a useful measure to minimize blood loss in these cases.

Accurately determining whether a tumor is extradural or intradural, and pinpointing its exact position relative to the dura and spinal canal, is essential for choosing the most appropriate surgical technique and reducing the risk of complications. In the wider context of spinal metastatic disease, it is also important to differentiate spinal metastases from primary spinal tumors. Treatment typically addresses both the spinal lesion and the underlying systemic cancer, with objectives focused on alleviating pain, preserving neurological function, maintaining spinal stability, enhancing quality of life, and carefully weighing systemic therapies and radiation sensitivity against the potential risks of surgery.

Keywords: Extradural spinal tumors; Spine neoplasms; Spinal metastases; Spinal instability neoplastic score (SINS); Epidural spinal cord compression (ESCC); Bilsky classification; NOMS framework.

СОВЕРШЕНСТВОВАНИЕ ПРИНЯТИЯ ХИРУРГИЧЕСКИХ РЕШЕНИЙ У ПАЦИЕНТОВ С ЭКСТРАДУРАЛЬНЫМИ ОПУХОЛЯМИ ПОЗВОНОЧНИКА

Хушбоков Иброхим Сайфуллаевич *e-mail: ibrohimxushboqov.95@gmail.com*
Джуманов Камолиддин Нуриддинович *e-mail: djumanovkamoliddin@gmail.com*
Ибрагимов Акобир Исмоилович *e-mail: akobiribragimov@gmail.com*

Республиканский специализированный научно-практический центр нейрохирургии, Ташкент, Узбекистан. Адрес: г. Ташкент, Мирзо-Улугбекский район, ул. Хумоюн, дом 40а
Email: admin@neuro.uz Тел.: +998 (71) 264-96-10

✓ ***Резюме***

Экстрадуральные опухоли позвоночника — это новообразования, расположенные за пределами твёрдой мозговой оболочки, чаще всего в эпидуральном пространстве или в пределах тел и других структур позвонков. В отличие от них, интрапуральные опухоли развиваются внутри дурального мешка. Подавляющее большинство экстрадуральных опухолей позвоночника имеют метастатическое происхождение и возникают вследствие гематогенного распространения первичных злокачественных опухолей, таких как рак молочной железы, лёгкого, предстательной железы, почки, щитовидной железы, а также меланома, лимфома, миелома и различные злокачественные новообразования желудочно-кишечного тракта. Эти опухоли часто вызывают болевой синдром, компрессионные переломы и коллапс позвонков, нестабильность позвоночника или неврологические нарушения вследствие компрессии нервных корешков или спинного мозга.

Первичные экстрадуральные опухоли встречаются значительно реже и могут быть как доброкачественными, так и злокачественными, при этом их клиническое течение и исходы в значительной степени зависят от гистологического типа. Гистологические характеристики опухоли имеют решающее значение при выборе тактики лечения, поскольку позволяют оценить прогноз и влияют на принятие терапевтических решений. Распределение опухолей по степени агрессивности — от медленно прогрессирующих до быстро прогрессирующих — помогает прогнозировать послеоперационную выживаемость, определять объём хирургического вмешательства и необходимость проведения дополнительной терапии.

Некоторые гиперваскулярные метастатические опухоли, включая метастазы почечно-клеточного рака, рака щитовидной железы, гепатоцеллюлярной карциномы, меланомы и некоторые гигантоклеточные опухоли, связаны с повышенным риском значительной кровопотери во время операции. В таких случаях предоперационная эмболизация может быть эффективной мерой для уменьшения объёма интраоперационной кровопотери.

Точное определение того, является ли опухоль экстрадуральной или интрапуральной, а также установление её точного расположения по отношению к твёрдой мозговой оболочке и позвоночному каналу имеет принципиальное значение для выбора наиболее подходящей хирургической техники и снижения риска послеоперационных осложнений. В более широком контексте метастатического поражения позвоночника также важно дифференцировать метастазы в позвоночник от первичных опухолей позвоночника. Лечение, как правило, направлено одновременно на устранение патологического очага в позвоночнике и контроль основного системного онкологического заболевания. Основными целями являются уменьшение болевого синдрома, сохранение неврологических функций, поддержание стабильности позвоночника, улучшение качества жизни, а также тщательное сопоставление возможностей системной терапии и чувствительности опухоли к лучевой терапии с потенциальными рисками хирургического вмешательства.

Ключевые слова: экстрадуральные опухоли позвоночника; новообразования позвоночника; метастазы в позвоночник; шкала неопластической нестабильности позвоночника (SINS); эпидуральная компрессия спинного мозга (ESCC); классификация Bilsky; система NOMS.

Decision-Making Challenges in Spine Oncology

Decision - making in spine oncology is inherently complex and demands a multidisciplinary approach to customize treatment for each patient. Neurosurgeons, radiation oncologists, medical oncologists, and rehabilitation specialists collaborate to strike a balance between tumor control and the preservation of neurological function and quality of life. The main factors that guide treatment choices include the tumor's location, type, and growth pattern, along with the patient's overall health and existing comorbidities, as well as the potential impact of therapies on daily functioning and motor abilities.

Surgical planning frequently prioritizes decompression of the spinal cord and stabilization of the spine over radical tumor excision. This reflects a clinical focus on safeguarding neurologic function while addressing any mechanical instability that may be present. Critical elements in decision-making start with an evaluation of neurological status, which measures the tumor's effect on strength, walking ability, and degree of spinal cord compression. Tumor biology also plays a key role, as it determines how aggressive the disease is and how responsive it may be to surgery, radiation, or systemic treatments. Additionally, the extent of systemic disease—meaning how widespread the cancer is elsewhere in the body—helps clarify whether spinal intervention should take precedence at a given time and guides the balance between intensive treatment and maintaining function.

There is no fixed survival threshold that automatically dictates a particular course of action, highlighting the importance of individualized evaluation and shared decision-making between clinicians and patients. Spine surgeons also assess mechanical instability when considering the need for stabilization. In metastatic disease, structural weakening may call for stabilization using implants or augmentation techniques to alleviate pain and avert further vertebral collapse, even in the absence of severe neurological impairment. In more uncertain cases, however, close observation, bracing, or radiotherapy might be chosen over immediate surgical hardware placement.

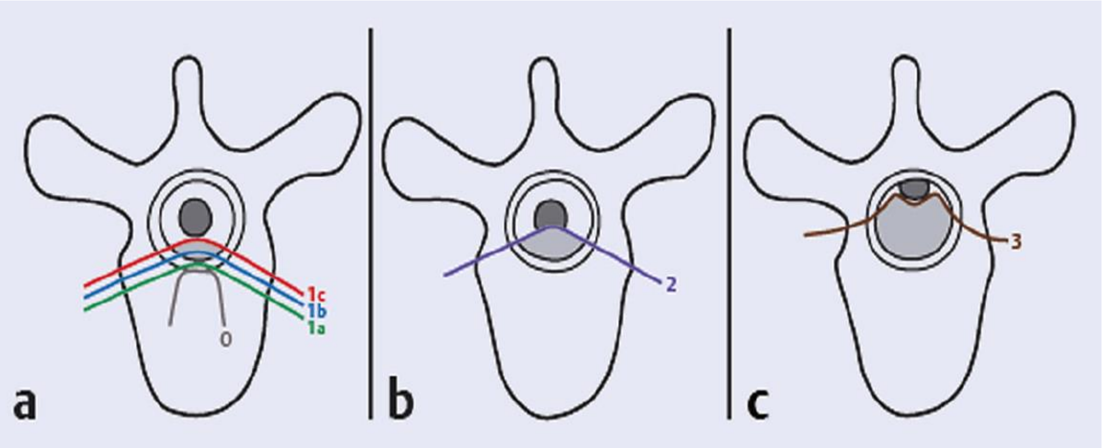

Fig. 1.1a–c Schematic representation of the 6-point epidural spinal cord compression (ESCC) grading scale16. Grade 0, tumor is confined to bone only. (a) Grade 1, tumor extension into the epidural space without deformation of the spinal cord. This is further divided into 1a, epidural impingement but no deformation of the thecal sac; 1b, deformation of the thecal sac without spinal cord abutment; and 1c, deformation of the thecal sac with spinal cord abutment but no compression. (b) Grade 2, spinal cord compression but cerebrospinal fluid (CSF) is visible. (c) Grade 3, spinal cord compression without visible CSF. Grades 0, 1a, and 1b are considered for radiation as first treatment in the lack of mechanical instability. Grades 2 and 3 define high-grade ESCC. Note: Used with permission from Bilsky MH, Laufer I, Fourney DR, et al. Reliability analysis of the epidural spinal cord compression scale.

The evaluation of instability often employs the Spinal Instability Neoplastic Score (SINS), a scoring system that takes into account tumor location, mechanical pain, quality of the bone lesion, spinal alignment, degree of vertebral body collapse, and involvement of posterolateral structures. Based on these criteria, the spine is classified as stable, potentially unstable, or unstable. A higher score tends to favor surgical stabilization as part of the treatment plan, demonstrating how a quantitative tool can inform clinical judgments in oncologic spine care.

These challenges are further compounded by tumor biology. Some cancers respond well to radiotherapy or systemic agents, potentially reducing the need for surgical decompression, whereas others are relatively radioresistant and may demand more aggressive surgical intervention to achieve meaningful symptom relief. Consequently, different primary tumors often require distinct therapeutic strategies, even when they appear similar on MRI. Careful interpretation of tumor biology is therefore essential for effective treatment planning.

Operative versus Non-Operative Management

In treating extradural spinal tumors, management decisions generally follow a stepwise evaluation of surgical suitability and the anticipated influence of tumor biology on treatment response. Across current clinical algorithms, patients who are not candidates for surgery are directed toward non-surgical options such as radiation or medical therapy, underscoring the fundamental principle that a patient's ability to tolerate an operative procedure is essential before any surgical planning can proceed. Similarly, the patient's overall medical condition—often described as operability or assessed through systemic evaluation—is a critical factor in early decision-making, with non-operative approaches preferred when the risks of surgery outweigh the expected benefits.

Clinical presentation and neurological status are key drivers in guiding management. In major decision frameworks, the degree of neurological impairment or the severity of spinal cord compression typically steers care toward surgical decompression, unless the tumor histology is known to be highly responsive to radiation or chemotherapy. This highlights the central role of tumor biology in shaping treatment choices. Spinal instability or the threat of pathological fracture also pushes management toward surgical stabilization to restore or preserve spinal integrity and function. On the other hand, tumors that are strongly sensitive to chemotherapy or conventional radiotherapy may be managed primarily with non-surgical approaches when appropriate.

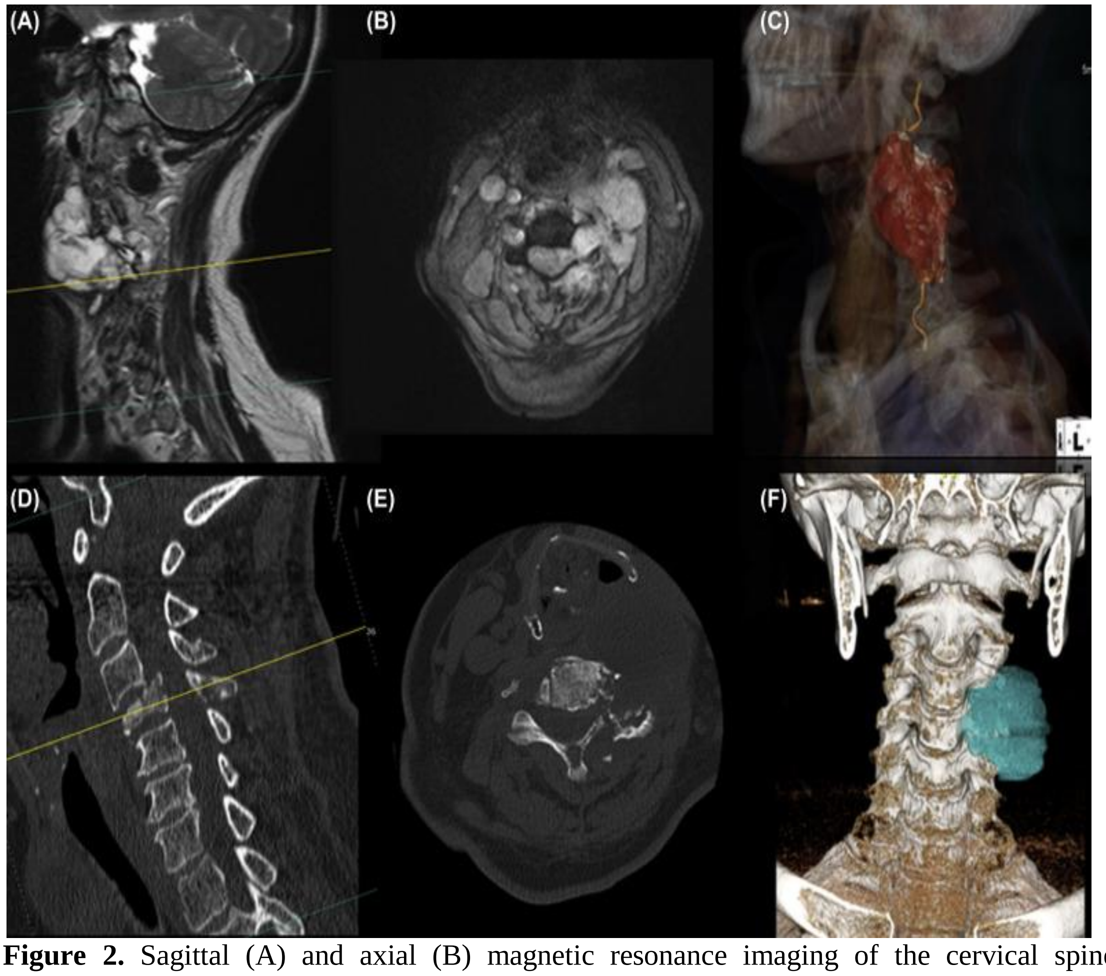

Figure 2. Sagittal (A) and axial (B) magnetic resonance imaging of the cervical spine (T2 sequence) demonstrating a chondrosarcoma involving the C3, C4, and C5 vertebral bodies. The tumor extends anterolaterally encompassing the left vertebral artery [C – computed tomography (CT)–angio reconstruction] as well as infiltrating the left C3, C4, and C5 nerve roots. Sagittal (D), axial (E), and three-dimensional reconstruction (F) of CT scan of the cervical spine in the same patient demonstrating a pathological compression fracture of the C4 vertebral body with destruction of the left side facets, pedicle, and lamina by tumoral infiltration.

The selection of a surgical approach depends on more than just clinical findings; it is also influenced by regional anatomy, prior treatments, and patient-specific factors. Anatomical limitations can restrict access and dictate the most suitable surgical route. In certain cases, collaborating with an access surgeon or using less invasive techniques may enhance safety and improve outcomes. Avoiding areas that have previously been irradiated or operated on can reduce the risk of wound healing complications, while compromised pulmonary function may rule out certain approaches, such as transthoracic access.

Preoperative planning also takes into account the extent of prior therapy and the tumor's vascularity, as both affect intraoperative risk and the feasibility of en bloc resection. Some clinical series advocate routine preoperative embolization for hypervascular metastatic spinal tumors to minimize bleeding during radical resection, though the availability of interventional radiology and the urgency of certain cases can limit its use. The review of preoperative imaging and careful patient selection for embolization highlight the multidisciplinary nature of surgical planning in this context.

When surgery is considered for metastatic extradural disease, common indications include neurological deficits, mechanical back pain, and an expected survival of more than a few months. Surgical goals range from decompression to stabilization and reconstruction. Postoperative decisions—such as the timing of radiotherapy or chemotherapy—reflect a careful balance between reducing wound complications and achieving optimal oncologic control. Evidence suggests that delaying radiotherapy after surgery may negatively affect local control and survival in some instances. These considerations reinforce that the overall treatment plan often integrates surgery with subsequent adjuvant therapies to achieve the best possible outcomes while preserving or improving quality of life and functional status.

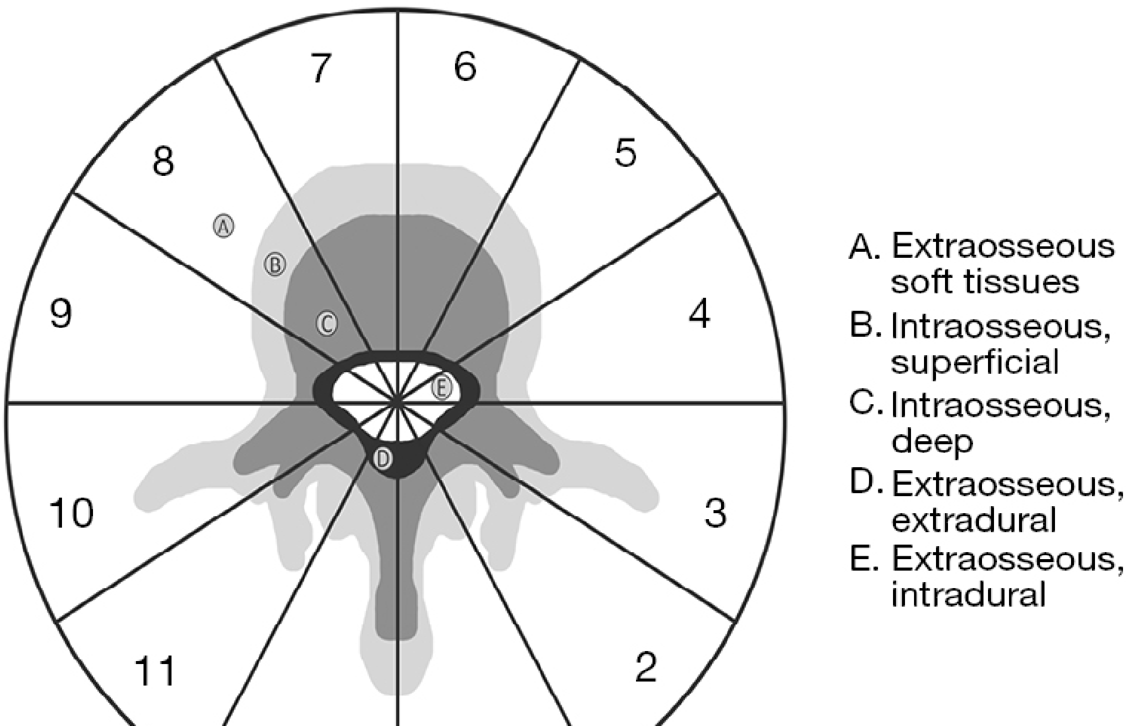

Figure 3. The Weinstein-Boriani-Biagini (WBB) anatomic classification system for spinal tumors. The location of the lesion is described using twelve radiating zones [1–12] in the axial plane of the vertebral body, and 5 concentric layers (A-E) of tumor involvement.

In certain studies, surgical approaches emphasize minimally invasive or less extensive resections when feasible, with the aim of reducing perioperative morbidity, speeding recovery, and enabling earlier return to adjuvant treatments. Comparative analyses describe a spectrum of strategies, from posterior-only to combined anterior-posterior approaches, with selection guided by tumor location, extent, and required surgical margins. Postoperative plans typically include radiotherapy and/or systemic therapy. Across this range, the operative plan is customized to maximize decompression and stabilization while minimizing complication risks, recognizing that successful oncologic control often depends on the timely integration of postoperative therapies.

Assessment and Diagnostic Workflow

Automated and expert-enhanced assessment of Bilsky metastatic epidural spinal cord compression (MESCC) on thoracic spine MRI is a central component of the diagnostic workflow used to guide surgical decision-making in extradural spinal tumors. In a retrospective study, patients with known MESCC diagnosed on MRI between September 2015 and September 2025 were included. Axial T2-weighted images were used for Bilsky classification labeling, performed by experienced musculoskeletal and neuroradiologists, to train a deep learning (DL) model based on a prototypical convolutional neural network. Internal data were split, with 82% allocated for training and validation and 18% reserved for testing. External testing was also conducted to evaluate the model's generalizability. The test sets were labeled by a musculoskeletal radiologist as the reference standard, and interobserver variability was further assessed through independent labeling by a neuroradiologist, a spine surgeon, and a radiation oncologist.

Process and Labeling Framework

The Bilsky MESCC classification served as the reference framework for labeling MRI studies, enabling automated detection and grading of MESCC on axial thoracic spine T2-weighted images. The study highlighted the feasibility of using deep learning to automatically classify MESCC, thereby supporting triage and clinical decision-making.

To benchmark performance and assess reliability, the test sets were independently labeled by multiple specialists—including a neuroradiologist, a spine surgeon, and a radiation oncologist—in addition to the reference-standard musculoskeletal radiologist. This allowed for evaluation of interobserver agreement and comparison with the model's output.

Clinical Utility and Workflow Integration

The deep learning model demonstrated reliable performance in automatically assessing Bilsky classification on thoracic spine MRI. Potential clinical benefits include earlier diagnosis, prioritization of MRI scans for urgent reporting, and support for non-subspecialist radiologists during out-of-hours reporting. Such integration could enhance communication and referral pathways among oncology, radiation oncology, and spine surgery teams.

A deployment framework is described in which incoming MRI studies first undergo region-of-interest (ROI) detection with clinician involvement. The DL model then predicts the Bilsky classification and returns results to clinicians within the workflow. This integrated approach supports rapid triage and decision-making, potentially reducing delays in treatment planning—whether for radiotherapy or emergent surgical decompression.

The envisioned workflow prioritizes early detection and accurate Bilsky grading to inform treatment decisions, including radiotherapy planning versus emergent surgical decompression. By triaging urgent cases and supporting clinicians during high-demand periods, this approach aims to improve functional outcomes and optimize resource utilization in spine oncology care.

The study also mentions the use of distributed training and integration into healthcare-image analytics platforms, such as Apache SINGA within MLCask, to support scalable deployment in clinical environments.

Preoperative Risk Assessment and Decision Tools

Preoperative risk assessment for spine surgery increasingly relies on predictive models and validated risk calculators that can be integrated into clinical workflows and electronic health records (EHRs) to support shared decision-making. In the context of thoracolumbar fusion, a predictive model was developed to identify preoperative risk factors for postoperative venous thromboembolism (VTE) and to enable rapid integration into EHR systems. The model demonstrated acceptable discriminatory ability, as reflected by an area under the curve (AUC) of 0.683. It utilized preoperative factors known to surgeons at the time of scheduling, with operative time included only when it could be reasonably estimated beforehand.

Comparative benchmarking plays a key role in validating new risk tools. The performance of emerging models has been measured against established instruments such as the ACS-NSQIP morbidity calculator, which has been shown to be a valid tool for assessing the risk of postoperative complications following spine surgery. This comparative approach helps ensure that newer models offer at least equivalent—if not superior—discriminative power relative to widely used benchmarks.

Efforts to incorporate risk assessment into practice emphasize the importance of preoperative data capture and operability within clinical systems. The thoracolumbar fusion study explicitly aimed to produce a model that could be rapidly embedded into EHRs for real-time validation, highlighting the practical goal of translating risk prediction into decision-support tools at the point of care. Across various spine procedures, preoperative factors such as age, body mass index (BMI), and other comorbidities have consistently emerged as significant predictors of perioperative risk, informing both patient counseling and perioperative planning.

Beyond individual models, systematic reviews and guidelines underscore the importance of rigorous methodology in evaluating preoperative risk tools. Meta-analytic approaches to VTE prophylaxis after elective spine surgery analyze randomized trials to inform best practices, with careful attention to heterogeneity and risk-of-bias assessment to ensure the reliability of recommendations used in decision-making about perioperative prophylaxis strategies. Tools and methodologies for assessing bias, such as RoB 2, and for synthesizing evidence, including random-effects models, support the credibility of risk assessment instruments that underpin surgical planning and patient consent.

Surgical Planning and Operative Decision Support

Effective surgical planning for spinal metastases requires the integration of oncologic objectives, mechanical stability, prior treatments, and patient-specific factors to guide the selection of resection strategy, stabilization method, and surgical approach. The overarching goal is to relieve compression of neural elements and preserve or restore spinal stability while minimizing morbidity, recognizing that many interventions are performed with palliative intent.

Strategies and Decision Frameworks

Evaluation of spinal stability and indications for stabilization: The presence of mechanical instability resulting from neoplastic involvement constitutes a key indication for surgical stabilization or percutaneous vertebral augmentation, regardless of the tumor's chemosensitivity or radiosensitivity. Identifying instability during clinical assessment guides the decision to proceed with stabilization procedures in order to prevent progression of deformity and neurological compromise.

Treatment algorithms and planning frameworks: Several structured algorithms have been described to support decision-making in spinal metastases, including the Algorithm for Spinal Metastases (based in Bologna) and the neurologic, oncological, mechanical, and systemic (NOMS) framework used at major cancer centers. While individualized care remains essential, these models demonstrate how tumor biology, mechanical stability, and systemic status are integrated to guide intervention choices.

Extent of prior treatment and resection strategy: Planning must take into account previous operations or radiotherapy, as these affect wound healing risk, tissue planes, and the feasibility of additional resection or instrumentation. The surgeon must decide whether to pursue intralesional versus en bloc resection, balancing the goals of local tumor control against the morbidity associated with more radical procedures. In many metastatic cases, piecemeal (intralesional) resections are preferred due to the palliative context, although solitary lesions with favorable histology or longer predicted survival may warrant more extensive en bloc approaches.

Surgical Approach and Access Considerations

Access planning and anatomy: The choice of surgical approach is shaped by regional anatomical constraints, as well as the patient's pulmonary status and prior treatment history. In some instances, avoiding previously irradiated or operated sites is preferred to reduce wound complications, while in others the tumor location or comorbidities may dictate a particular route. Access surgeons with specialized expertise may provide safer or more effective exposure when complex trajectories are required.

En bloc versus intralesional resection: Surgeons must determine the appropriate strategy for tumor resection. Most metastases are addressed intralesionally due to the palliative nature of care. Nevertheless, en bloc resection may be considered in select cases—such as those involving indolent histologies, solitary metastases, or longer survival predictions—where achieving tumor-free margins could meaningfully influence outcomes.

Hypervascular histologies and preoperative embolization: For highly vascular tumors, preoperative embolization can reduce intraoperative blood loss and facilitate safer resections, particularly when multilevel or anterior approaches are anticipated.

Minimally Invasive and Hybrid Techniques

Minimally invasive strategies and stabilization: Minimally invasive surgical (MIS) approaches can broaden the pool of eligible patients by reducing perioperative morbidity and accelerating recovery, while still aiming to achieve adequate decompression and stabilization. MIS techniques offer advantages such as smaller incisions, preservation of normal anatomy, and reduced tissue trauma, although data on MIS decompression without instrumentation remain limited.

Microscopically assisted techniques with augmentation: Emerging approaches, such as Microscopically-Assisted Uninstrumented Spinal Tumor Decompression (MUST-D), seek to combine decompression with cement augmentation to serve as a proxy for stabilization, addressing concerns about long-term instability in selected patient groups. Comparative studies have reported postoperative stability with cement augmentation and no new instability, though larger series are needed to confirm durability across broader populations.

Imaging Findings That Drive Operative Urgency

Imaging plays a central role in determining the urgency of intervention for patients with extradural spinal tumors. Magnetic resonance imaging (MRI) is the primary modality for identifying the level and severity of epidural spinal cord compression and for guiding operative planning. Whole-spine MRI is often recommended to detect noncontiguous or multifocal disease, which may alter the treatment strategy.

Epidural Spinal Cord Compression and Tumor Level

MRI provides detailed visualization of epidural spinal cord compression (ESCC), its extent, and its relationship to the thecal sac and spinal cord. The degree of compression and the involvement of neural structures help stratify the urgency for decompression and stabilization. Routine preoperative spinal tumor imaging includes sagittal screening from the skull base (C1) to the sacrum, with axial cuts through suspicious areas. The most informative sequences are T1-weighted, T2-weighted fast spin echo, and T2-weighted fat-suppressed STIR. T1 hypointensity and STIR hyperintensity help identify sites of bone disease, while T2 axial images assess the extent of epidural compression. These findings guide the surgical plan and the need for urgent decompression.

Vertebral Integrity and Instability Assessment

CT complements MRI by providing detailed information on bone destruction, fracture risk, and spinal alignment—all of which are critical for assessing mechanical instability and planning stabilization procedures if needed. Vertebral body collapse and progressive deformity contribute to mechanical pain and may signal the need for urgent stabilization.

Multifocal Disease and Surgical Planning

Whole-spine imaging is emphasized because spinal metastases frequently involve more than one level and may be noncontiguous. Detecting additional metastases informs whether a localized or more extensive surgical approach is required, and whether radiotherapy fields or systemic therapy need adjustment.

Imaging assessment often includes evaluation of vertebral body collapse, mechanical instability, posterior element involvement, and overall spinal alignment. These radiographic features—sometimes summarized in scoring systems—help determine whether rapid stabilization, such as instrumentation or cement augmentation, is warranted in addition to oncologic treatment. Minimally invasive stabilization may be considered when imaging demonstrates mechanical instability with focal pain or micromotion.

Intraoperative Strategies

Minimally invasive techniques are prioritized regardless of the chosen surgical approach, utilizing smaller incisions, specialized instruments, and real-time imaging to enhance precision. These approaches are associated with reduced blood loss, less postoperative pain, shorter hospital stays, and faster return to daily activities, reflecting a broader commitment to optimized patient recovery during spine tumor resections and stabilization.

When selecting a surgical plan, collaboration with multidisciplinary teams is encouraged to optimize reconstruction and soft-tissue management. In cases where immediate flap reconstruction is indicated, involvement of a plastic surgeon and the use of local muscle advancement flaps, rotational flaps, or free tissue transfer can significantly reduce wound-healing complications. The quality of bone and the extent of tumor involvement are critical determinants of fixation stability; implants must engage bone of adequate quality to maintain spinal reconstruction and prevent loosening.

Intraoperative monitoring plays a central role in preserving neurological function. Surgeons routinely employ neurophysiological monitoring, including somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs), to assess spinal cord integrity in real time throughout the procedure. Expeditious diagnosis and prompt surgical intervention are emphasized to maximize potential neurological recovery when dealing with spinal cord compression.

Blood management and coagulation are integral to intraoperative strategy, with detailed preoperative anticoagulation data and intraoperative assessment guiding decisions about coagulation factors and blood product use. Careful perioperative planning for hemostasis aims to minimize bleeding risks, particularly in patients on antithrombotic therapy, and can influence the choice between more extensive resections and preservation of anatomical structures.

Preoperative planning for en bloc resections considers tumor invasiveness, proximity to vital structures, and the feasibility of achieving complete margins. Imaging and staging inform the aggressiveness of the planned resection, with a balance sought between oncologic control and preservation of function. In selected cases, preoperative airway and nutritional risk assessments—such as tracheostomy and percutaneous gastrostomy—may be warranted due to the extent of cervical or thoracic involvement and anticipated perioperative needs.

Intraoperative decision-making is guided by frameworks and criteria for discussing the extent of resection, reconstruction, and stabilization. The Neurologic, Oncologic, Mechanical and Systemic (NOMS) framework provides a structured approach to choosing interventions for spinal cord compression, emphasizing timely decompression when indicated and appropriate stabilization strategies to maintain alignment and mechanical integrity.

Postoperative Management and Follow-Up

Postoperative management in patients with extradural spinal tumors often emphasizes timely adjuvant therapy, careful monitoring for complications, and functional recovery to optimize quality of life. In many series, postoperative radiotherapy and/or chemotherapy were administered approximately two weeks after surgery, aiming to consolidate local control while allowing initial wound healing. The timing of adjuvant treatment is frequently influenced by intraoperative factors and postoperative recovery, with delays potentially impacting local control and overall outcomes.

Complications and Recovery

The most common postoperative complication reported across cohorts was surgical site infection or wound dehiscence, occurring in 9 of 146 patients (6.2%) in the nonemergency group and 4 of 70 patients (5.7%) in the emergency group in one multicenter assessment, with pneumonia noted as the second most common complication in the corresponding groups. These trends persisted after propensity score matching. These data underscore the continued risk of wound complications and pulmonary issues even after minimally invasive or expedited surgical approaches.

The median Eastern Cooperative Oncology Group performance status (ECOG PS) at surgery differed between groups, being 3 in the nonemergency group and 4 in the emergency group in at least one report, highlighting the influence of pretreatment functional status on perioperative risk and recovery. Limitations noted in analyses suggest that differences in major medical complications may relate to intraoperative variables such as blood loss and duration of anesthesia exposure, particularly in prone-position approaches.

Following surgery, the speedy restoration of ambulation and timely initiation of adjuvant therapy have been emphasized as critical goals, given the potential for delayed radiotherapy to compromise local control and survival in some spine metastasis scenarios. Several studies advocate minimally invasive surgical techniques when feasible, citing reduced incision size, less muscle dissection, and shorter anesthesia times as factors that may lower complication rates and accelerate recovery, thereby enabling faster postoperative ambulation and earlier adjuvant treatment. The relationship between postoperative mobility and survival has been observed in assessing functional outcomes, with improvements in mobility contributing to quality of life after decompression and stabilization.

Postoperative outcomes commonly tracked include complications within 30 days, neurological status—including ambulatory status—at early follow-up, and survival metrics from the date of operation. In analyses of postoperative outcomes, neurological recovery and time to ambulation are used alongside time to radiotherapy, local recurrence, and overall survival to gauge success and plan further management. The need for ongoing surveillance remains essential, with imaging and clinical assessments guiding decisions about additional systemic therapy, radiation planning, and potential re-interventions.

The overall management paradigm emphasizes balancing oncologic control, maintenance of neurological function, and patient-centered goals, particularly in a palliative context where quality of life is a primary consideration.

Within broader decision-making frameworks, the choice of surgical approach—anterior, posterior, or combined—often favors minimally invasive techniques when appropriate, with the aim of reducing intraoperative morbidity and facilitating rapid postoperative recovery to support adjuvant treatments. Across the literature, rapid surgical intervention when indicated, supported by adjuvant therapies, is positioned as a key factor in preserving function and potentially extending survival in selected patients. The overall approach remains tailored to the individual patient's anatomy, tumor biology, and clinical status, with multidisciplinary planning guiding the sequencing and integration of surgery, radiotherapy, and systemic therapy.

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