



# Thirty-day complication and readmission rates associated with resection of metastatic spinal tumors: a single institutional experience

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**Background:** This study aims to assess 30-day complication and unplanned readmission rates associated with resection of metastatic spinal tumors.

**Methods:** Medical records were reviewed for 135 adults who underwent elective resection of a spinal cord tumor. Patient demographics, comorbidities, and tumor characteristics were collected. Tumor pathology was analyzed and diagnosed by a pathologist. The primary outcomes were intra- and 30-day post-operative complication and readmission rates.

**Results:** Of the 135 spinal tumor resections, 30 (22.2%) cases were metastatic. The most common tumor pathology was bone (13.3%) and the most common locations were thoracic (45.2%), and cervical (32.7%). Most patients had an open surgery (96.7%), with a mean laminectomy/laminoplasty level of  $1.9 \pm 1.5$  and mean operative time of  $328.4 \pm 658.0$  min. There was a 3.3% incidence rate of intraoperative durotomies, with no spinal cord or nerve root injuries. Post-operatively, 44.8% of patients were transferred to the intensive care unit (ICU). The most common post-operative complications were weakness (20.0%), new sensory deficits (16.7%), and hypotension (13.3%). The mean length of stay was  $8.8 \pm 7.6$  days, with the majority of patients discharged home (96.7%). The 30-day readmission rate was 9.7%, with the most common 30-day complications being uncontrolled pain (16.7%), sensory-motor deficits (13.3%), and fever (10.0%).

**Conclusions:** Our study suggests that weakness, sensory deficits, and uncontrolled pain are the most common complications after resection of spinal metastases, with a relatively high associated 30-day readmission rate. Further studies are necessary to corroborate our findings and identify strategies to reduce complication and readmission rates after resection of spinal metastases.

**Keywords:** Spine; spine tumor; metastasis; postoperative complications; readmission

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## Introduction

Surgical resection of spinal metastases is challenging and represents a difficult treatment paradigm due to associated complication rates, patient morbidities, and poor outcomes (1,2). Spinal metastasis has been estimated to occur in 5–30% of primary cancers, with the most common primary sites coming from breast, prostate, and kidney (3). Metastatic spinal tumors often compress the spinal cord producing pain, loss of mobility, incontinence, and overall decreased quality of life (4). With modern advances in oncologic therapeutic approaches, life expectancy for spinal metastases patients have been extended and spinal metastases are now seen with increasing prevalence (5).

Although a curative state is not achieved, surgical decompression has been shown to significantly alleviate disabling symptoms and improve quality of life compared to other monotherapies, such as radiation therapy alone (6,7). However, due to the reduced state of health of these patients, there is an increased risk for peri-operative complications and morbidity associated with surgical resection (8-13). With a growing national emphasis on reducing overall complication and readmission rates, risk stratifying patients and addressing avoidable complications after resection of spinal metastases is necessary to optimize quality of care and reduce the disparaging healthcare costs (14-17). While previous studies have explored in-hospital complication rates and surgical outcomes for patients undergoing metastatic spinal tumor resections (8-13), there is a paucity of data investigating 30-day complication and readmission rates.

The aim of this study is to investigate the 30-day complication and unplanned readmission rates associated with surgical resection of metastatic spinal tumors.

## Methods

In this retrospective study, we reviewed the medical records of 135 adult ( $\geq 18$  years old) patients who underwent elective spine surgery for resection of spinal cord tumor at a major academic institution from 2005 to 2015. Institutional Review Board approval was obtained before initiation of the study. Tumor pathology was analyzed and diagnosed by a board-certified pathologist. Of the 135 reviewed cases, 30 (22.2%) were identified as metastatic by pathology and clinical presentation. The primary outcomes of this study were intra- and 30-day complication and unplanned

readmission rates of the metastatic tumor resection cohort.

Demographic variables evaluated were patient gender, race, age, and body mass index (BMI). Comorbidities included depression, anxiety, coronary artery disease (CAD), atrial fibrillation (A-Fib), hypertension (HTN), peripheral vascular disease (PVD), diabetes, deep vein thrombosis (DVT), pulmonary embolism (PE), hyperlipidemia (HLD), chronic kidney disease (CKD), and current smoking status. Tumor characteristics evaluated were pathology-determined primary tumor location and anatomic level of metastasis to the spine. Intraoperative variables recorded were operative approach (open *vs.* minimally invasive), number of vertebral levels involved in laminectomy/laminoplasty, operative time, estimated blood loss (EBL), drain placement, and use of somatosensory evoked potentials (SSEP), transcranial motor evoked potentials (TcMEP), and electromyography (EMG). Intra-operative complications assessed were spinal cord injury, nerve root injury, and durotomy.

Post-operative complications recorded were length of hospital stay, intensive care unit (ICU) transfer, length of ICU stay, urinary tract infection (UTI), delirium, fever, surgical site infection (SSI), ileus, hypotension, hematoma, PE, DVT, stroke, weakness, sensory deficit, and urinary retention. Discharge disposition and 30-day complication and readmission rates were also evaluated.

Parametric data were expressed as mean  $\pm$  standard deviation (SD) and compared using the Student's *t*-test. Nonparametric data were expressed as median (interquartile range) and were compared using the Mann-Whitney U test. Nominal data were compared with the  $\chi^2$  test. All tests were 2-sided and were statistically significant if the P value was  $< 0.05$ . Statistical analysis was performed using JMP Version 12 (SAS Institute Inc., Cary, North Carolina, USA).

## Results

Of the 135 spinal tumor resection cases reviewed, 30 (22.2%) were found to be metastatic and were included in this study. The mean age and BMI of the metastatic cohort was  $53.1 \pm 17.5$  years and  $27.6 \pm 6.0$  kg/m<sup>2</sup>, respectively (Table 1). The majority of the metastatic cohort was male (63.3%) and White (71.4%) (Table 1). The prevalence of comorbidities included depression (16.7%), anxiety (20.0%), CAD (16.7%), A-Fib (3.3%), HTN (33.3%), PVD (3.3%), diabetes (6.7%), DVT (6.7%), HLD (30.0%), CKD (6.7%), and current smoking status (13.3%) (Table 1). The most prevalent primary tumor pathologies associated with spinal metastases included bone (13.3%), Gastrointestinal/

**Table 1** Demographic, comorbidities, and tumor characteristics and spine location

Variables	Cohort (n=30)
Male (%)	63.3
White (%)	71.4
Age (Years)	53.1±17.5
BMI (kg/m <sup>2</sup> )	27.6±6.0
Depression (%)	16.7
Anxiety (%)	20.0
CAD (%)	16.7
A-Fib (%)	3.3
HTN (%)	33.3
PVD (%)	3.3
Diabetes (%)	6.7
DVT (%)	6.7
PE (%)	0.0
HLD (%)	30.0
CKD (%)	6.7
Current smoker (%)	13.3
Tumor characteristics (%)	
Primary pathology—most common	
Bone	13.3
GI/GU tract	13.3
Skin	10.0
Lung	6.7
Liver	6.7
Kidney	6.7
Prostate	6.7
Location	
Cervical	32.7
Cervical—thoracic	14.4
Thoracic	45.2
Thoracic—lumbar	4.8
Lumbar	2.9

BMI, body mass index; CAD, coronary artery disease; A-Fib, atrial fibrillation; HTN, hypertension; PVD, peripheral vascular disease; DVT, deep vein thrombosis; PE, pulmonary embolism; HLD, hyperlipidemia; CKD, chronic kidney disease; GI/GU, Gastrointestinal/Genitourinary.

**Table 2** Intraoperative variables and complications

Variables	Cohort (n=30)
Minimally invasive approach (%)	3.2
Open approach (%)	96.7
Laminectomy/laminoplasty levels	1.9±1.5
SSEP (%)	36.7
TcMEP (%)	40.0
EMG (%)	30.0
Operative time (min)	328.4±658.0
EBL (mL)	947.5±876.2
Spinal cord injury (%)	0.0
Nerve root injury (%)	0.0
Durotomy (%)	3.3
Drain placement (%)	70.0

SSEP, somatosensory evoked potential; TcMEP, transcranial motor evoked potential; EMG, electromyography; EBL, estimated blood loss

Genitourinary (GI/GU) tract (13.3%), skin (10.0%), lung (6.7%), liver (6.7%), kidney (6.7%), and prostate (6.7%) (*Table 1*). The most prevalent spinal tumor location was thoracic alone (45.2%), followed by cervical alone (32.7%) and cervical-thoracic (14.4%), *Table 1*.

The vast majority of metastatic tumor resections were performed by open surgical approach (96.7%) (*Table 2*). The mean number of laminectomy/laminoplasty levels was 1.9±1.5 vertebral levels (*Table 2*). The prevalence of intraoperative monitoring utilized in during the resections included 36.7% SSEP, 40.0% TcMEP, and 30.0% EMG (*Table 2*). The mean operative time and EBL was 328.4±658.0 minutes and 947.5±876.2 mL, respectively (*Table 2*). The incidence of durotomy was 3.3%, with no intra-operative nerve root or spinal cord injury occurring. A surgical drain was placed in 70.0% of cases (*Table 2*).

The mean length of hospital stay was 8.8±7.6 days (*Table 3*). ICU transfer occurred in 44.8% of cases, with a mean length of ICU stay being 1.7±3.0 (*Table 3*). Inpatient post-operative complications included UTI (6.7%), delirium (6.7%), fever (6.7%), ileus (3.3%), hypotension (13.3%), hematoma (3.3%), stroke (3.3%), weakness (20.0%), sensory deficit (16.7%), and urinary retention (10.0%) (*Table 3*). There were no instances of post-operative SSI, PE, or DVT (*Table 3*).

The most common discharge disposition was home

**Table 3** Postoperative complications and 30-day readmission rate

Variables	Cohort (n=30)
Post-operative hospital course	
LOS (days)	8.8±7.6
ICU transfer (%)	44.8
Length of ICU stay (days)	1.7±3.0
UTI (%)	6.7
Delirium (%)	6.7
Fever (%)	6.7
SSI (%)	0.0
Ileus (%)	3.3
Hypotension (%)	13.3
Hematoma (%)	3.3
PE (%)	0.0
DVT (%)	0.0
Stroke (%)	3.3
Weakness (%)	20.0
Sensory deficit (%)	16.7
Urinary retention (%)	10.0
Discharge disposition	
Home (%)	96.7
Skilled nursing facility (%)	3.3
30-day readmission and complications	
30-day readmission (%)	9.7
Uncontrolled pain (%)	16.7
Sensory-motor deficit (%)	13.3
Fever (%)	10.0
Hardware failure (%)	3.3
Wound dehiscence (%)	3.3
Altered mental status (%)	3.3
Pneumonia (%)	3.3

LOS, length of hospital stay; ICU, intensive care unit; UTI, urinary tract infection; PE, pulmonary embolism; DVT, deep vein thrombosis.

(96.7%), followed by skilled nursing facility (3.3%). The readmission rate within 30 days of discharge was 9.7% (Table 3). The most common 30-day complications were uncontrolled pain (16.7%) and sensory-motor deficit

(13.3%), followed by fever (10.0%), hardware failure (3.3%), wound dehiscence (3.3%), altered mental status (3.3%), and pneumonia (3.3%) (Table 3).

## Discussion

In this retrospective study of metastatic spinal tumor resections, we observed a relatively high 30-day hospital readmission rate, with the most prevalent 30-day complications being weakness, sensory deficits, and uncontrolled pain.

There have been a few prior studies that have attempted to identify complication and readmission rates associated with metastatic spinal tumor resections. In a retrospective study of 164 patients who underwent resection of metastatic spinal tumors, Schairer *et al.* demonstrated an unplanned 30-day hospital readmission rate of 16.8%, with 7.7% of 1-year readmissions due to pain and 3.3% for palliative care (13). Similarly, in a retrospective study of 118 patients who underwent resection of extradural spinal metastases, Lau *et al.* reported a 90-day readmission rate of 11.9%, with a diagnosis of lung metastasis as an independent predictor of readmission (18). In a prospective study of 282 patients undergoing surgery for spinal metastases, Jansson *et al.* observed an overall complication rate of 20%, with 5% of patients experiencing worsened motor deficits post-operatively (19). In another retrospective study of 26,233 patients with surgically managed spinal metastases, Patil *et al.* showed an inpatient complication rate of 21.9%, with pulmonary and postoperative hemorrhages or hematomas as the most common complications reported (8). Analogous to the aforementioned studies, our study suggests that patients undergoing spinal metastasis resection are at high risk of overall post-operative complications in addition to unplanned readmissions.

High complication rates associated with metastatic spinal tumor resections have been attributable to both the technical difficulty of the procedure and baseline health status of the patient population. Specifically, en bloc resections have been found to increase the complexity and prevalence of intraoperative complications when resecting spinal cord tumors (20,21). In a retrospective study of 1,035 patients undergoing en bloc resection for spinal tumors, Boriani *et al.* observed an overall 34.3% intra-operative complication rate, with 2.2% of patients who subsequently died due to associated complications (22). Challenges include distortion of normal anatomy by tumor, tumor involvement of vital structures, compromise of integrity

of surrounding bone used in reconstruction, and frequent requirement for simultaneous anterior and posterior surgical approach (20). Therefore, there have been efforts to modify en-bloc surgical techniques to optimize surgical resection and minimize associated complications. For instance, in a retrospective study of 33 patients who underwent a modified, 2-stage total en bloc spondylectomy for spinal tumors, Shah *et al.* demonstrated that the modified technique in selected patients increased visualization of anterior vessels and reduced spinal cord injuries (23). Along with the complexity of the surgical resections, metastatic cancer patients have compromised nutritional status and overall health, and are inherently at an increased surgical risk (10,11). However, despite the high associated morbidity with resection, surgical intervention for spinal metastasis remains the most effective palliative treatment option (6,7,9,24). Therefore, further efforts in optimizing patient selection and surgical approach are necessary maximize the patient benefit and minimize injuries associated with these procedures.

Increasing attention towards decreasing complication and readmission rates are important considerations to ensure optimal patient care, but also to lower healthcare costs. Surgical complications have been estimated to increase cost of hospitalization anywhere from \$9,607 for minor complications (25,26) to \$159,245 for the most severe complications (27). Moreover, unplanned readmissions are estimated to cost the US health care system over \$20 billion annually (28). Patil *et al.* demonstrated that a single in-house, post-operative complication increases the mean length of hospital stay by 7 days and hospital charges by over \$20,000 in patients undergoing metastatic spinal tumor resection (8). Similarly, in a retrospective study of 15,545 intramedullary spinal cord tumor resections, Sharma *et al.* also found that a single complication increased total hospital charges by more than \$20,000 (29). Lau *et al.* reports that patients undergoing epidural metastasis resection who experience a complication accrue approximately twice the hospital cost (>\$40,000) compared to patients without complications (18). Furthermore, the authors found that the mean cost of hospital readmissions was approximately \$20,078 in this patient population (18). With exorbitant healthcare costs becoming an increasingly pressing public health issue, the need for targeted efforts to reduce expensive hospital complications and readmissions is readily apparent (30).

One of the most significant ways to decrease morbidity associated with metastatic spinal tumor resection is to

improve the ability to determine surgical candidacy in the pre-operative setting (31). Given the palliative nature of these procedures, the remaining survival and potential benefit to the quality of life of the patient must be carefully weighed against the risk of complication and prolonged or repeated hospitalization secondary to surgery (31). For this reason, there has been growing interest in the development of prognostic scoring systems to aid surgeons in making this challenging determination (14-17). Accordingly, a number of risk calculators for spinal metastasis resection have been developed including Bauer (32), Tokuhashi (33,34), Tomita (14), van der Linden (35), and Sioutos (31,36). These systems include pre-operative risk factors such as characteristics and type of primary tumor, neurologic deficit, extent and location of metastases, and other medical comorbidities to predict remaining survival (14,31-36). Multiple studies have been conducted to validate these predictive systems. In a retrospective study comparing surgery versus conservative treatment in 254 patients with spinal metastases, Wibmer *et al.* found that of the previously mentioned seven systems, all were capable of distinguishing between good and poor prognosis (31). The most significant limitation of these scoring systems is that they are designed to only predict remaining survival, but do not include other important information such as surgical complications and readmission rates. In order to reduce patient morbidity and health care expenses, we aim for our study to inform the creation of future risk calculators that reflect both post-operative complication and readmission rates.

This study has limitations with implications for its interpretation. Readmissions to unaffiliated hospitals were not identified, which may have resulted in an underestimate of 30-day readmission and complication rates. Our small sample size limits our ability to make any firm conclusions. Finally, although pre- and perioperative variables were prospectively recorded into the study registry at the time of surgery, these variables were retrospectively analyzed for the purposes of this study and are subject to the drawbacks associated with all retrospective reviews. Despite these limitations, this study identifies 30-day readmission rate and common postoperative complications after surgical resection of metastatic spinal tumors.

## Conclusions

Our study suggests that weakness, sensory deficits, and uncontrolled pain are the most common complications occurring between the time of surgery and 30-day post

discharge, and are associated with a relatively high 30-day readmission rate. Further studies are necessary to corroborate our findings and identify strategies to reduce 30-day complication and readmission rates after surgical resection of metastatic spinal tumors.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Ethical Statement:* Institutional Review Board approval was obtained before initiation of the study (Pro00066331).

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