Malignant peripheral nerve sheath tumors of the spine: results of surgical management from a multicenter study

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OBJECTIVE Malignant peripheral nerve sheath tumors (MPNSTs) are rare soft-tissue sarcomas. Resection is the mainstay of treatment and the most important prognostic factor. However, complete resection of spinal MPNSTs with tumor-free margins is challenging due to the likelihood of residual tumor cells. The objective of this study was to describe whether the type of Enneking resection in the management of spinal MPNSTs had an effect on local recurrence and survival.

METHODS The AOSpine Knowledge Forum Tumor developed a multicenter database that includes demographic, diagnostic, therapeutic, local recurrence, and survival data on patients with primary spinal column tumors. Patients who had undergone surgery for a primary spinal MPNST were included and were analyzed in 2 groups: 1) those undergoing Enneking appropriate (EA) resections and 2) those undergoing Enneking inappropriate (EI) resections. EA surgery was performed if there was histopathological evidence of an intact tumor pseudocapsule and at least a marginal resection on a vital structure. EI surgery was performed if there was an intentional or inadvertent transgression of the margin.

RESULTS Between 1993 and 2012, 29 primary spine MPNSTs were identified in 12 (41%) females and 17 (59%) males with a mean age at diagnosis of 40 ± 17 years (range 5–74 years). The median patient follow-up was 1.3 years (range 42 days to 11.2 years). In total, 14 (48%) patients died and 14 (48%) patients suffered a local recurrence, 10 (71%) of whom died. Within 2 years after surgery, the median survival and local recurrence were not achieved. Data about Enneking appropriateness of surgery were available for 27 patients; 9 (33%) underwent an EA procedure and 18 (67%) underwent an EI procedure. Enneking appropriateness did not have a significant influence on local recurrence or survival. Twenty-two patients underwent adjuvant treatment with combined chemo- and radiotherapy (n = 7), chemotherapy alone (n = 3), or radiotherapy alone (n = 12). Adjuvant therapy had no significant influence on recurrence or survival.

CONCLUSIONS The rates of recurrence and survival were similar for spinal MPNSTs regardless of whether patients had an EA or EI resection or received adjuvant therapy. Other factors such as variability of pathologist interpretation, PET CT correlation, or neurofibromatosis Type 1 status may play a role in patient outcome. Nonetheless, MPNSTs should still be treated as sarcomas until further evidence is known. The authors recommend an individualized approach with careful multidisciplinary decision making, and the patient should be informed about the morbidity of en bloc surgery when considering MPNST resection.

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MALIGNANT peripheral nerve sheath tumors (MPNSTs) are rare soft-tissue sarcomas originating from Schwann cells or pluripotent cells of neural crest origin and account for 3%–10% of all soft-tissue sarcomas.[14,24] The WHO coined the term "malignant peripheral nerve sheath tumor" to replace previous heterogeneous and sometimes misleading terminology, such as "malignant schwannoma," "malignant neurilemmoma," "neurogenic sarcoma," and "neurofibrosarcoma."[14,24] The incidence of MPNST in the general population is 0.001%, and it is higher in patients with neurofibromatosis Type 1 (NF1) (3%–5%).[14] In addition to NF1, another important risk factor is prior radiation exposure. A review of the literature has shown that 4%–11% of MPNSTs are thought to arise from previously irradiated areas.[14] MPNSTs can appear either de novo or from sarcomatous degeneration within a preexisting plexiform neurofibroma.[14,24] They can originate from peripheral nerve branches or sheaths of peripheral nerve fibers, and the most common locations are the trunk, limbs, and head and neck.[24] Only 2%–3% of all MPNSTs arise from the spinal nerves, and the 5-year survival rate for this location is less than 20%, a poor prognosis because of local recurrence or systemic spread.[16] Resection of MPNSTs followed by radiation therapy is the standard treatment for extraspinal MPNSTs.[13] The surgical technique of en bloc resection achieving wide margins is an important prognostic factor in achieving local tumor control.[23] The role of chemotherapy and the development of biologics are still being defined.[3,14,19] En bloc resection of spinal MPNST with wide margins can be difficult because of residual tumor cells on such vital structures as the dura, other critical nerves, viscera, or large blood vessels, as well as skip lesions.

The AOSpine Knowledge Forum Tumor (AOSKFT) has developed a multicenter, multinational database to gather information pertaining to a range of primary spinal tumors. By combining data from multiple centers, a higher number of MPNSTs could be analyzed, despite the rarity of this tumor. Although other studies have reported larger numbers of MPNSTs, those numbers either include all peripheral nerves or are generated from administrative databases.[12,17,21] To our knowledge, we report the highest number of MPNSTs solely arising from the axial skeleton along with individual patient data. The objective of this study was to describe whether the type of Enneking resection in the management of spinal MPNSTs had an effect on local recurrence and survival.

Methods

Patient data were extracted from the AOSpine Multicenter Primary Spinal Tumor Database, which includes approximately 1500 patients treated between 1981 and 2012 at 13 spine centers across North America, Europe, and Australia. Contributing centers were included based on adequate primary tumor caseload (> 10 patients), expertise in histopathology, and a history of excellence in epidemiological and outcome measurements. Each center received institutional review and ethics committee approval prior to data entry. For this study, patients were included if they had been treated surgically for a primary diagnosis of MPNST arising from the spine between 1993 and 2012. Data were compiled via a secure web-based application (REDCap, Vanderbilt University) both prospectively and retrospectively from hospital clinical notes and local databases. The AOSKFT met regularly and addressed areas of concern within the data identified by appointed study coordinators, in addition to direct communication between coordinators and individual centers.

Collected data included demographics, diagnostic data, Enneking staging,[9,10] therapeutic data, local recurrence, tumor size, and survival data retrieved cross-sectionally. Recurrence was defined as local tumor reappearance after total resection or tumor growth after subtotal resection on a postoperative MRI.

Surgical treatment for these lesions was defined as either Enneking appropriate (EA) or Enneking inappropriate (EI) based on the premise that an EA resection for an MPNST is en bloc resection with wide or marginal margins and that EI resection for an MPNST is a piecemeal or an intralesional resection. The pathologists' assessment of surgical margins was used as the final arbiter as to whether the procedure had been performed in an EA or EI manner. Those patients who had undergone a previous surgical intervention for their MPNST with resections described as intralesional were also considered to have undergone EI resection in their definitive surgery. MPNST is a malignant lesion, and clinical outcome has been described as being dependent on resection. EA surgery for a high-grade MPNST would therefore be traditionally categorized in the extremity as an en bloc resection to achieve wide margins (i.e., removing the tumor as a single specimen with a cuff of normal tissue). Often, spinal MPNSTs involve several compartments, including nerve, soft tissue, and bone. An EA resection would include en bloc resection with wide margins of each compartment. If the margin had been transgressed either intentionally or inadvertently, the surgery would have been deemed an EI even if the surgical plan had been EA resection. To be deemed an EA resection, both surgical perception regarding intraoperative transgression and histopathological evidence were required.

Descriptive statistics were used to evaluate the patient and tumor data. Cohort differences were analyzed using the Student t-test for continuous variables and Fisher's exact test for categorical variables. The Kaplan-Meier survival curves and log-rank tests were used to analyze time to first local recurrence and survival data over a 2-year postoperative period. Statistical significance was determined as $p \leq 0.05$. All statistical analyses were performed using Stata (version 12.0, StataCorp).

Results

Twenty-nine primary spine MPNSTs were identified in 12 (41%) females and 17 (59%) males with a mean age at diagnosis of 40 ± 17 years (range 5–74 years). The mean tumor dimensions were 7.2 ± 4.8 cm (range 0.3–20 cm) × 5.5 ± 3.0 cm (range 1.2–13 cm) × 5.0 ± 3.0 cm (range 0.3–13 cm); 22 (76%) lesions were located within the mobile spine, and the remaining 7 (24%) were in the fixed spine. The median patient follow-up was 1.3 years (range 42 days

TABLE 1. Summary of patient demographic and clinical characteristics

Variable	Value
Mean age in yrs (n = 29)	
At diagnosis	40 ± 17
At surgery	41 ± 17
Sex (n = 29)	
Female	12 (41)
Male	17 (59)
Pain at diagnosis (n = 29)	
No	2 (7)
Yes	27 (93)
Pathological fracture at diagnosis (n = 28)	
No	26 (93)
Yes	2 (7)
Previous spine tumor operation (n = 29)	
No	19 (66)
Yes	10 (34)
Method of diagnosis (n = 29)	
Open biopsy	8 (28)
CT-trocar biopsy	13 (45)
Intraop biopsy	8 (28)
ASIA & Frankel grade (n = 23)*	
B	1 (4)
D	7 (30)
E	15 (65)
Preop embolization (n = 29)	
No	22 (76)
Yes	7 (24)
Adjuvant therapy (n = 29)	
No	7 (24)
Yes	22 (76)
Timing of chemotherapy (n = 29)	
Preop	5 (17)
Postop	1 (3)
Both	4 (14)
None	19 (66)
Timing of radiation therapy (n = 28)	
Preop	9 (32)
Postop	7 (25)
Both	2 (7)
None	10 (36)
Local recurrence over the study period (n = 29)	
No	15 (52)
Yes	14 (48)
2-year local recurrence (n = 29)	
No	18 (62)
Yes	11 (38)
Survival over study period (n = 29)	
Alive	15 (52)
Dead	14 (48)

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TABLE 1. Summary of patient demographic and clinical characteristics

Variable	Value
2-yr survival (n = 29)	
Alive	17 (59)
Dead	12 (41)

ASIA = American Spinal Injury Association.
Values are presented as the number of patients (%) unless indicated otherwise. Mean values are presented as the mean ± SD.
* When a discrepancy between American Spinal Injury Association and Frankel score occurred, the more severe score was chosen.

to 11.2 years). Ten (34%) patients had a previous spine tumor operation, and procedures in 8 of these patients (80%) were reported as intralesional resections, thus considered EI procedures. Patient demographic and clinical characteristics are summarized in Table 1.

Enneking Appropriateness

Data about Enneking appropriateness of surgery were available for 27 patients; 9 (33%) received an EA procedure, and 18 (67%) received an EI procedure. Clinical characteristics for each cohort of Enneking appropriateness are outlined in Table 2, and there were no significant differences between the cohorts.

Local Recurrence

In total, 14 (48%) patients suffered a local recurrence. Within 2 years after surgery, the median local recurrence was not achieved. Considering only those patients for whom we have data available for Enneking appropriateness, 5 (56%) of 9 EA patients and 8 (44%) of 18 EI patients suffered a local recurrence (Table 2). Kaplan-Meier analysis conducted over a 2-year period following resection demonstrated no difference between the EA and EI cohorts for time to first local recurrence (p = 0.385; Fig. 1).

Survival

Fourteen (48%) patients died during the study period. Within 2 years after surgery, the median survival for MPNST patients was not achieved. Considering only those patients for whom we have data available for Enneking appropriateness, 4 (44%) of 9 EA patients and 9 (50%) of 18 EI patients died (Table 2). Kaplan-Meier analysis conducted over a 2-year period following resection demonstrated no difference between the EA and EI cohorts for survival (p = 0.962; Fig. 2).

Adjuvant Therapy

Twenty-two patients underwent adjuvant treatment with combined chemo- and radiotherapy (n = 7), chemotherapy alone (n = 3), or radiotherapy alone (n = 12). Adjuvant therapy had no significant influence on recurrence or survival.

Discussion

To our knowledge, this study represents the largest se-

TABLE 2. Study characteristics according to Enneking appropriateness

Variable	EA (n = 9)	EI (n = 18)	p Value
Mean age in yrs			
At diagnosis	38.9 ± 16.3	40.1 ± 18.5	0.874*
At surgery	40.4 ± 17.1	41.3 ± 18.5	0.899*
Sex			0.683†
Female	3 (33)	9 (50)	
Male	6 (67)	9 (50)	
Method of diagnosis			0.227†
Open biopsy	1 (11)	7 (39)	
CT-trocar biopsy	6 (67)	6 (33)	
Intraop biopsy	2 (22)	5 (28)	
Spinal location			0.136†
Mobile	5 (56)	16 (89)	
Fixed	4 (44)	2 (11)	
No. of vertebral levels spanned by tumor			0.364†
1	3 (33)	6 (33)	
2 or 3	3 (33)	10 (56)	
≥4	3 (33)	2 (11)	
Tumor grade‡			0.333†
Low (I)	1 (11)	0 (0)	
High (II)	8 (89)	18 (100)	
Adjuvant therapy			0.367†
No	3 (33)	3 (17)	
Yes	6 (67)	15 (83)	
Local recurrence over study period			0.695†
No	4 (44)	10 (56)	
Yes	5 (56)	8 (44)	
2-yr local recurrence			0.683†
No	5 (56)	12 (67)	
Yes	4 (44)	6 (33)	
Survival over study period			1.000†
Alive	5 (56)	9 (50)	
Dead	4 (44)	9 (50)	
2-yr survival			1.000†
Alive	5 (56)	10 (56)	
Dead	4 (44)	8 (44)	

Values are presented as the number of patients (%) unless indicated otherwise. Mean values are presented as the mean ± SD.
* Student t-test.
† Fisher's exact test.
‡ WHO grades.

FIG. 1. Kaplan-Meier analysis of first time to local recurrence over a 2-year postoperative period comparing EA versus EI resections. The number at risk indicates the number of patients included in the analysis. Information regarding EA/EI and timing of local recurrence is known for 25 patients. Median local recurrence was reached at 1.2 years postoperatively for EA patients and was not reached for EI patients during this period.

Indeed, spinal MPNSTs have previously been described as having a significantly poorer outcome than their nonspinal equivalent.[4,14] Survival in patients undergoing EA and EI resections in our series (56% and 50%, respectively) has improved over that previously reported (20%).[16,19] More modern studies also report higher survival rates; however, factors that may have influenced the higher survival rates seen in our series compared with historical controls may be related to the tertiary care nature of the centers contributing data or to improved modern surgical management.

Stadler et al. evaluated an administrative database and reported on 64 patients with MPNST;[21] the 5-year survival rate was 65%. Although they reported higher numbers of patients, the granularity of that data set is limited because it arises from an administrative database. Vital factors such as pathological confirmation, tumor size, and type of surgery cannot be garnered from an administrative database. Moreover, descriptive coding of the diagnosis and the procedure performed are examples of details that are largely reliant on a coder, not the surgeon. The reliance on a coder may induce inaccuracies in reporting. For instance, in their study, Stadler and coauthors found that patients who underwent radiation therapy and surgery had a higher rate of mortality than patients who underwent surgery alone. Although it does not make clinical sense that radiation therapy would induce higher mortality, such a finding may be the result of a selection bias that could not be further elucidated because of absent data. In this series, more aggressive tumors with significant spread, piecemeal resection, or vital structure invasion may have been selectively biased to receive radiation therapy. Thus, although an administrative database can provide high numbers of patients to study, lack of granularity, reliance on coders, and inability to obtain detailed clinical information limit detailed interpretation.

In our study, we did not find a difference in recurrence rate or survival based on EI or EA resection. While considering MPNST as a sarcoma, one would expect that with an EA resection, there would be better progression-free

ries of MPNSTs arising solely from the spine and with individual data collected from centers (as opposed to an administrative database) to date. There are other larger series in which extremity or axial MPNSTs are discussed, but the anatomical constraints of spinal MPNSTs preclude generalization from papers that also include extremity MPNSTs; however, the paradigms developed for nonspinal MPNSTs can be extrapolated to spinal lesions.
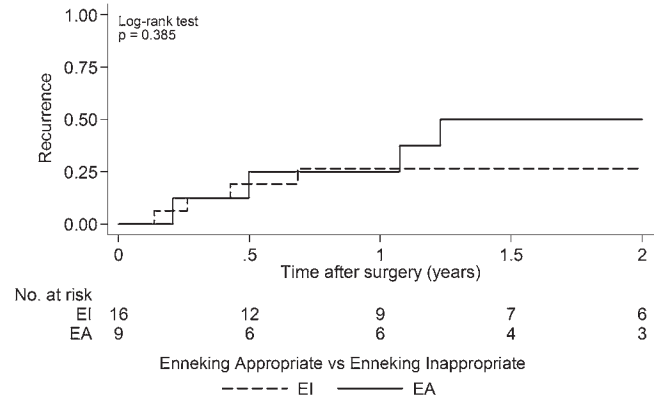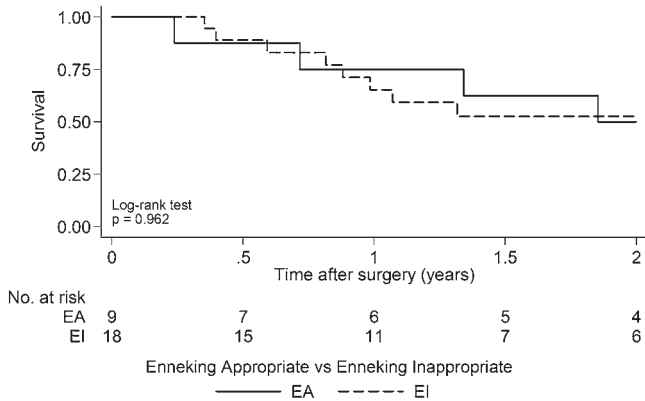
FIG. 2. Kaplan-Meier analysis of survival over a 2-year postoperative period comparing EA versus EI resections. The number at risk indicates the number of patients included in the analysis. Information regarding EA/EI is known for 27 patients. Median survival was reached at 1.9 years postoperatively for EA patients and was not reached during this period for EI patients.

survival but not necessarily a benefit in overall survival.[23] An EA resection for an MPNST is defined as an en bloc resection that achieves wide margins. The most probable explanation for equivalent local control in the EI and EA cohorts is that the biology and anatomy of the tumor precludes obtaining wide margins even when an en bloc resection is performed. Even with histologically negative margins, wide resections of MPNSTs are complicated by the spread along nerves outside of the gross tumor and the presence of multiple skip lesions. For this reason, the resection of an extremity or plexus MPNST by convention involves en bloc resection with a 2-cm margin of the nerve(s) adjacent to the gross tumor. Additionally, spinal MPNSTs often involve several compartments in addition to the nerve, such as epidural and intradural space, bone, and soft tissue. This multicompartment invasion significantly complicates the ability to achieve wide margins and in turn defines microscopic spread compared with nonspinal MPNSTs. While en bloc resection is technically feasible in some patients, the ability to truly achieve a wide margin is restricted by at-risk structures, such as the spinal cord, dura, major blood vessels, and the esophagus. Additionally, the expected survival benefit in the EA group may be adversely impacted by the increased morbidity associated with these procedures compared with EI, specifically intralesional piecemeal resections.

Given the constraints of achieving en bloc resection to achieve wide margins, adjuvant radiation therapy is critically important to consider in these patients.[13] In our series, more patients received radiation therapy in the EA group than the EI group (83% vs 67%, respectively). This may in part explain the failure to show benefit in the EA compared with the EI group. In studies examining the outcomes of nonspinal MPNSTs, radiation has demonstrated a significantly improved progression-free survival but not overall survival.[23] The doses required to treat sarcomas in conventional fractions (1.8–2 Gy) are greater than 60–70 Gy. High-dose delivery to spinal MPNSTs requires either proton beam therapy or specialized photon delivery systems, such as image-guided intensity-modulated radia-

tion therapy or volumetric arc therapy.[6,22] More recently, spine stereotactic radiosurgery has been used to treat spinal sarcomas. Two studies have examined the use of stereotactic radiosurgery as definitive therapy for primary and metastatic tumors. Folkert et al. reviewed 88 patients with 120 metastatic sarcoma lesions.[11] The 12-month local control was superior in those receiving high-dose single-fraction (median dose 24 Gy) compared with high-dose hypofractionated radiation (median 28.5 Gy in 3–6 fractions) (90.8% vs 84.1%, respectively [p = 0.007]).[11] Chang et al. reported the outcomes of 27 patients treated for 32 spine sarcomas with doses ranging from 16 to 45 Gy in 1–3 fractions with a median single fraction dose of 21.8 Gy.[6] Local control rates were reported to be 96.7% at 6 months, 78.3% at 1 year, and 76.9% at 2 years.[6] Both radiation dose and volume were associated with radiographic control at 2 years.[6] High-dose conventional fractionated radiation therapy and stereotactic radiosurgery are effective for treating spinal sarcomas, including MPNSTs. The optimal strategy of integrating radiation therapy is currently unknown. The question remains whether radiation therapy should be offered as a pre- or postoperative adjuvant. Additionally, a major concern is the ability to define the microscopic spread of tumor and skip lesions that are the hallmarks of MPSNTs.

Another factor that may help explain the failure of EA to achieve improved outcomes over EI resections is the inconsistency of the reporting of histological grades and the pathologists' interpretations among institutions. A cellular schwannoma has some pathological features of MPNST in terms of having increased mitotic figures, but it may clinically behave very distinctly.[1,2,20] If the pathologist's evaluation noted one area of the specimen that appeared to be an MPNST but the specimen was actually a cellular schwannoma, a higher survival rate despite a local recurrence could be explained. Moreover, pathologists do not always agree on the diagnosis; what may seem a cellular schwannoma to one pathologist may be classified as an MPNST by another since one factor that is used is the number of mitotic figures per high-power field. The criteria to distinguish between cellular schwannoma and MPNST are based on a spectrum of mitotic figures per high-power field, and this is not universally agreed on by all pathologists.[1,2] Thus, if one pathologist grades a cellular schwannoma as an MPNST and another pathologist grades it as a cellular schwannoma, an EA resection of a cellular schwannoma may not necessarily improve survival compared with an EI resection. If such patients were included in our study, this may be a reason the survival data did not show a difference.

One of the difficulties with interpreting outcomes with MPNST is the point at which the lesion shifts from benign to malignant. Eventually, this shift may be determined by genetic markers, but currently and within our series, it relies on an individual pathologist's determination of mitotic figures per high-power field. The diagnoses of a cellular schwannoma and low-grade MPNST therefore may overlap, yet the outcomes resulting from EA and EI surgery are expected to differ between cellular schwannoma and MPNST. Core biopsies will also be open to interpretation, and sampling error as cellularity might vary through the
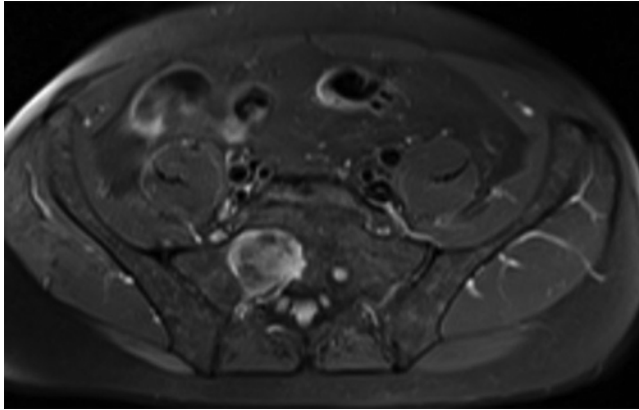
FIG. 3. Axial MR image of the sacrum with contrast demonstrating an example of an S-1 MPNST.
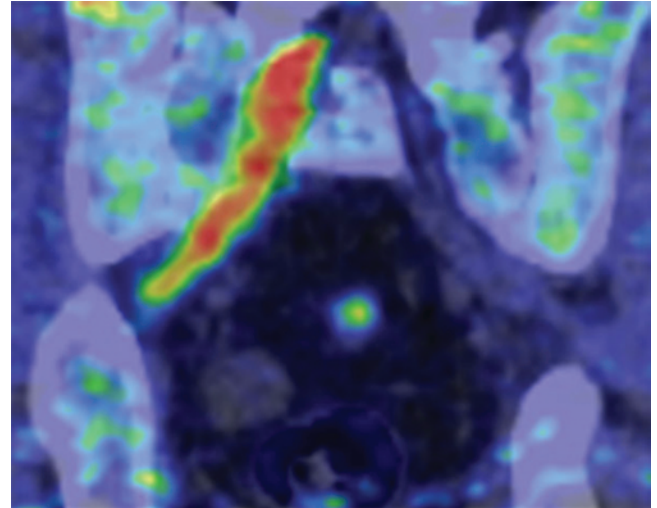

FIG. 4. PET CT image of the MPNST demonstrating the extent of the increased uptake along the course of the S-1 nerve root. Figure is available in color online only.

specimen. Planning potentially highly ablative surgery associated with morbidity based on such a result poses a significant clinical conundrum. In addition, given the nature of the nervous structure involved, one cannot rely on a pathologist to truly comment on margins. Microfilament branches from the primarily affected nerve may well carry tumor to distant sites. Such pathways for tumor spread would be impossible to detect preoperatively with current imaging techniques, intraoperatively by the surgeon, or by the pathologists because skip lesions may occur.

Another confounding variable in this study is NF1. This may be a confounding variable in 2 ways. Because many MPNSTs in NF1 patients may be in plexiform neurofibroma bundles, growth after resection might represent continued growth secondary to NF1, not necessarily growth secondary to MPNST. This would account for a longer survival despite what would be called a local "recurrence." By the same token, MPNSTs in patients with NF1 have a much worse prognosis than those who do not have NF1, thus potentially decreasing survival in this subset of the population.[8] Thus, despite an EA resection in patients with NF1 who have an MPNST, the aggressive nature of MPNST in patients with NF1 may induce the MPNST to spread much more quickly and extensively beyond the confines of what is seen on MRI. Moreover, MPNST in NF1 patients may be much more difficult to clearly resect because of the multiple tumors present in the field. Thus, there may have been a variable associated with NF1 status that affected survival, and this could have lowered the survival rate in patients with NF1 despite EA resection. Unfortunately, because of the ambispective nature of data collection and the limited data fields collected, it is unclear how much or how little of our findings were associated with NF1. Nonetheless, the presence or absence of NF1 may have played a confounding role in our observation, but we unfortunately were unable to track this variable.[8]

Another factor that might have affected our outcomes is imaging. The preoperative MRI study may not have accurately represented the extent of atypical activity seen on PET CT (Figs. 3 and 4). It has been shown that PET CT is useful for staging and restaging patients with MPNSTs and that PET CT is more sensitive than whole-body MRI when evaluating NF1 patients for MPNST.[7,15,18] A PET CT

study may be useful for directing a biopsy toward the more concerning areas of a tumor, and such an area may not have been identified on MRI. Moreover, an increased standardized uptake value on PET CT leads one to be suspicious for MPNST, but one must balance the increased PET CT uptake and the morbidity of en bloc surgery. Additionally, it should be recognized that benign neurofibromas and schwannomas can have markedly elevated standardized uptake values, especially when they are symptomatic.[5] The balance still lies in determining what degree of morbidity is acceptable while trying to achieve a possibly imperfect oncological result, even with the best planned and well-executed surgery. Unfortunately, in our series, PET CT data were not uniformly available, and we could not make any correlation with PET CT findings, survival, local recurrence, and extent of tumor involvement. For future studies, correlation with MRI, PET CT findings, and extent of tumor involvement will be important factors to address.

There are many limitations to this study. First, the rarity of MPNSTs has resulted in relatively small patient numbers, even with a multicenter, multinational collection data set. Because of these small numbers, the study is underpowered to account for confounding variables and to identify statistically significant changes. Another limitation is the ambispective nature of this study. This limits our ability to have collected more accurate data points about the factors listed earlier, such as NF1 and PET CT status. There was also variability in follow-up. Although many patients died during follow-up, each center may have had different points of follow-up. The length of follow-up was also relatively short in some cases; not all patients reached a follow-up of at least 1 year postoperatively.

Despite not reaching statistical significance for local recurrence or survival with regard to EA versus EI resection, MPNSTs are still currently considered sarcomatous tumors on the spectrum of aggressiveness and, where appropriate, should still be treated as such. The influence of other variables could have played a very pivotal role in

affecting local recurrence and survival yet could not be further explored in this study. Where technically feasible, en bloc surgery should be considered; however, due to the poor outcomes from both EA and EI surgery, we would not recommend surgery associated with high morbidity in cases in which doubt remains over the pathology or when wide resection is not feasible based on anatomical constraints. High-dose radiation therapy is strongly recommended, regardless of the nature of the resection. In such cases, further studies such as PET CT or genetic testing for NF1 may be considered to provide further confirmation that MPNST is indeed the correct diagnosis.

Conclusions

In our series, we found that the rates of recurrence and survival were similar for patients regardless of whether they had undergone an EA or EI resection for spinal MPNST. In addition, other factors, such as variability of pathologist interpretation, PET CT correlation, or NF1 status, may have affected survival. Nonetheless, MPNSTs should still be treated as sarcomas until further, more definitive studies can delineate the behavior characteristics of specific MPNSTs. Future studies should consider including such data points as mitotic figures per high-power field, PET CT and MRI correlation, and NF1 status. We would recommend an individualized approach with careful multidisciplinary decision making, and the patient should be informed about the morbidity of en bloc surgery when considering MPNST resection.

Acknowledgments

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Disclosures

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