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Histopathological and Clinical Examination of Spinal Tumors: A Single-Center Experience and Literature Review

Spinal Tümörlerinin Histopatolojik ve Klinik İncelemesi: Tek Merkez Deneyimi ve Literatür Taraması

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ABSTRACT

Spinal tumors are distributed across various anatomical compartments and include diverse histopathological subtypes. However, most studies in the current literature focus on a limited range of tumor types or specific subgroups. This study aims to provide a comprehensive analysis of spinal tumors, offering a broader perspective on their clinical and pathological characteristics. We retrospectively reviewed clinical data from patients who underwent surgery for spinal tumors arising from the spinal cord or spinal column between 2010 and 2023. Clinical characteristics such as age, gender, presenting symptoms, histopathological features, tumor location, and anatomical compartment were evaluated. Approximately half of the spinal tumors in our series were located in the extradural compartment. Among these, metastatic tumors accounted for 68% of cases, representing 31% of all spinal tumors. Intradural pathological subtypes, in decreasing order of frequency, were: schwannoma, meningioma, ependymoma, and astrocytic tumors; primary spinal column tumors included chordoma, hemangioma, and chondrosarcoma. Local pain was the most common initial symptom, particularly in ependymomas (47.8%). Motor deficits were most frequently associated with glial tumors (17%). This study demonstrates the broad pathological spectrum of surgically treated spinal tumors. Despite an accelerating diagnostic trend, the findings indicate only a modest increase in the need for surgical intervention in spinal metastases.

Keywords: Chordoma, extradural tumors, initial symptoms of spinal tumors, intradural tumors, primary spinal tumors, spinal metastases

ÖZ

Spinal tümörleri farklı anatomik kompartmanlarda gözlenir ve birçok histopatolojik alt tip içermektedir. Ancak mevcut literatürdeki çoğu çalışma, sınırlı sayıda tümör tipine veya belirli alt gruplara odaklanmaktadır. Bu çalışma, spinal tümörlerinin kapsamlı bir analizini sunmayı ve klinik ve patolojik özelliklerine daha geniş bir bakış açısı sunmayı amaçlamaktadır. 2010 ile 2023 yılları arasında omurilik veya vertebral kolondan köken alan spinal tümörler nedeniyle opere edilen hastaların klinik verileri retrospektif olarak incelenmiştir. Yaş, cinsiyet, ilk semptomları, histopatolojik özellikler, tümörün lokalizasyonu ve anatomik kompartmanları gibi karakteristik özellikler değerlendirilmiştir. Serimizdeki spinal tümörlerinin yaklaşık yarısı ekstradural kompartmanda yer almaktadır. Bunların arasında metastatik tümörler vakaların %68'ini oluşturmaktadır ve tüm spinal tümörlerinin %31'ini temsil etmektedir. İntradural kompartmandaki patolojik alt tipler, sıklık sırası azalan şekilde: schwannoma, menenjioma, ependiyoma ve astrositik tümörler; primer vertebral kolon tümörleri arasında kordoma, hemanjiyom ve kondrosarkom yer almaktadır. Lokal ağrı, özellikle metastazlarda (%75,2) en sık görülen başlangıç semptomuydu. Motor defisit ise en sık glial tümörlerle (%63,0) gözlemlenmiştir. Bu çalışma, cerrahi olarak tedavi edilen spinal tümörlerin geniş bir patolojik spektrumda olduğunu göstermektedir. Artan tanı oranlarına rağmen, bu bulgular spinal metastazlarda cerrahi müdahalede gerekliliğinde ılımlı bir artış olduğunu göstermektedir.

Anahtar Sözcükler: Kordoma, ekstradural tümörler, intradural tümörler, primer spinal tümörler, spinal metastazlar

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INTRODUCTION

The term "spinal tumors" refers to neoplasms arising from the spinal cord, the vertebral column, or the surrounding structures. They are commonly classified according to their anatomical compartment as intramedullary–intradural, extramedullary–intradural, and extradural. The most frequently affected compartment is the extradural space. Within this region, metastatic spinal tumors (MSTs) (e.g., multiple myeloma, prostate, breast, thyroid, and lung) are the most frequently observed, whereas primary spinal osseous tumors (e.g., chordoma, haemangioma, and osteoblastoma) are rare (1-3). Within the intradural space, the most common subtypes are meningiomas, schwannomas, and ependymomas (4,5).

Given that localized spinal pain is an almost universal human experience, the increasing use of imaging techniques, along with their expanding indications, has led to an increase in incidental detection of spinal column-related neoplasms, although less frequently than other incidental pathologies (6,7). Despite the increasing prevalence of spinal neoplasms and advances in diagnostic and therapeutic capabilities, accurate incidence data for spinal tumor subtypes remain scarce. The main reasons for this include the heterogeneity of data sources across existing studies, the inclusion of cases treated with specific therapeutic approaches, and the focus on particular histopathological subtypes. Because spinal tumors are diverse, the incidence and characteristics of specific subgroups are often reported. Consequently, the accurate incidence of pathologies involving all compartments relevant to spinal surgery has yet to be established.

The clinical presentation of spinal tumors ranges from local and radicular pain to neurological deficits of varying severity due to compression of the spinal neural elements (8,9). In terms of treatment, the primary surgical principle for benign tumors is to employ techniques that allow maximum exposure and resection while minimizing damage to spinal stability. With the increasing adoption of minimally invasive approaches in spinal surgery, hemilaminectomy—once avoided due to the risk of inadequate decompression and unintended spinal cord injury—has now become more widely accepted (10,11). A multidisciplinary approach is generally the most appropriate choice for MSTs. Surgical intervention for metastatic tumors aims to relieve spinal cord compression, reduce tumor burden as much as possible, separate the tumor from critical tissues, and allow time for adjunctive treatments. It is also crucial to protect patients with active oncological conditions from the risks and complications of major surgeries.

In this study, conducted at one of the largest neurosurgery centers in Türkiye, we retrospectively reviewed the records of 407 patients with spinal tumors who underwent surgery from 2010 onward. Based on this review, we present our clinical experience in light of current literature.

MATERIALS AND METHODS

The routinely collected prospective electronic medical records of all operations for the treatment of spinal column tumors were retrospectively evaluated. Gazi University Ethics Committee reviewed and approved the research protocol for this study (approval number: 2023-1351, date: 18.04.20239). Patients who underwent surgery between 2010 and 2023 were included in the cohort. Various surgeons from the spine team at our clinic performed all operations. Baseline medical data, such as age, gender, presenting symptoms, and pathology, were included.

The tumors were classified as cervical, cervicothoracic, thoracic, thoracolumbar, lumbar, and sacral based on their level. Tumors involving the C7-T1 and T12-L1 segments were classified as cervicothoracic and thoracolumbar junctions, respectively. The cohort was segmented into axial anatomical compartments using magnetic resonance imaging and classified as intramedullary, intradural-extramedullary (ID-EM), or extradural tumors according to axial location within the spinal column. We excluded cases in which biopsy or vertebral augmentation had been performed, cases with relapses, and patients under 18 years of age. Data from cases with at least two years of radiological follow-up were evaluated to assess spinal alignment.

Since this study did not involve a defined cohort, statistical tests were unnecessary. Instead, the findings were evaluated descriptively, focusing on clinical observations and histopathological characteristics.

RESULTS

A total of 491 patients who underwent surgery were considered for inclusion in the study, of whom 84 were excluded due to relapsed tumors or biopsy. Finally, 407 patients were enrolled: 198 females and 209 males, with a mean age of 50.2 ± 16.2 years.

The most common histological types were metastases (n = 129, 31.7%), schwannoma (n = 59, 14.5%), meningioma (n = 52, 12.8%), and ependymoma (n = 46, 11.3%). The gender distribution and median age varied by histological type (Table 1). Histological examination revealed the presence of various tumors in the other group, including five arachnoid cysts, four cavernomas, two angiosarcomas, five Ewing sarcomas, three hemangioblastomas, one lipoma, one medulloblastoma, one osteoblastoma, two osteofibromas, and one subependymoma. According to the axial location of the tumors within the spinal cord, 21.4% (n = 87) of the tumors were intramedullary, 27.3% (n = 111) were ID-EM 46.2% (n = 188) were extradural, involving the vertebral bone, while the remaining 5.1% (n = 21) exhibited a multicomponent pattern. Five metastases and three Ewing sarcomas were ID-EM, whereas two metastases were intramedullary.

The distribution of clinical symptoms was as follows: local pain (n = 241; 59.2%), motor deficit (n = 183; 45%), and sensory deficit (n = 143; 35.1%). Local pain was the most common clinical symptom across all histological subtypes. It was most frequently observed in metastases (n = 97; 75.2%), meningiomas (n = 32; 61.5%), schwannomas (n = 33; 55.9%), and ependymomas (n = 22; 47.8%). Glial tumors were most commonly associated with motor deficits at presentation (n = 17, 63.0%), while sensory deficits were most frequently observed in metastases. All clinical symptoms are summarized in Table 2. Regarding tumor location, 16.5% (n = 67) were in the cervical region, 3.7% (n = 15) in the cervicothoracic region, 39% (n = 159) in the thoracic region, 4.7% (n = 19) in the thoracolumbar region, 31% (n = 126) in the lumbar region, and 5.1% (n = 21) in the sacral region (Table 3).

Eight cases were operated on via an anterior approach, while the others were operated on via a posterolateral approach.

Table 1. Demographic information and gender distribution of histopathological subtypes.

	Female		Male		Total		The median age
	n	%	n	%	n	%	
Meningioma	40	20.2	12	5.7	52	12.8	58.9 ± 17
Schwannoma	31	15.7	28	13.4	59	14.5	42.2 ± 13
Ependymoma	21	10.6	25	12.0	46	11.3	42.2 ± 14
Astrocytic tumors	20	10.1	7	3.3	27	6.6	40.4 ± 15
Epidermoid tumors	2	1.0	5	2.4	7	1.7	41.1 ± 8
Dermoid tumors	2	1.0	5	2.4	7	1.7	33.7 ± 10
Other intradural tumors	7	3.5	8	3.8	15	3.7	-
Metastases	46	23.2	83	39.7	129	31.7	59.1 ± 13
Chordoma	6	3.0	11	5.3	17	4.2	58.2 ± 10
Hemangioma	8	4.0	2	1.0	10	2.5	51.5 ± 13
Chondrosarcoma	5	2.5	1	0.5	6	1.5	35.3 ± 14
Osteosarcoma			5	2.4	5	1.2	46.2 ± 24
Aneurysmal bone cyst	1	0.5	3	1.4	4	1.0	40.0 ± 11
Giant cell tumor	2	1.0	1	0.5	3	0.7	47.3 ± 23
Ewing sarcoma	3	1.5	2	1.0	5	1.2	34.2 ± 10
Other mesenchymal tumors	3	1.5	6	2.9	9	2.2	-
Unclassified	1	0.5	5	2.4	6	1.5	-
Total	198		209		407		

Table 2. Distribution of common symptoms by axial location.

	Local pain		Motor deficits		Sensory deficits	
	n	%	n	%	n	%
Intramedullary	50	57.5%	36	41.4%	28	32.2%
Ependymoma	22	47.8%	14	30.4%	15	32.6%
Astrocytic tumors	15	55.6%	17	63.0%	7	25.9%
Intradural-extramedullary	66	59.5%	57	51.4%	46	41.4%
Meningioma	32	61.5%	24	46.2%	24	46.2%
Schwannoma	33	55.9%	26	44.1%	19	32.2%
Extradural	125	63.5%	90	45.7%	69	35%
Metastases	97	75.2%	74	57.4%	50	38.8%
Chordoma	7	41.2%	5	29.4%	7	41.2%
Other primary bone tumors*	18	42.9%	9	21.4%	11	26.2%

*Hemangioma, chondrosarcoma, osteosarcoma, aneurysmal bone cyst, giant cell tumor, Ewing sarcoma, other mesenchymal tumors.

Hemilaminectomy was performed in 103 cases. Among the 143 bilateral laminectomy cases with at least two years of follow-up after surgery, 23% showed a radiological increase in the local kyphosis angle; however, none required reconstruction with instrumentation. A total of 16 patients (4%) underwent posterior instrumentation during the initial surgery. Among them, 9 had metastases, 6 had tumors of bone origin, and 1 had a schwannoma with extradural extension.

DISCUSSION

This study focused on the histological distribution, demographic characteristics, and epidemiological features of all spinal neoplasms treated surgically. The cases had a mean age of 50 ± 16 years, with an equal gender distribution. The mean age was higher in cases of metastasis, meningioma, and chordoma than in other pathologies, consistent with previous reports. Data analysis revealed that spinal tumors were most frequently located in the extradural compartment (46.2%), a proportion that although slightly lower than figures reported in the literature, is within a comparable range (12).

Table 3. Distribution of histopathological subtypes by spinal level.

	Cervical		Cervicothoracic		Thoracic		Thoracolumbar		Lumbar		Sacrum	
	n	%	n	%	n	%	n	%	n	%	n	%
Meningioma	6	11.5	2	3.8	39	75.0	2	3.8	3	5.8	-	-
Ependymoma	14	30.4	4	8.7	7	15.2	3	6.5	18	39.1	-	-
Schwannoma	13	22.0	2	3.4	15	25.4	2	3.4	26	44.1	1	1.7
Astrocytic tumors	7	25.9	2	7.4	10	37.0	3	11.1	3	11.1	2	7.4
Metastases	9	7.0	4	3.1	59	45.7	4	3.1	45	34.9	8	6.2
Hemangioma	0	-	-	-	8	80.0	-	0.0	2	20.0	-	-
Chordoma	5	29.4	-	-	2	11.8	1	5.9	1	5.9	8	47.1
Chondrosarcoma	0	-	-	-	1	16.7	-	0.0	5	83.3	-	-
Total	67	16.5	15	3.7	159	39	19	4.7	126	31	21	5.1

Metastases accounted for 68% of lesions in the extradural compartment and 31% of all spinal tumors, representing the most common subtype of spinal neoplasms, as reported in previous studies. Among primary bone tumors located in the extradural compartment, chordoma (9%) and haemangioma (5%) were the most frequently observed. Contrary to the commonly held view, primary spinal tumors constituted 10% of spinal tumors, a relatively high proportion (3,6).

Intradural tumors are among the rarest tumor types, comprising 4–8% of central nervous system tumors (13,14). Extramedullary lesions are the most common intradural lesions. The most frequently observed tumors within the ID-EM category are meningiomas, which account for 16–25% of cases (5,14,15). These tumors typically occur in women and are most often found in the thoracic vertebrae. In our series, meningiomas comprised 22% of ID-EM tumors, with a female-to-male ratio of 3.5:1. In only one case, the tumor extended from the dural defect into the epidural space rather than the intradural space. Extradural meningiomas can also mimic schwannomas (16,17). Despite the relatively advanced mean age at diagnosis (58.9 ± 17 years), they generally show a good prognosis, provided there is no invasion of the arachnoid or pia mater (18,19).

Although schwannomas are reported as the second most common tumor in ID-EM, epidemiological studies report that schwannomas are more common than meningiomas (15). They are mainly located intradurally, originating from the dorsal root, but 10–15% extend extradurally. They are observed at roughly equal frequency in both sexes, and the average age at diagnosis is 47 years. Our findings are consistent with those reported in the literature and with findings from our series. Schwannomas can occur as solitary or multiple lesions at any spinal level, but despite numerous series in the literature, there is no consensus regarding the most commonly affected spinal level. In their recent meta-analysis, Alvarez-Crespo et al. (20) reported that the cervical region is the most common segment. Contrary to what has been reported in the literature, we found that the lumbar region was the most common site in our series, accounting for 44.1% of cases. Schwannomas are known to be slow-growing tumors and generally present with radicular pain and myelopathic findings; however, in our series, local pain was the most frequently observed symptom (21,22).

Ependymomas are usually benign lesions, most commonly occurring in the cervical region. The incidence is slightly male-predominant, and in our series males accounted for 54%. The bimodal age distribution of ependymomas is a recognised feature; the mean age in our series is 42.0 ± 1.9 years. The relatively high mean age in our cohort may result from including only adult patients. The most common symptoms at diagnosis are local pain and sensory deficits. However, owing to the greater accessibility of radiological imaging, diagnoses are made earlier; therefore, sensory deficit complaints are more frequently observed (23). In our series, local pain was observed in 47.8% of patients, while a sensory deficit was present in 32.2%.

In our series, astrocytomas accounted for 42% of primary intramedullary tumors, with a mean patient age of 40.2 years. Contrary to the literature, a female predominance (64.3%) was observed in our study. Motor and sensory deficits are more frequently observed in spinal cord astrocytomas than in other intradural tumors (24,25). In our series, the most commonly observed symptom was motor deficit. This finding may be attributed to increased edema caused by early changes in the tumor microenvironment of astrocytomas (24,26). Compared with childhood, spinal astrocytomas in adults are associated with a worse prognosis (27). Tumor grade and histological type play a crucial role in determining prognosis. In particular, a well-defined surgical dissection plane in pilocytic lesions increases the likelihood of total resection (28,29). Although intraoperative neuromonitoring has been observed to encourage more extensive surgical resection in anaplastic astrocytomas, studies have shown that even gross total resection does not contribute to survival in glioblastomas (30,31).

Spinal column lesions, the majority of which are bone metastases, are increasingly encountered owing to improved survival among patients with primary malignancies (32,33). Extradural lesions account for approximately 60% of spinal oncological cases (12). In our series, 46.2% of spinal tumors were extradural, with the thoracic region the most commonly involved site. MSTs are the most frequently observed extradural lesions. Approximately 10–30% of cancer patients develop spinal metastases; however, it is estimated that only 10–20% of these cases become symptomatic (2,34,35). Consistent with the literature, three-quarters of the

cases in our series were located in this anatomical region; only four were intradural. MSTs typically spread hematogenously through the extensive venous plexus of the vertebrae. Anatomically, they tend to extend posteriorly to involve the pedicle. Despite their high prevalence, MSTs often present with minimal clinical symptoms. This highlights the importance of routine metastasis screening and early detection programs (36). During our screening, localized pain was detected in three-quarters of MST cases, whereas sensory or motor deficits were observed in half of cases. The inclusion of only surgically treated patients in our series may have influenced these findings.

Primary bone tumors of the spine (PSTs) are rare and mostly benign lesions (6). This group includes hemangiomas, osteoid osteomas, aneurysmal bone cysts, osteochondromas, neurofibromas, giant cell tumors of bone, and eosinophilic granulomas. Benign primary bone tumors account for approximately 41% of all bone tumors. However, conflicting reports exist regarding which primary bone tumor is most frequently observed. Dang et al. (6) reported giant cell tumors as the most common PST in their series, whereas Kelley et al. (37) identified multiple myeloma as the most frequently observed PST. This discrepancy arises from differences in the theoretical classification of myeloma, as many studies consider it a metastatic, rather than a primary, spinal tumor. In our series, the proportion of benign lesions was low, and the most frequently observed tumor was chordoma. This result appears lower than those reported in the literature, likely due to the high number of chordoma cases in our series. The role of the center where the study was conducted as a referral center for complex spinal tumors may have contributed to this finding. Benign lesions are often diagnosed incidentally, as their clinical presentation tends to be non-specific and subtle. In most cases, observation is the preferred treatment approach. However, in patients with persistent pain or neurological compression, surgical intervention may become necessary (38).

Primary malignant spinal tumors generally exhibit locally aggressive behavior (6). The most common subtypes include chordoma, chondrosarcoma, Ewing sarcoma, and osteosarcoma. Although these tumors can develop at any vertebral segment, they most frequently occur at the cranial and caudal ends of the spine. The sacrum and cervical spine were the most common locations in our series, with prevalence rates of 47% and 29%, respectively. The age at diagnosis of chordomas varies widely; consistent with the literature, the mean age in our series was 58.1 ± 9.37 years, with a male predominance. Surgery is the primary treatment modality; however, defining the tumor margins intraoperatively remains challenging. Currently, maximal surgical resection followed by adjuvant therapy is the most effective approach for local disease control.

Posterior approaches are used in nearly all surgical procedures for intradural tumors. The techniques most commonly used are hemilaminectomy and laminectomy. In spinal surgery, there is a growing trend toward minimally invasive techniques to preserve stability and minimize muscle damage. In line with this trend, the literature suggests an increasing preference for hemilaminectomy in tumor resection (10,39). Although unilateral hemilaminectomy offers theoretical advantages such as reduced blood loss, earlier discharge, and faster recovery, cohort studies have shown no significant superiority over laminectomy in these aspects (39). In our series, protective laminectomy preserving the facet joints was the predominant approach for intradural tumors (168/226). Despite an increased kyphotic angle observed radiologically during follow-up, no patients exhibited clinical symptoms requiring reconstruction. Among the cases that underwent bilateral laminectomy, 25 of involved the junctional region. Midline bilateral laminectomies, performed while preserving the facet joints, can be considered reliable methods for tumor resection because of their extensive exposure.

Study Limitions

Our study has limitations owing to its retrospective design. First, because our cohort included only surgically treated patients, those managed conservatively were not evaluated. Secondly, some spinal tumor subtypes had small sample sizes, which may have led to discrepancies in incidence rates compared with those reported in the literature. Additionally, this study may be criticized for relying on data from a single institution, which could introduce selection bias. Another limitation is the incomplete follow-up data for some cases. Nevertheless, data obtained from a national referral center will contribute to the epidemiological and descriptive literature.

Conclusion

This study has established a comprehensive database on spinal tumors by analyzing data from 407 patients with various tumor types. The primary aim is to reveal the true prevalence of spinal neoplasms requiring surgical intervention. Although metastases constitute the majority of diagnostically identified spinal tumors, their proportion in surgical series does not markedly differ from that of other spinal pathologies.

Ethics

Ethics Committee Approval: This study was conducted in accordance with institutional ethical standards and the Declaration of Helsinki. Gazi University Ethics Committee reviewed and approved the research protocol for this study (approval number: 2023-1351, date: 18.04.20239).

Informed Consent: Written informed consent for publication of this case report and any accompanying images was obtained from the patient's next of kin.

Footnotes

Authorship Contributions

Surgical and Medical Practices: T.T., M.E.Y., G.K., F.H.D., A.M.K., Ö.H.E., A.K., Concept: T.T., P.K., A.K., Design: T.T., P.K., A.M.K., Ö.H.E., A.K., Data Collection or Processing: Ö.Ö., Z.G., F.H.D., A.M.K., Analysis or Interpretation: Ö.Ö., G.K., Literature Search: T.T., Ö.Ö., Z.G., G.K., Writing: T.T., Ö.Ö., P.K., M.E.Y., A.K.

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