*Original Article*

AO SPINE

Global Spine Journal
2023, Vol. 13(2) 276–283

DOI: 10.1177/21925682221994799
journals.sagepub.com/home/gsj
SAGE

# Imaging Characteristics and Surgical Outcomes in Patients With Intraspinal Solitary Fibrous Tumor/Hemangiopericytoma: A Retrospective Cohort Study

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## Abstract

**Study Design:** Retrospective cohort study.

**Objectives:** Intraspinal solitary fibrous tumor (SFT)/hemangiopericytoma (HPC) is often misdiagnosed preoperatively as schwannoma or meningioma because its imaging characteristics are not well understood. As postoperative prognosis differs among the 3 lesions, predicting the probability of SFT/HPC preoperatively is essential. Thus, this study investigates the imaging characteristics of SFT/HPC compared with those of schwannoma or meningioma and evaluates surgical outcomes.

**Methods:** The preoperative imaging findings, tumor resection extent, recurrence and regrowth rates, and neurological improvement were compared between 10 patients with SFT/HPC and 42 patients with schwannoma or 40 patients with meningioma.

**Results:** Most patients with SFT/HPC showed isointensity on both T1- and T2-weighted images compared with patients with schwannoma ($P = 0.011$ and 0.029, respectively) and no significant difference compared with patients with meningioma ($P = 0.575$ and 0.845, respectively). Almost all patients with SFT/HPC showed highly uniformizing enhancement patterns, similar to those with meningioma ($P = 0.496$). Compared with meningioma, SFT/HPC lacked the dural tail sign and intratumoral calcification and exhibited irregular shape. Of the 5 patients who underwent partial resection, 60% exhibited tumor recurrence and regrowth following surgery.

**Conclusions:** Complete *en bloc* surgical resection should be attempted in patients with intraspinal SFT/HPC to prevent postoperative recurrence or regrowth. As this tumor is often preoperatively misdiagnosed, we recommend that the imaging findings exhibited in this study should be used to positively suspect SFT/HPC. This will enhance patient outcomes by enabling more appropriate preoperative surgical planning.

## Keywords

solitary fibrous tumor/hemangiopericytoma, schwannoma, meningioma, surgical outcomes, recurrence, regrowth

## Introduction

Solitary fibrous tumor (SFT)/hemangiopericytoma (HPC) is a rare tumor of the central nervous system. This tumor is commonly located in the brain, and its occurrence in the spine is extremely rare.[1] Studies have shown that patients with intraspinal SFT/HPC have a mean age at surgery of 33.8 years and are more likely to be males than females. Most cases are intradural

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extramedullary tumors, which are localized at the level of the cervical or thoracic spine.[2,3] However, few studies have compared SFT/HPC with other spinal cord tumors in terms of preoperative imaging features. Because the method and degree of resection have a direct impact on surgical outcomes for this tumor, appropriate preoperative diagnosis using imaging examinations should increase the likelihood of a favorable prognosis.

Distinguishing SFT/HPC from schwannoma, meningioma, and other spinal cord tumors has been challenging because characteristic imaging findings of these tumors have not been well described. Therefore, most patients are misdiagnosed with schwannoma or meningioma preoperatively. In incomplete tumor removal, such as partial resection (PR), residual SFT/HPC can spread to the spinal cord and other tissues, which causes tumor recurrence and regrowth.[4,5] Thus, to improve clinical outcomes, distinguishing intraspinal SFT/HPC from other types of tumors preoperatively is essential.

This study investigates the characteristics of intraspinal SFT/HPC using preoperative magnetic resonance imaging (MRI) and computed tomography (CT) and compares its specific features with those observed in intraspinal schwannomas or meningiomas, which are considered to be more frequent among spinal tumors. In addition, we evaluated the clinical outcomes after surgical resection of SFT/HPC.

## Methods

### Study Design and Patients

In total, 10 patients with intraspinal SFT/HPC were surgically treated at our department between 2006 and 2018. Demographic, surgical, and imaging data was retrospectively obtained by reviewing the patients' records. Intraspinal SFT/HPC, schwannoma, and meningioma were histologically categorized using the 2016 World Health Organization (WHO) classification from grade I to III. To form the comparison group, patients with intraspinal schwannoma (WHO grade I) or meningioma (WHO grade I; meningothelial, fibrous, transitional, psammomatous) were matched to those with SFT/HPC according to age, sex, site, lesion localization, and tumor size at a ratio of 1:4. Finally, 42 patients with schwannoma and 40 patients with meningioma were identified from a database of patients with spinal cord tumors who underwent surgical resection between 2006 and 2018. The minimum follow-up period was 24 months.

MRI was performed postoperatively to confirm the extent of tumor resection. We classified them into 2 types, namely, gross total resection (GTR) and PR, according to the operative records. The standard definition of GTR was used in this study (i.e., removal of 100% of the tumor based on the absence of residual tumor documented microscopically and no evidence of neoplasm in the tumor bed). The procedure was considered PR when a small tumor fragment was reluctantly left in place based on the documented removal of 50%-99% of the tumor on intraoperative ultrasonography or postoperative MRI findings.[6]

The diagnosis of SFT/HPC or other types of tumor was confirmed by pathological evidence collected after tumor resection. The tumors were categorized based on morphological data, including operative findings and preoperative radiological data.

This study was approved by the committee on ethics and institutional review board (approval number: 20 110 142), and all subjects provided informed consent for inclusion.

### Assessment of Neurological Function

We assessed the postoperative functional recovery and neurological status of patients with SFT/HPC, schwannoma, or meningioma using the Modified McCormick Scale (MMCS; grade I, normal gait; grade II, mild gait disturbance not requiring support; grade III, gait with support; grade IV, assistance required; and grade V, wheelchair needed).[7,8]

Each MMCS grade was collected by 2 or more orthopedic surgeons to decrease the interobserver variation.

### Statistical Analysis

Data is expressed as mean $\pm$ standard error of the mean, and categorical variables are presented as percentages. The Fisher's exact test was performed to evaluate differences in the extent of tumor resection, MRI and CT findings, rate of tumor recurrence and regrowth, and MMCS grades. $P < 0.05$ was used to denote statistical significance. Statistical analyses were conducted using SPSS, version 23.0 (IBM Corp., Armonk, NY, USA).

## Results

### Demographic Information and Preoperative Imaging Findings

The demographics and characteristics of the 10 patients with SFT/HPC are presented in Tables 1 and 2. This study included 6 (60.0%) males and 4 (40.0%) females with ages ranging from 25 to 68 years (mean age, 50.6 $\pm$ 13.3 years).

MRI revealed that SFT/HPC was detected at the cervical, thoracic, and lumbar sites in 4 (40.0%), 4 (40.0%), and 2 (20.0%) patients, respectively. Six (60.0%) of the 10 patients with SFT/HPC had intradural extramedullary tumors, whereas the remaining 4 patients had intramedullary and extramedullary (1/10 case, 10.0%), intramedullary (1/10 case, 10.0%), and cauda equina (2/10 cases, 20.0%) tumors. The mean diameter of the tumors on the sagittal view was 2.5 $\pm$ 2.2 (range, 1.0-8.3) cm. All 10 cases were pathologically diagnosed with spindle-cell tumor according to the intraoperative frozen section. Using the WHO classification, 6 (60.0%) cases were diagnosed with low-grade tumors (WHO grade I) and 4 (40.0%) were diagnosed with high-grade tumors (WHO grades II and III).

Comparison of imaging features of SFT/HPC, schwannoma, and meningioma are summarized in Table 3, and representative MRI findings are shown in Figure 1. Most patients with SFT/HPC significantly exhibited isointensity on both T1-weighted

**Table 1.** Demographics of 10 Patients With Intraspinal SFT/HPC.

| Item | Value |
|---|---|
| **Age, (y/o)** | 50.6 (25-68) |
| **Gender, no. (%)** | |
| Men | 6 cases (60.0) |
| Women | 4 cases (40.0) |
| **Site, no.** | |
| Cervical | 4 cases (40.0) |
| Thorax | 4 cases (40.0) |
| Lumber and sacral | 2 cases (20.0) |
| **Localization of the lesion, no.** | |
| Intradural extramedullary | 6 cases (60.0) |
| Intramedullary and extramedullary | 1 case (10.0) |
| Intramedullary | 1 case (10.0) |
| Cauda equina tumor | 2 cases (20.0) |
| **Tumor length, (cm)** | 2.5 (1.0-8.3) |
| **WHO classification** | |
| **I** | 6 cases (60.0) |
| **II** | 1 case (10.0) |
| **III** | 3 cases (30.0) |

Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; WHO, world health organization.

images (T1WI) and T2-weighted images (T2WI) preoperatively compared with those with schwannoma (SFT/HPC: T1, 9/10 cases [90.0%] and T2, 8/10 cases [80.0%] vs. schwannoma: T1, 19/42 cases [45.2%], $P = 0.011$, and T2, 23/42 cases [54.7%], $P = 0.029$). Furthermore, almost all patients with SFT/HPC significantly demonstrated a highly uniformizing enhancement pattern after the administration of gadolinium diethylenetriamine pentaacetic acid (Gd-DTPA), whereas a heterogeneous or cystic lesion enhancement pattern was observed in approximately half of the patients with schwannoma (SFT/HPC, 9/10 cases [90.0%] vs. schwannoma, 20/42 cases [47.6%]; $P = 0.030$). Only one of the 42 patients with schwannoma exhibited specific findings for SFT/HPC, showing isointensity on T1WI and uniformizing Gd-DTPA enhancement.

In contrast, most patients with meningioma showed isointensity on both T1WI and T2WI and uniformizing enhancement pattern preoperatively, which were similar to the findings in patients with SFT/HPC (SFT/HPC vs. meningioma: T1, 30/40 cases [75.0%], $P = 0.575$; T2, 29/40 cases [72.5%], $P = 0.845$; uniformizing enhancement: 38/40 cases [95.0%], $P = 0.496$). Most patients with meningioma exhibited the dural tail sign on MRI, and >50% showed intratumoral calcification on preoperative CT. However, no patients with SFT/HPC exhibited such imaging features of meningioma preoperatively (dural tail sign: SFT/HPC, 0/10 cases [0%] vs. meningioma, 37/40 cases [92.5%], $P < 0.001$; intratumoral calcification: SFT/HPC, 0/10 [0%] vs. meningioma, 17/33 cases [51.5%], $P = 0.003$). Only 1 of the 40 patients with meningioma showed imaging findings similar to those found in patients with SFT/HPC as above. Furthermore, almost all patients with SFT/HPC exhibited irregular-shaped tumors, that is, multilobular appearance on the sagittal view on MRI, whereas the edges of tumors were well defined in all cases of meningioma (irregularly shaped: SFT/HPC, 9/10 cases [90.0%] vs. meningioma, 0/40 cases [0%], $P < 0.001$). However, all 10 patients with SFT/HPC were misdiagnosed with schwannoma or meningioma on preoperative radiology.

## Surgical Characteristics

Surgical treatment and outcomes are presented in Table 4. All patients with SFT/HPC underwent tumor resection using the posterior approach. Although GTR was attempted in all surgical cases, it was achieved in 5 (50.0%) patients, whereas PR was achieved in 5 (50.0%) patients. We reluctantly had to perform PR because the amount of bleeding during surgery obscures the relevant surgical field (n = 3) or intraoperative spinal cord monitoring indicated deterioration in the motor evoked potential, which heralded impending neurological paralysis (n = 2). The mean surgical time was 354.1 $\pm$ 66.2 (range, 291-412) min, and the estimated blood loss was 220.4 $\pm$ 97.3 (range, 130-690) mL. Intraoperative frozen section diagnosis (rapid pathological examination) showed irregular arrangement of spindle-like cells on Hematoxylin-eosin (HE) staining in all cases. An immunohistochemical examination showed that all of the tumor cells were positive for STAT6 staining, and negative for epithelial membrane antigen (EMA) and S-100. CD34 was positive in 9 out of the 10 cases (90.0%) (representative pathological images are shown in Figure 2). Two patients had postoperative complications: neurological deficits immediately after surgery (n = 1) and cerebral infarction (n = 1). No patients received postoperative adjuvant radiotherapy or chemotherapy. Extraspinal bone metastases were not observed postoperatively in any patients at the final follow-up.

Among the 5 patients who underwent PR, 3 (60.0%) exhibited tumor recurrence and regrowth during the follow-up period (WHO grade II, 1 case; grade III, 2 cases), and the mean follow-up duration of tumor recurrence and regrowth was 24.7 $\pm$ 17.0 (range, 5-35) months. All these cases required repeat tumor resection thereafter. However, no patients died during the observation period. The number of patients with SFT/HPC who underwent GTR was significantly lower than those with schwannoma and meningioma (SFT/HPC, 50.0% vs. schwannoma, 85.7%, $P = .025$; SFT/HPC, 50.0% vs. meningioma, 100%, $P < 0.001$), and the rate of tumor recurrence and regrowth was significantly higher in patients with SFT/HPC than in patients with schwannoma or meningioma (SFT/HPC, 30.0% vs. schwannoma, 0%, $P = 0.005$; SFT/HPC, 30.0% vs. meningioma, 0%, $P = 0.006$) (Table 5).

Neurological improvement was assessed using MMCS. Preoperatively, among the patients with SFT/HPC, only 1 (10.0%) was classified as grade II, 7 (70.0%) were classified as grade III, and 2 (20.0%) were classified as grade IV. Meanwhile, only 1 (10.0%) patient was classified as grade I, 3 (30.0%) were classified as grade II, 3 (30.0%) were classified as grade III, and 3 (30.0%) were classified as grade IV at the final follow-up (Table 4). The neurological status of only 1 (10.0%) patient

**Table 2.** Characteristics of 10 Patients With Intraspinal SFT/HPC.

| Patient | Gender | Age (y/o) | Site | Localization of the lesion | Tumor size (cm) | MRI findings | Pre-operative diagnosis | Intraoperative frozen section diagnosis | Extent of tumor resection | WHO grade | Recurrence and regrowth (month) | Metastasisc | Follow up (month) | Preoperative MMCS | Postoperative MMCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Men | 25 | Cervical | Intra- and extramedullary | 1.7 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Meningioma or Exophytic ependymoma | Spindle cell tumor | PR | I | NR | None | 100 | III | II |
| 2 | Men | 68 | Cervical | Intradural extramedullary | 1.4 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Meningioma | Spindle cell tumor | PR | III | 34 | None | 118 | IV | IV |
| 3 | Women | 49 | Lumber | Cauda equina tumor | 1.9 | T1WI low, T2WI low, Gd-DTPA heterogeneous | Schwannoma or Meningioma | Spindle cell tumor | GTR | I | NR | None | 34 | III | III |
| 4 | Women | 44 | Thorax | Intramedullary | 1.0 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Schwannoma | Spindle cell tumor | GTR | I | NR | None | 36 | III | III |
| 5 | Women | 65 | Lumber | Cauda equina tumor | 8.3 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Schwannoma | Spindle cell tumor | PR | II | 5 | None | 38 | IV | IV |
| 6 | Men | 55 | Thorax | Intradural extramedullary | 1.6 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Meningioma | Spindle cell tumor | PR | III | NR | None | 50 | III | III |
| 7 | Men | 49 | Thorax | Intradural extramedullary | 1.3 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Meningioma | Spindle cell tumor | PR | III | 35 | None | 58 | III | IV |
| 8 | Women | 53 | Cervical | Intradural extramedullary | 3.7 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Schwannoma | Spindle cell tumor | GTR | I | NR | None | 26 | II | II |
| 9 | Men | 62 | Thorax | Intradural extramedullary | 1.6 | T1WI iso, T2WI low, Gd-DTPA uniformity | Schwannoma | Spindle cell tumor | GTR | I | NR | None | 30 | III | II |
| 10 | Men | 36 | Cervical | Intradural extramedullary | 2.2 | T1WI iso, T2WI iso, Gd-DTPA uniformity | Meningioma | Spindle cell tumor | GTR | I | NR | None | 27 | III | I |

Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; T1WI, T1-weighted images; T2WI, T1-weighted images; Gd-DTPA, gadolinium diethylenetriamine pentaacetic acid; GTR, gross total resection; PR, partial resection; WHO, world health organization; NR, no recurrence; MMCS, modified McCormick scale.

**Table 3.** Imaging Features of Intraspinal SFT/HPC and Comparison With Schwannoma or Meningioma (Each Item is the Most Frequent Feature).

| Item | SFT/HPC (n = 10) | Schwannoma (n = 42) | Meningioma (n = 40) |
|---|---|---|---|
| T1WI | **isointensity** | low intensity | isointensity |
| T2WI | **isointensity** | isointensity | isointensity |
| Enhancement pattern | **uniformizing** | heterogeneous | uniformizing |
| Dural tail sign | **(-)** | (-) | (+) |
| Intratumoral calcification | **(-)** | (-) | (+) |
| Edges of tumor | **multilobular appearance** | well defined | well defined |

Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; T1WI, T1-weighted images; T2WI, T1-weighted images.

improved from grade III to grade I and that of 2 (20.0%) patients improved from grade III to grade II. Overall, no significant neurological improvement was observed among the patients with SFT/HPC ($P = 0.284$). Contrarily, the postoperative neurological status significantly improved in patients with schwannoma ($P = 0.002$) and meningioma ($P = 0.026$) (Table 5).

## Discussion

We investigated the imaging features to aid in the preoperative diagnosis of intraspinal SFT/HPC. The images showed isointensity on both T1WI and T2WI, a highly uniformizing enhancement pattern after Gd-DTPA injection, the lack of the dural tail sign, no intratumoral calcification, and irregularities in tumor margins. This study found that no patients were

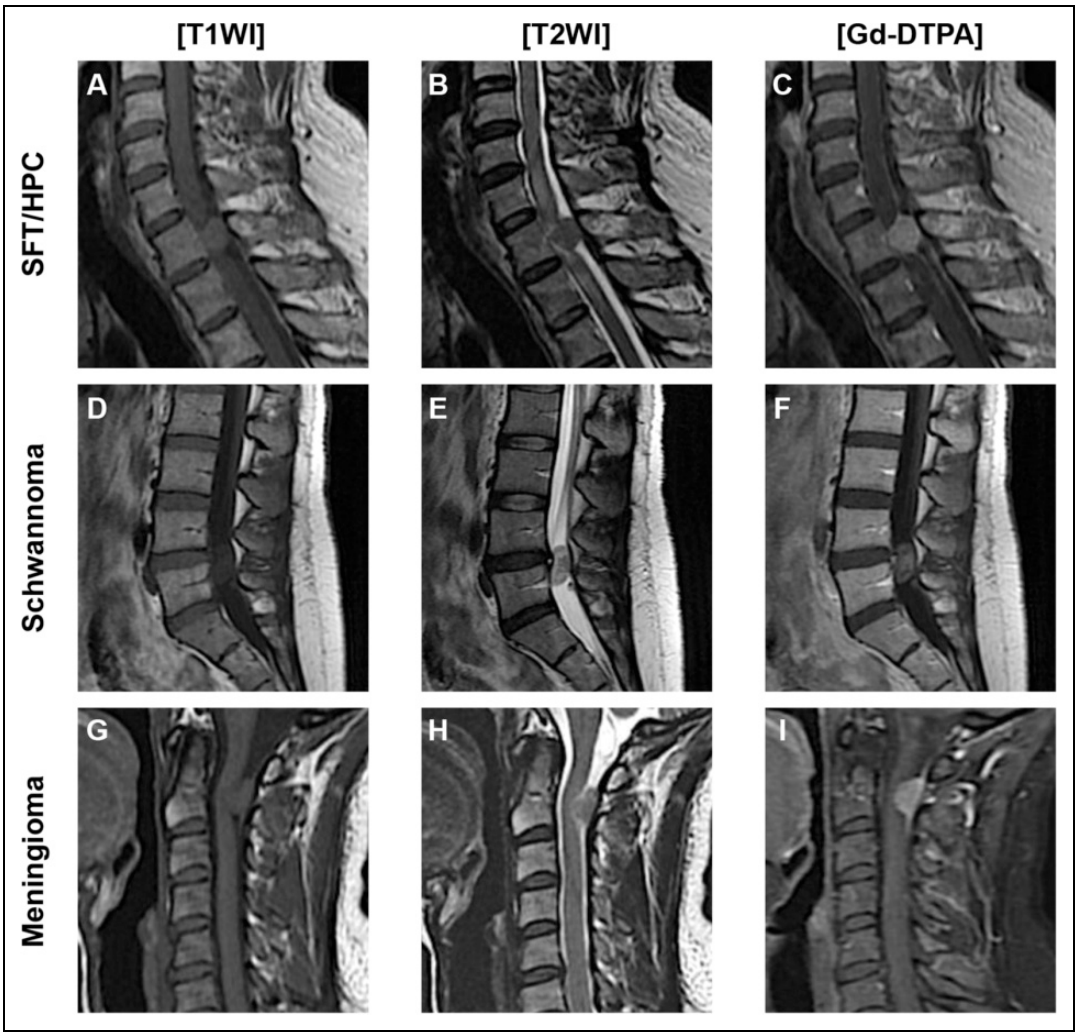


**Figure 1.** Representative sagittal MRI findings of patient with intraspinal SFT/HPC, schwannoma, and meningioma. SFT/HPC exhibited isointensity on both T1- (A) and T2-weighted images (B). T1-weighted MRI after injection of Gd-DTPA revealed an uniformizing enhancement pattern, the lack of the dural tail sign, and irregularities in tumor margins (C). By contrast, schwannoma showed low intensity on T1- (D), isointensity on T2-weighted images (E), and heterogenous Gd-DTPA enhancement pattern (F). Meningioma showed isointensity on both T1- (G) and T2-weighted images (H), uniformizing enhancement pattern and dural tail sign (I). Edges of tumor were well defined in both schwannoma and meningioma. Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; T1WI, T1-weighted image; T2WI, T2-weighted image; Gd-DTPA, gadolinium diethylenetriamine pentaacetic acid.

**Table 4.** The Surgical Treatment and Outcomes of 10 Patients With Intraspinal SFT/HPC.

| Item | Value |
|---|---|
| **Resection, no. (%)** | |
| GTR | 5 cases (50.0) |
| PR | 5 cases (50.0) |
| **MMCS** | |
| Pre-Ope | I; 0 case, II; 1 case, III; 7 cases, IV; 2 cases, V; 0 case |
| Post-Ope | I; 1 case, II; 3 case, III; 3 cases, IV; 3 cases, V; 0 case |
| **Surgical time (minutes)** | 354.1 (291-412) |
| **Blood loss (ml)** | 220.4 (130-690) |
| **Postoperative complication, no. (%)** | |
| Neurological deficits | 1 case (10.0) |
| Cerebral infarction | 1 case (10.0) |
| **Recurrence and regrowth, no. (%)** | |
| **(+)** | 3 cases (30.0; WHO II 1 case, III 2 cases) |
| **(-)** | 7 cases (70.0) |
| **Duration of tumor recurrence and regrowth (months)** | 24.7 (5-35) |

Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; GTR, gross total resection; PR, partial resection; MMCS, modified McCormick scale; WHO, world health organization.

diagnosed with SFT/HPC using preoperative radiology. The findings of this study have important implications for the treatment of SFT/HPC because they enable more accurate diagnosis using MRI, which will allow appropriate planning of surgery. This will improve patient outcomes if intraoperative bleeding from the tumor and postoperative dissemination can be minimized.

Intradural schwannoma exhibits diverse MRI characteristics because it is histologically composed of Antoni A and B patterns in variable proportions.[9,10] These results indicate that SFT/HPC and schwannoma can be distinguished using preoperative MRI. We found only 1 patient with schwannoma who exhibited similar findings to those with SFT/HPC. Most cases of SFT/HPC exhibit a highly uniformizing enhancement pattern on MRI because of the rich vascular formation with many dilated vessels.[11-14,15] Meanwhile, schwannoma is characterized by a rim around the tumor or a heterogeneous enhancement pattern. Schwannomas are pathologically relevant to thrombosis of degenerating blood vessels, hemorrhage, and microcystic foci, which could account for the lack of enhancement of the lesion parenchyma.[13,14] According to previous findings, we found that 9 of 10 patients with spinal SFT/HPC (90.0%) presented a highly uniformizing enhancement pattern, whereas a cystic lesion or heterogeneous enhancement pattern was detected in approximately half of the patients with schwannoma. The uniformly and strongly enhanced tumor image is a characteristic of SFT/HPC and can also be a useful MRI characteristic for comparing SFT/HPC with schwannoma.

Meningiomas show low intensity or isointensity on T1WI, isointensity or high intensity on T2WI, and a uniformizing enhancement pattern.[16,17] In this study, 26 (65.0%) of the 40 patients with meningioma had findings similar to those of patients with SFT/HPC, which were difficult to distinguish on preoperative MRI. Studies have suggested that intracranial SFT/HPC is more likely to show irregular shapes, vascularity, less calcification, lack of the dural tail sign, and destruction/invasion of the surrounding bone than meningioma. Most cases of meningioma show intratumoral calcification on CT and the appearance of the dural tail sign on MRI preoperatively.[5,16,18-20,15,21] In this study, no patient with SFT/HPC exhibited the dural tail sign or intratumoral calcification, and 9 (90.0%) of the 10 patients showed irregularly shaped tumors (multilobular appearance) preoperatively. In contrast, most patients with meningioma (92.5%) manifested the dural tail sign, 51.5% showed intratumoral calcification, and all cases exhibited tumors with well-defined edges. No patients with meningioma exhibited all imaging findings observed in patients with SFT/HPC. The dural tail sign is not a feature of meningioma only because some studies have stated that the dural tail sign may be due to the enhancement of the dura adjacent to the tumors as well as tumors extending into the subarachnoid and subdural spaces.[16,17] However, considering the results of this study, the dural tail sign could be a useful MRI and CT characteristic at least for differentiating SFT/HPC from meningioma. Moreover, irregular-shaped tumors, such as those with a multilobular appearance, were regarded a positive suspicion for SFT/HPC, which could help distinguish SFT/HPC from meningioma preoperatively. Therefore, we must make a comprehensive judgment based on the findings of intratumoral calcification, the dural tail sign, the shapes of the tumor, and other factors. Recently, Chen et al. have reported that diffusion-weighted and susceptibility-weighted MRI could differentiate intracranial SFT/HPC from meningioma and concluded that normalized apparent diffusion coefficient and intratumoral susceptibility signal intensity scores are useful in distinguishing these tumors.[17] To date, any of these sequences have not been performed on spinal imaging. In the future, the use of these imaging techniques may be useful in differentiating intraspinal SFT/HPC from meningioma, which will be a topic for future studies.

For patients with SFT/HPC, surgical intervention and the extent of resection have a significant impact on postoperative outcomes. In this study, 5 (50.0%) of the 10 patients with SFT/HPC did not achieve GTR; among them, 3 had tumor recurrence and regrowth. In contrast to these unfavorable results, no tumor recurrence was observed in patients who underwent GTR (n = 5; 50.0%). Similar findings were reported by Liu et al. who found a subtotal resection rate of 46.0% and a tumor recurrence rate of 91.6% among patients with SFT/HPC.[5] These high recurrence and regrowth rates in patients with SFT/HPC who underwent PR could be due to tumor dissemination caused by central debulking and piece-by-piece removal.[19,22] Therefore, based on our findings, we recommend the use of MRI and CT to facilitate a more accurate

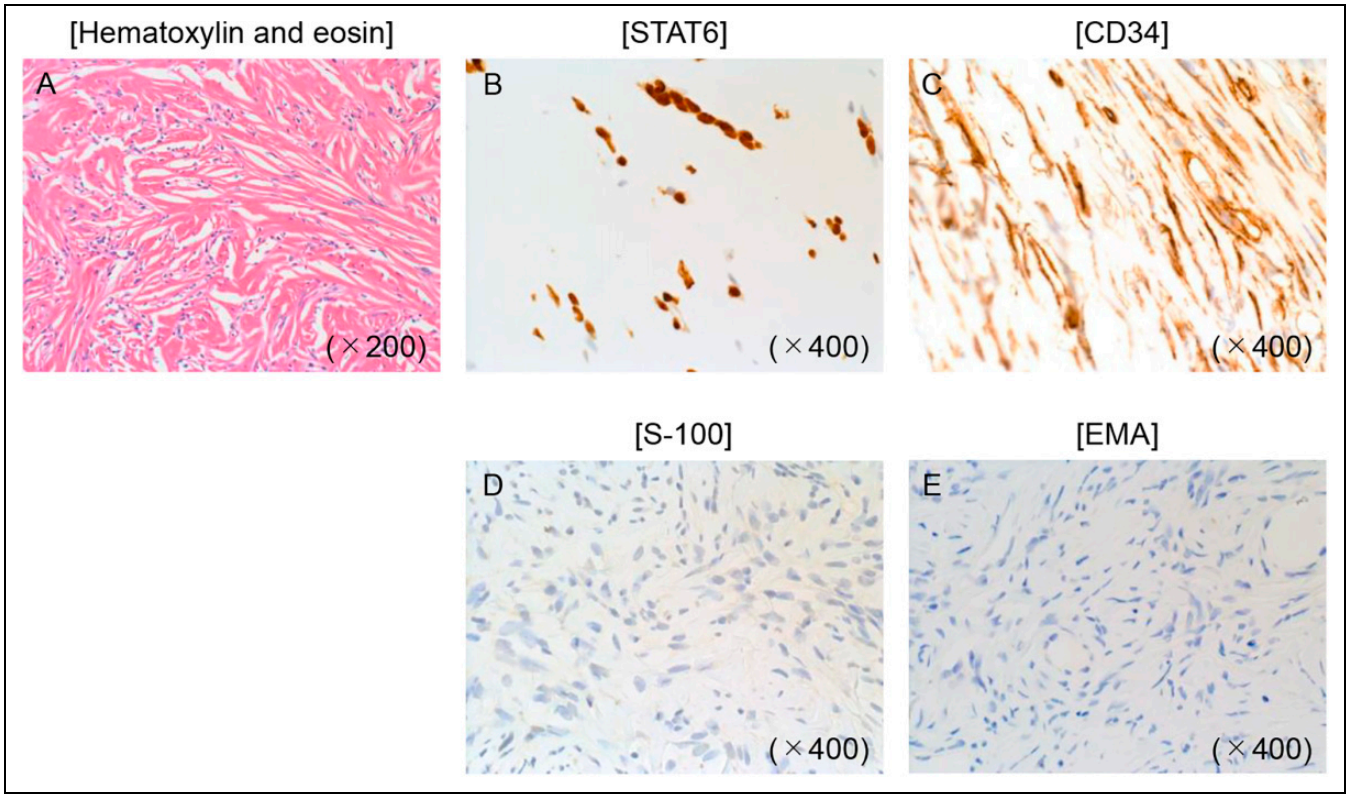


**Figure 2.** Representative histopathological findings for patients with spinal SFT/HPC. SFT/HPC showed irregular arrangement and "patternless pattern" of spindle-like cells on Hematoxylin-eosin staining (A). An immunohistochemical examination exhibited that SFT/HPC was positive for STAT6 (B) and CD34 (C). Meanwhile, S-100, which is positive in schwannoma (D), and EMA, which is positive in 50-100% of meningioma (E), are both negative in SFT/HPC. Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; EMA, epithelial membrane antigen.

**Table 5.** Comparison of Postoperative Outcomes of Intraspinal SFT/HPC, Schwannoma, and Meningioma.

| Item | SFT/HPC (n = 10) | Schwannoma (n = 42) | Meningioma (n = 40) |
|---|---|---|---|
| GTR rate (%) | 50.0 | 85.7 | 100 |
| Recurrence and regrowth rate (%) | 30.0 | 0 | 0 |
| Neurological improvement rate in MMCS | 30.0 | 81.0 | 70.0 |

Abbreviations: SFT/HPC, solitary fibrous tumor/hemangiopericytoma; GTR, gross total resection; MMCS, modified McCormick scale.

preoperative diagnosis and to perform a complete *en bloc* surgical resection to prevent tumor dissemination and recurrence. This surgical technique entails the removal of the entirety of a tumor without violation of its capsule. Thorough surgical planning and procedures could reduce tumor recurrence and may improve the rates of local control and overall survival in patients with intraspinal SFT/HPC.

The final diagnosis of SFT/HPC is determined by histopathological examination, and the differential diagnosis includes schwannoma, meningioma, neurofibroma, and ependymoma.[1] Tumor tissue findings of SFT/HPC are characterized by an irregular arrangement and "patternless pattern" of spindle cell tumors on HE staining, and positive for STAT6 on immunostaining in almost all SFT/HPC but not in other tumors.[2,23] In addition, SFT/HPC are often positive for vimentin, CD34, Bcl2, or CD99.[1,4] On the other hand, S-100, which is positive in schwannoma, and EMA, which is positive in 50-100% of meningioma, are both negative in SFT/HPC.[5,23] Therefore, the results of these various immunostaining are quite important in differentiating SFT/HPC from other tumors. In fact, all of the cases exhibited positive for STAT6 staining, and negative for EMA and S-100 on immunohistochemistry in this study.

Our study has some notable limitations. First, this study adopted a retrospective design, which inevitably lowered the evidence level. Second, the surgical outcomes may have been influenced by the differing techniques, experience, and skills of the 5 surgeons who performed SFT/HPC resection. Finally, the sample size was small, and the statistical power was not strong enough to draw conclusions for the precise clinical outcomes for our patients. Despite these limitations, disseminating these results is essential because SFT/HPC is an extremely rare spinal cord tumor, and its demographics and surgical outcomes are not well described. In addition, the clinical features that we describe in this study may assist surgeons in explaining patients with symptomatic SFT/HPC their prognoses.

## Conclusions

To prevent postoperative recurrence or regrowth, complete *en bloc* surgical resection should be planned preoperatively to avoid tumor dissemination. Understanding the imaging characteristics and diagnosing SFT/HPC accurately before surgery are important to improve patient outcomes.

### Acknowledgments

The authors would like to thank Enago (www.enago.jp) for the English language review.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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