



Stereotactic radiosurgery versus surgical resection for spinal hemangioblastoma: A systematic review



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ABSTRACT

Spinal cord hemangioblastomas are benign vascular tumors arising sporadically in approximately 70–80% of cases. They can also be manifestations of von Hippel-Lindau (VHL) disease, as these patients will often have multiple spinal hemangioblastomas. Historically, surgical management of symptomatic intramedullary hemangioblastomas has been considered the treatment of choice. However, recently, stereotactic radiosurgery has been utilized as an adjuvant therapeutic modality, and some have suggested it may have utility as the primary treatment option for these tumors. Because of the rarity of spinal hemangioblastomas, management options, clinical outcomes, and prognostic factors have not yet been fully elucidated. The National Institutes of Health (PubMed) was queried to identify all studies describing treatment of spinal hemangioblastomas. Focus was narrowed to institutional retrospective reviews, and comparisons were drawn regarding outcomes of both stereotactic radiosurgery and surgical resection. Stereotactic radiosurgery achieves stable or reduced tumor size with relatively little adverse clinical outcome long-term. Meanwhile, surgical resection results in successful removal of the tumor with approximately 96% stable or improved long-term clinical effect. Cross-platform analysis has been challenging when comparing efficacy amongst treatment modalities for this rare tumor. For the institutional retrospective reviews that exist, researchers tend to collect and record data in a multitude of fashions, making direct comparisons problematic. As such, the authors propose use of a national registry to input data prospectively about spinal cord hemangioblastomas.

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1. Introduction

Spinal cord hemangioblastomas are benign vascular tumors accounting for 3% of central nervous system tumors, and comprising 2–6% of all tumors within the spinal cord [1–3,41]. Hemangioblastomas arise sporadically in approximately 70–80% of cases, however 20–30% of these lesions are manifestations of von Hippel-Lindau (VHL) disease, a heritable multisystem cancer syndrome [1,3–5,39,40,42]. Hemangioblastomas are the most common lesions associated with VHL, and patients with this disease will frequently have multiple spinal cord hemangioblastomas with risk of developing additional tumors throughout their lifetime [2,6].

Although histologically benign, intramedullary hemangioblastomas can result in significant neurological symptoms as a result of their size, location, and venous congestion with associated peritumoral edema [3,7,8]. More than 50% of these spinal cord tumors have accompanying syringomyelia, which may also contribute to neurological sequelae [9].

Surgical management of symptomatic intramedullary hemangioblastomas has been considered highly effective and is the treatment of choice [5,6,8,10–23]. However, surgical resection can carry high risk with potential for poor prognosis, especially in the upper cervical spinal cord [7]. More recently, stereotactic radiosurgery has served as a therapeutic adjuvant, optimizing tumor dose while sparing the spinal cord [24,25]. It provides a noninvasive alternative to surgery and has been increasingly utilized in primary management of central nervous system hemangioblastomas [26]. Conversely, radiation-induced myelopathy has been reported in patients undergoing stereotactic radiosurgery to the spine with potential permanent neurological detriment [27–31].

Because of the rarity of spinal hemangioblastomas, management tactics, clinical outcomes, and risk factors affecting prognosis have not yet been fully realized. The aim of the present study was to review the outcomes of both radiosurgery and surgical resection of spinal cord hemangioblastomas. By performing cross-platform analysis and comparing these two groups, our goal was to provide a means in which the medical community can determine the safest, most efficacious treatment options for spinal hemangioblastomas.

2. Methods

2.1. Data source

The National Institutes of Health (PubMed) was queried to identify all studies describing treatment of spinal hemangioblastomas. Initial search terms included, “spine,” “spinal,” “hemangioblastoma,” “benign,” “tumor,” “radiation,” “radiosurgery,” “surgery,” and “surgical.” Article reference lists were additionally utilized to identify other pertinent studies. Criteria for final selection included a demonstration of qualitative and quantitative data specifically regarding spinal hemangioblastoma treated either by stereotactic radiosurgery or surgical resection. Focus was narrowed to institutional retrospective reviews of their own data. When data combined all benign spinal tumors, including low grade astrocytomas and ependymomas, this information was excluded unless detailed data could be isolated specifically for hemangioblastoma. Case reports were excluded. Ultimately, our analysis consisted of 4 articles assessing radiosurgical treatment of spinal hemangioblastoma, and 10 articles assessing surgical resection of a total of 538 tumors. However, all radiosurgery manuscripts were from a sin-

gle institution, and, known via personal correspondence, there was some overlap in patients.

3. Results

3.1. Stereotactic radiosurgery

Our literature review yielded 4 manuscripts in which authors performed retrospective institutional reviews of stereotactic radiosurgery specifically for spinal hemangioblastomas, (Table 1) [6,29,32,33]. However, all 4 reports were from a single institution, and some patient overlap exists (personal communication). No statistics can therefore be calculated for all patients and tumors presented. Rather, data has been calculated separately for each of the individual studies. Averages of each study were calculated, after which overall averages were determined. All treatment utilized the CyberKnife system (Accuray Incorporated, Sunnyvale, California, United States of America). Authors did not routinely include maximum and average tumor sizes nor whether the locations were intramedullary, extramedullary, or combined. When tumor location was reported, an average of 65% involved the cervical spine, 32% involved the thoracic spine, and 3% involved the lumbar spine. Treatment plans typically included an average dose of 21 Gy over 1–3 fractions. Of those reported, an average of 56% of tumors reduced in size, 42% remained stable, and 2% progressed at the time of follow up, which ranged from 1 to 3 years. While three studies reported no complications, the largest study (27 tumors treated) identified 3 (11%) complications [29]. One patient developed unilateral foot drop 5 months after radiosurgery, and two patients had “sensory deficits,” although further details were not reported. In a study involving 16 tumors treated, post-radiation edema was seen in two C7 lesions; however, no clinical radiation toxicity was appreciated [6].

3.2. Surgical resection

Our literature review yielded 10 studies in which authors performed retrospective institutional reviews of surgical resection specifically for spinal hemangioblastomas, totaling 538 tumors (Table 2) [1–3,5,7,9,16,34–36]. However, given the variability in data presented in each study, there exists a different number of tumors or patients for each variable assessed. As such, this resulted in differing denominators for each data point reviewed.

3.3. Tumor characteristics and extent of resection

When tumor location was reported, 50% (227/457) were in the cervical spine, 42% (192/457) were in the thoracic spine, and 8% (38/457) were in the lumbar spine. Most authors did not clearly identify if the tumor was intramedullary, extramedullary, or a combination of the two. When specified, involvement was intramedullary in 33% (119/361) cases, extramedullary in 30.7% (104/339) cases, and combined in 40% (137/339) cases. Of note, one study did not specify whether non-intramedullary tumors were extramedullary or combined. This study was excluded when comparing extramedullary and combined values. This resulted in varied denominators and subsequent percentages.

Total resections were achieved in 92% (493/538) of tumors. Subtotal resections were often attributed to intraoperative bleeding, while other causes were loss of somatosensory evoked

Table 1
Tumor and Treatment Characteristics in Spinal Hemangioblastomas treated with Stereotactic Radiosurgery.

Study	Data collected (years)	Tumors treated (n)	Patients (n)	Median or average age (years)	Tumor location: spinal cord level (n, %)	SRS treatment		Reported Outcome, Recurrence (n, %)	Complications	Average or median time of last follow-up
						average dose (Gy)	average fractions (n)			
Ryu, Kim, Chang (2003)	1998–2003	7				21	1–3	Reduced size (2, 29%), Stable (5, 71%)	No significant treatment-related complications	12 months
Daly, Choi, Gibbs et al. (2011)	2001–2008	27	19	30	Cervical (12, 44%) Thoracic (14, 52%) Lumbar (1, 4%)	20 (n=7) 18–25 (n=12)	single (7) 2–3 (12)	86% actuarial local tumor control at 3 years	1 case unilateral foot drop 5 months after SRS, 2 cases sensory deficits (11%)	3 years
Moss, Choi, Adler (2009)	1991–2006	16	11	43	Cervical (8, 50%) Thoracic (7, 44%) Lumbar (1, 6%)	21 (77% isodose line)	1–3	Reduced size (6, 38%), Stable (9, 56%), Progressed (1, 6%); 92% actuarial local control at 3 and 5 years	Post-radiation edema at two C7 lesions, no radiation toxicity	37 months
Chang, Meisel, Hancock et al. (1998)	1989–1996	2	2	41	Cervical (2, 100%)	21	3	Reduced size (2, 100%)	none	14 months

Note: All studies were written at the same institution, so there is likely significant overlap of patients.

potentials (SSEPs), ventral position of the tumor, and poor clinical status [3,9,34,35]. The authors did not routinely include tumor size, use of pre-operative embolization, and levels involved in the surgical resection.

3.4. Clinical outcomes

With regards to clinical outcomes, the McCormick clinical grading scale was almost always assessed by clinicians pre- and post-operatively (Table 3) [37]. However, outcomes were typically reported in the literature as stable, improved, or deteriorated without further qualifying the extent of improvement or deterioration. Furthermore, only a few authors specified data for all three outcomes. One study only reported deterioration, while another remarked solely on improvement rates. Two other studies reported stable and improved outcomes without commenting on deterioration. Given this, the data calculated in our study only included data where it was explicitly clear whether the outcome was stable, improved, or deteriorated. As such, the denominators for each of these outcomes varied. When explicitly reported, 37% (64/171) of patients demonstrated clinical improvement, 14% (40/276) demonstrated deteriorated neurological status at long-term follow-up, and 59% (87/148) of patients were noted as stable. Mehta et al. remarked that of the 108 patients treated in their series, 6% (6) had improved outcomes, 80% (86) were stable, and 15% (16) had worsened outcomes at time of final follow-up [2]. Of note, timing of reported outcomes varied dramatically as well, ranging anywhere from 17 months to 7 years.

Few authors discussed early post-operative neurological consequences in comparison to long-term outcomes. Li et al. noted that “several” patients had new or worsening symptoms in their post-operative course, including weakness, hypoesthesia, paresthesias, radicular pain, limb spasticity, bowel/bladder dysfunction, and dyspnea. However, all patients had McCormick scores of I or II at final follow up, which was an average 21 months post-operatively [7]. Mehta et al. reported 61% of patients had new or worsening neurological signs and symptoms immediately post-operatively, most of which were mild in severity and did not result in a decrease in McCormick grade. Most symptoms resolved within 2 days to 6 weeks. For those with worsening McCormick grade (15%), 70% resolved within 5 days to 4 months post-operatively, and patients returned to their pre-operative baselines. At 6 months post-operatively, 96% had stable or improved outcome [2]. Parker et al. noted that 5% of patients had worsening McCormick classifications in the early post-operative period (48 h post-surgery). However, at final follow-up, there was no deterioration in the non-VHL patients but 24% worsened McCormick grades in the VHL patients, many of whom had multiple resections [5]. For all patients combined within that study, 17% had a decline in McCormick grades at final follow-up. Pietila et al. reported transient deterioration in 17% (5) tumors resected. Transient formication, in which patients experienced sensations resembling small insects crawling on their skin, was experienced in 6.7% (2) of tumors resected [16].

3.5. Post-operative complications

Few of the papers discussed post-operative complications. Of those reported, complications occurred in 11.3% (30/265) of the tumors surgically treated. Liu et al. reported a 23% (5/22) rate of post-operative complications including cerebrospinal fluid leakage, failed extubation requiring a tracheostomy, epidural hematoma requiring surgical evacuation, and wound dehiscence [36]. Mehta et al. reported complications in 6% (13/218) of patients. These complications included cerebrospinal fluid leakages, superficial wound infection, and both intra- and extradural hematomas requiring surgical evacuation [2]. Serban and Exergian reported 1

Table 2
Tumor and Treatment Characteristics in Spinal Hemangioblastomas treated with Surgical Resection.

Study	Data Collected (years)	Tumors treated (n)	Patients (n)	Average Age (years)	Tumor Location; spinal cord level (n, %)	Tumor Location (n, %)	Extent of Resection (n, %)	Post-operative complications (rate 11.3%)	Recurrence (rate 5.5%)	Clinical outcome (n, %)	Average or Median time of last follow-up
Liu, Jain, Sankey et al. (2016)	1996–2014	22	21	45	Cervical (13, 59%) Thoracic (9, 41%) Lumbar (0)	Intramedullary (20, 91%)	Total (21, 95%) Subtotal (1, 5%)	5 (23%)	2 (10%)	Improved symptoms (9, 43%) Long-term dysfunction (12, 57%)	17 months
Deng, Wang, Wu et al. (2014)	2007–2011	116	92	33	Cervical (58, 50%) Thoracic (49, 42%) Lumbar (9, 8%)	Intramedullary (48, 41%) Extramedullary (25, 22%) Combined (43, 37%)	Total (109, 94%) Subtotal (7, 6%)			Improved (38, 41%) Stable (40, 44%) Deteriorated (14, 15%)	50 months
Parker, Aghakhani, Ducati et al. (2009)	1985–2002	60 (34 treated)	34		Cervical (28, 47%) Thoracic (25, 42%) Lumbar (7, 11%)		Total (29, 85%) Subtotal (5, 15%)			Deteriorated (6, 17%)	
Mehta, Asthagiri, Bakhtian et al. (2010)	1984–2008	218	108	33	Cervical (102, 47%) Thoracic (96, 44%) Lumbar (20, 9%)	Intramedullary (46, 21%) Extramedullary (78, 36%) Combined (94, 43%)	Total (217, 99.5%)	13 (6%)		Improved (6, 6%) Stable (86, 80%) Deteriorated (16, 15%)	7 years
Li, Wang, Niu et al. (2016)	2008–2013		25	37			Total (25, 100%)		0	All patients were McCormick Grade I or II at final follow-up	21 months
Joaquim, Ghizoni et al. (2015)	2000–2014	37	16	34	Cervical (11, 69%) Thoracic (5, 31%)		Total (37, 100%)			Improved (2, 13%) Stable (13, 81%) Deteriorated (1, 6%) at 6 months	48 months
Bostrom, Kanther, Grote et al. (2014)	1987–2007	5	5				Total (4, 80%) Subtotal (1, 20%)		2 (40%)	Improved (1, 20%) Stable (3, 60%) Deteriorated (1, 20%)	
Serban & Exergian (2013)	2003–2009		5	40	Cervical (2, 40%) Thoracic (3, 60%)	Intramedullary (5, 100%)	Total (4) Subtotal (1)	1 (20%)		Stable (4, 80%) Deteriorated (1, 20%)	
Harati, Satopaa, Mahler et al. (2012)	1997–2011	20	17	43	Cervical (13, 65%) Thoracic (5, 25%) Lumbar (2, 10%)		Total (16) Biopsy (1)	2 (10%)	0	Improved (4, 24%) Stable (13, 76%)	57 months
Pietila, Stendel, Schilling et al. (2000)	1995–1999	30	15	27			Total resection (30, 100%)			Improved (6, 20%) Stable (17, 6%)	20 months

case of his 5 patients (20%) who had motor deficits after an intraoperative hemorrhage, which resolved at 4 months [3]. Lastly, Harati et al. reported complications in 10% (2/20) of patients, including one patient with a wound infection, and a second patient who developed post-operative hematoma and spinal instability requiring additional surgery [35].

3.6. Recurrence rates

In contrast to the radiosurgery papers, authors reviewing surgical outcomes routinely reported clinical outcomes yet rarely reported recurrence rates. Of those reported, this would account for an overall recurrence rate of 5.5% (4/73) of tumors surgically treated. Liu et al. reported 9% (2/22) recurrences, one of which occurred 6 months post-operatively, and the other 1 month post-operatively [36]. Bostrom et al. reported 2 recurrences within the same patient, which was the only patient who had subtotal resection [34]. Li et al., and Harati et al., specifically reported no recurrences at follow-up at 21 months and 57 months, respectively [7,35].

3.7. Effects on syringomyelia

Only two studies reported post-operative effect on associated syringes. Deng et al. experienced a syrinx reduction in 83.1% (59/71) of patients with a syrinx [9]. Mehta et al. achieved a syrinx reduction in 96% (127/132) of syringes [2]. From these two studies, an average of 91.6% (186/203) of syringes decreased in size following surgical tumor resection.

4. Discussion

Spinal cord hemangioblastomas are rare, benign vascular tumors originating from embryonic remnant tissues of mesodermal origin [7,38]. They are composed of stromal cells and capillaries and are highly vascularized [1,6,32]. They tend to be solid tumors with varying degrees of associated spinal cord edema and dilation of the central canal [7]. According to the World Health Organization classification system, these are classified as Grade I lesions [1,32] (Fig. 1).

The available literature has echoed a common consensus that microsurgical extirpation is highly effective and is the treatment of choice for symptomatic intramedullary hemangioblastomas [5,6,8,10–23]. However, management has become more controversial in patients with VHL disease who often have multiple lesions [7]. In this setting, when removal or even observation may be problematic, the primary goal may be symptomatic palliation [43]. Due to the highly vascularized nature of hemangioblastomas, and given their location within the spinal cord, surgical resection can carry a high complication risk, especially in the upper cervical spinal cord [7]. Preoperative embolization may be utilized to reduce perioperative blood loss, optimizing opportunity for total resection while preserving spinal cord function [6,44]. While surgical resection of spinal hemangioblastomas has traditionally been the mainstay of management, radiation has served as a therapeutic adjuvant [24]. More specifically, conventional radiotherapy has been used to treat hemangioblastomas in the adjuvant, recurrent, or inoperable settings [25,26,45,46]. This includes multiple tumors with extensive spinal cord disease as well as post-operative residual disease or recurrence [26]. This is of particular utility in patients with VHL and multiple lesions throughout their spine [6]. However, radiation dose is limited by spinal cord tolerance, as radiation field arrangements do not discriminate between tumor and spinal cord [25].

In contrast to conventional radiotherapy, stereotactic radiosurgery minimizes the amount of normal tissue irradiated, thus



Fig. 1. MRI of the cervical spine following gadolinium injection. Imaging reveals a 5 mm superficial dorsally located homogeneously enhancing lesion with associated intramedullary hypointensity. This was resected and pathologically proven to be WHO I hemangioblastoma.

minimizing long-term neurological side effects of radiation [6]. Stereotactic radiosurgery improves local control by delivering large cumulative doses of radiation in fewer fractions with steep reduction in dose beyond the treatment region [24]. Stereotactic radiosurgery on spinal tumors is relatively new. It was first investigated in the mid-1990s, and in 1996, Hamilton et al., first reported the use of stereotactic radiosurgery for spinal pathology utilizing a linear accelerator (LINAC) [24,47]. In 2001, the Food and Drug Administration granted clearance for CyberKnife prototypes to be used in extracranial lesions, and studies have shown that CyberKnife as well as other radiosurgery platforms are accurate within 1 mm [48]. More recently, in 2011, a survey of 551 practitioners using stereotactic radiosurgery revealed that 67.5% were performing spine radiosurgery [24,45]. That being said, radiation-induced myelopathy has been reported in patients treated with stereotactic radiosurgery [27–31]. Management of radiation-induced myelopathy includes corticosteroids with possible combination of vitamin E and pentoxifylline, a phosphodiesterase inhibitor commonly prescribed to treat claudication symptoms in peripheral artery disease [24,49,50]. Hyperbaric oxygen, gabapentin, and/or physical therapy has also been utilized, and approximately half of patients' symptoms improve after treatment [24]. However, risk of radiation-induced myelopathy has been less than 1% when treated with a maximum spinal cord dose of 13 Gy in a single fraction or 20 Gy in three fractions [51]. More recent published spinal cord limits range from 10 to 14 Gy for the maximum dose or a partial volume tolerance of 10 Gy [29]. Given these findings, Moss et al. suggests that stereotactic radiosurgery “offers an attractive treatment alternative for inoperable lesions of VHL patients wishing to avoid the morbidities and mortality associated with multiple surgical resections” [6]. However,

Table 3
McCormick Clinical Grading Scale for Neurological Function (McCormick, 1990).

Grade	Definition
I	neurologically normal; mild focal deficit not significantly affecting function of involved limb; mild spasticity or reflex abnormality; normal gait
II	neurologically normal; mild focal deficit not significantly affecting function of involved limb; mild spasticity or reflex abnormality; normal gait
III	more severe neurological deficit; requires cane/brace for ambulation or significant bilateral upper-extremity impairment; may or may not function independently
IV	severe deficit; requires wheelchair or cane/brace with bilateral upper-extremity impairment; usually not independent

many authors continue to recommend conservative management of spinal hemangioblastomas that are asymptomatic [16,52].

The goal of the present study was to evaluate outcomes of both radiosurgery and surgical resection of spinal cord hemangioblastomas. By performing cross-platform analysis and comparing these two groups, our objective was to determine the optimal treatment recommendations for spinal hemangioblastomas. Currently, only one institution has published radiosurgery outcomes for these rare tumors, and relatively few institutions have reported their surgical outcomes. To our knowledge, none have attempted comparing the two modalities.

The outcomes reviewed in this study demonstrate that stereotactic radiosurgery achieves stable (42%) or reduced (56%) tumor size with relatively little adverse clinical outcome long-term, while 2% of tumors progressed. Meanwhile, surgical resection results in successful removal of the tumor with just 5.5% local recurrence rate. Long-term clinical effect is approximately 96% stable or improved. Statistical comparisons between the two groups could not be calculated due to patient overlap in the radiosurgery manuscripts (Table 4).

This study does have limitations. For instance, the indication for stereotactic radiosurgery, in lieu of surgical resection, was not reported in each paper, but could certainly play a role in outcomes. Ryu et al. noted that patients treated with radiosurgery either had recurrent tumors, had undergone several previous surgeries, had medical contraindications to surgery, or had declined open resection [33]. In Daly's study, 30% of tumors had undergone previous attempt at surgical resection, and radiosurgery was utilized for residual or recurrent disease [29]. Furthermore, cross-platform analysis has been challenging when comparing efficacy amongst treatment modalities. Spinal hemangioblastoma is a rare entity, and as such, there are few studies assessing the treatment modalities and outcomes for this specific tumor (Table 4). Of the institutional retrospective reviews that are available, authors tend to collect and record data in a multitude of fashions, making direct comparisons problematic. Moreover, important data such as tumor size was not routinely reported, and this information would be highly valuable when considering options for treatment. For instance, there is a possible size constraint on intramedullary tumors treated with stereotactic radiosurgery due to the potential for spinal cord toxicity. On this same note, larger tumors resected surgically may also increase risk of operative complications. This information would undoubtedly prove useful, and it is certainly an area for future study.

Although we have made some generalizations about the treatment modalities, a more detailed, accurate assessment would require standard outcomes analyses for these groups. The authors propose use of a national registry to input data prospectively about these tumors. Data to be recorded could include, but is not limited to, the list provided in Table 5. We plan to assemble this registry with hopes of performing more accurate data analyses in the future,

Table 4
Comparative Outcomes of Stereotactic Radiosurgery and Surgical Resection of Spinal Hemangioblastomas.

Treatment	Studies (n)	Tumors Treated (n)	Data Collected (years)	Average age (years)	Tumor Size	Tumor Location	Spinal Cord Involvement	Treatment	Recurrence/Tumor Control (%)	Complication Rate	Post-Treatment Clinical Status	Long-Term Clinical Outcome ^a	Average Follow-Up
SRS	4	unknown	1989–2008	38	NR	Cervical (65%) Thoracic (32%) Lumbar (3%)	NR	21Cy over 1–3 fractions	Reduced size (56%) Stable (42%) Progressed (2%)	Unable to calculate due to overlap in patients	Not reported	Unable to calculate due to overlap in patients	12–37 months
Surgery	10	538	1984–2014	36.5	NR	Cervical (50%) Thoracic (42%) Lumbar (8%)	Intramedullary (33%) Extramedullary (31%) Combined (40%) ^a	Total resection (92%)	5.5% recurrence	11.3%	When reported, many patients had temporary new or worsening symptoms	Improved (37%) Stable (59%) Deteriorated (14%)	17 months–7 years

NR – Not Regularly Reported.

^a Note that percentage totals for “Clinical Outcome” and “Spinal Cord Involvement” does not result in 100%, as the varying studies reported different outcomes, resulting in different denominators for those specific groups.

Table 5
Proposed data fields for a prospective spinal cord hemangioblastoma national registry.

Data field	Field definition
Age	Years
Gender	Male, Female
Date of treatment	Date
Spinal cord hemangioblastomas	number
Spinal cord hemangioblastomas treated	number
Location of each spinal tumor	cervical, thoracic, lumbar
Location of each tumor treated	cervical, thoracic, lumbar
Spinal cord involvement of each tumor	intramedullary, extramedullary, combined
Spinal cord involvement of each tumor treated	intramedullary, extramedullary, combined
Is patient symptomatic from the tumor being treated?	(yes/no)
Duration of symptoms prior to treatment	months
Volume size of tumor being treated	centimeters
Is there associated syringomyelia?	(yes/no)
Does patient have Von Hippel Lindau?	(yes/no)
Is stereotactic radiation being performed for primary or adjuvant therapy?	(yes/no), if yes, state primary or adjuvant
Stereotactic radiation dose (if applicable)	GY
Radiation fractions (if applicable)	number
Surgical resection plan (e.g.: how many levels of laminectomy, fusion?), if applicable	number
Resection outcome if applicable	total resection, subtotal resection, biopsy
Peri-operative complications, if applicable	
Pre-treatment McCormick Scale	number
Post-treatment McCormick Scale within: 2 weeks, then 3 months, 6 months, 12 months, 1 year, annually thereafter	number
Post-treatment complications: Less than 2 weeks, then 3 months, 6 months, 12 months, 1 year, annually thereafter	
Radiographic (MRI) findings of tumor post-treatment at: 3 months, 12 months, 1 year, annually thereafter	gone, reduced size, stable, progressed, recurred
Radiographic findings of syrinx post-treatment at: 3 months, 12 months, 1 year, annually thereafter	gone, reduced size, stable, progressed, recurred
Follow-up time	months
Event free survival (EFS) time	Number, Not applicable

thus providing additional insight to the pros and cons of both surgical and stereotactic radiosurgery treatment modalities for spinal hemangioblastoma.

5. Conclusion

The standard treatment for spinal hemangioblastoma remains surgery. The value of radiosurgery as an upfront treatment modality cannot be assessed based on data available at the present time. Cross-platform analysis has been challenging when comparing efficacy amongst treatment modalities for this rare tumor, given the relative paucity of data and the varying ways in which the records are reported. As such, the authors propose use of a national registry to input information prospectively about spinal cord hemangiomas, allowing for more detailed and accurate assessment of risks and benefits of stereotactic radiosurgery as well as surgical resection. The medical community can then determine the safest, most efficacious treatment options for spinal hemangioblastomas.

Conflict of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.clineuro.2017.01.012>.

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