IGKRF Project Proposal: Outcomes of Gamma Knife radiosurgery for foramen magnum meningiomas: An international multicenter study

Gautam U. Mehta, M.D., and Jason P. Sheehan, M.D., Ph.D.

University of Virginia

Overview

Meningiomas are the most common benign extramedullary lesions of the foramen magnum, however optimal management remains undefined. Given their location, growth of foramen magnum meningiomas can cause significant morbidity, and complete microsurgical resection can be challenging. As an alternative, the results of stereotactic radiosurgery (SRS) have been reported for foramen magnum meningiomas in small case series (see table below). To more clearly define the outcomes of SRS and to delineate a rationale management paradigm for these lesions, we propose this multicenter project to analyze the safety and efficacy of SRS for foramen magnum meningiomas.

Keywords

Foramen magnum, gamma knife radiosurgery, meningioma, radiation, stereotactic radiosurgery
Background

Foramen magnum meningiomas represent only 2-3% of all meningiomas, but nearly 75% of all benign extramedullary lesions at the foramen magnum.\textsuperscript{1,5,9,15,16} While meningiomas are typically slow-growing neoplasms, tumor progression in this location can cause significant morbidity due to brainstem compression and/or lower cranial palsy. Given the overall relative infrequency of foramen magnum meningiomas, treatment outcomes and optimal management paradigms remain poorly defined.

Surgery has been the treatment of choice for these tumors for several decades. While surgery for posterior foramen magnum meningiomas can often be performed with minimal morbidity, resection of anterior and anterolateral lesions is complicated by a limited surgical corridor and critical intervening neurovascular structures. Tumors at these anterior and anterolateral locations represent greater than 90% of all foramen magnum meningiomas.\textsuperscript{7,11,17} The evolution of far-lateral skull base techniques have allowed for more extensive resection of a greater proportion of these tumors, while minimizing morbidity, however these remain challenging lesions to treat with microsurgery.\textsuperscript{1–3,6,8,12,16}

Since the 1990s, stereotactic radiosurgery (SRS) has been described as an alternative therapy for foramen magnum meningiomas (Table 1).\textsuperscript{4,10,13,14,19} Due to the infrequency of these lesions, only small case series have been reported to date ($N \leq 24$). These small series have indicated that SRS may be efficacious and safe, however the paucity of reported cases has neither allowed for survival analyses to determine progression-free survival after treatment, nor an analysis of factors that affect treatment outcome. We herein propose a multicenter study on the outcome of Gamma Knife
radiosurgery for foramen magnum meningiomas to more clearly define the role of SRS in the optimal management of these lesions.

**Purpose**

The purpose of this study is to define the outcomes of Gamma Knife radiosurgery for foramen magnums. Preoperative and treatment factors will be analyzed for their effect of treatment outcome. These data will be used to improve understanding of the role of SRS in the optimal management of foramen magnum meningiomas.

**Specific Aims**

1. Define the efficacy of Gamma Knife radiosurgery for foramen magnum meningiomas.
2. Define the safety of Gamma Knife radiosurgery for foramen magnum meningiomas.
3. Analyze preoperative and treatment factors for their effect on radiosurgical outcome.
4. Better define the role of SRS in the management of foramen magnum meningiomas.
5. Evaluate the neurological outcomes including brainstem and cranial nerve function associated with SRS for a foramen magnum meningioma.

**Data Collection**

Data will be collected using a standardized spreadsheet. Clinical factors will include patient age, gender, preoperative signs and symptoms, tumor location and
tumor size. Treatment characteristics will include radiosurgical dose and number of isocenters. Outcome measures will include clinical and imaging follow-up as well as complications.

Inclusion criteria will be a histologically confirmed WHO grade I meningioma or a tumor presumed to be a grade I meningioma based upon clinical history and neuro-imaging studies. Tumors will be considered to be foramen magnum meningiomas if the insertion zone is mainly located within the limits of the foramen magnum as previously described:

1. Anteriorly: lower third of the clivus and upper limit of the body of C2
2. Laterally: jugular tubercule and upper limit of the C2 lamina
3. Posteriorly: anterior edge of the squamous occipital bone and C2 spinous process

The specific location of the tumor will be defined using the classification schema described by George and colleagues:

1. Anterior: insertion is on both sides of the anterior midline
2. Antero-lateral: insertion is between the anterior midline and the dentate ligament

Posterior: insertion is posterior to the dentate ligament

**Statistical Analysis**

Primary outcome data (tumor and clinical control) will be evaluated using Kaplan-Meier analysis to determine progression-free survival from the time of treatment. The effect of preoperative and treatment variables on treatment outcome will be analyzed using univariate and multivariate analyses as appropriate. Statistical significance will be determined using a two-sided $P$-value of less than 0.05. Analyses will be performed

### Tables

Table 1. Previous studies on stereotactic radiosurgery for foramen magnum meningiomas.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Year</th>
<th>N</th>
<th>Volume treated (cm$^3$)</th>
<th>Mean Dose (Gy)</th>
<th>Tumor control</th>
<th>Median follow-up (mos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh</td>
<td>1999</td>
<td>5</td>
<td>mean 10.5 (1.8-18.5)</td>
<td>13.8 (10-16)</td>
<td>100% at last f/u</td>
<td>36 (12-60)</td>
</tr>
<tr>
<td>Stanford</td>
<td>2007</td>
<td>7</td>
<td>mean 2.2 (0.7-4.2)</td>
<td>17.7 (16-20)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>UVA</td>
<td>2010</td>
<td>5</td>
<td>median 6.8 (1.9-17)</td>
<td>12 (10-15)</td>
<td>80% at last f/u</td>
<td>60 (48-156)</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>2012</td>
<td>24</td>
<td>median 4.8 (0.7-15.9)</td>
<td>13 (11-15)</td>
<td>100% at last f/u**</td>
<td>47 (3-128)</td>
</tr>
<tr>
<td>NAGKC</td>
<td>2015</td>
<td>18</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Using Cyberknife stereotactic radiosurgery
**Of 21 evaluable patients
***Specific outcomes for foramen magnum meningiomas not separately described
References


