Intracranial Meningioma in Dogs and Cats: A Comparative Review

Abstract: Meningiomas are extraaxial tumors that arise from the arachnoid layer of the meninges. Seizures are the most common clinical sign in dogs; cats more often present with mentation changes, vision loss, and gait abnormalities. Meningiomas in both species grow slowly and have an insidious onset of clinical signs. These tumors are more likely to be malignant in dogs. Surgery, radiation, and chemotherapy can target the primary tumor, whereas steroids and anticonvulsants are confined to treating secondary effects of the tumor. Surgery is the preferred primary option for cats because the tumor can be excised completely in most cases. If the meningioma cannot be resected in its entirety, radiation therapy can increase survival time.

Menigioma is the most common primary brain tumor in dogs and cats. Most dogs with brain tumors are older than 5 years, with a median age of 9 years. Brain tumors are also a geriatric disease in cats (mean age: 12 years). Older male cats seem to be more prone to meningioma, whereas dolichocephalic breeds are overrepresented in dogs.

Today, the increasing availability of veterinary specialists for referral and advanced imaging is facilitating the diagnosis of meningioma. After the diagnosis is established, the decision to treat and the choice of protocol must be considered. In veterinary medicine, treatment issues include the cost, expected survival time, and quality of life. What one client deems acceptable in terms of clinical signs and life span for a pet may not be satisfactory for another client. It is imperative that veterinarians be informed about the most current treatment options and probable survival times so that clients can make the best informed decision for themselves and their pets. As human meningioma treatment evolves, veterinary patients should also benefit from additional, possibly less invasive, treatment options.

Clinical Findings
Meningiomas in cats and dogs typically have an insidious onset of clinical signs due to their slow growth rate. Pet owners may attribute subtle behavior changes to old age; several studies have found that clinical signs of meningiomas are present for an average of 1 to 3 months before diagnosis in cats. The severity of clinical signs depends on the growth rate and location of the meningioma, peritumoral edema, intracranial pressure, and compensatory mechanisms within the brain. Because meningiomas arise outside of the brain parenchyma, they cause a mass effect as they slowly compress normal brain tissue. If normal compensatory mechanisms are exhausted (i.e., decreased cerebrospinal fluid [CSF] and blood volume), clinical signs can become acutely worse.

Seizures are by far the most common clinical sign of intracranial meningioma in dogs, with the cerebral hemispheres being the most commonly affected. Patients can have normal neurologic findings initially; therefore, a brain tumor should be suspected in any dog older than 5 years that presents with a recent onset of seizures. Other clinical signs in dogs include ataxia, blindness, and behavior changes.
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Seizures can also occur with meningioma in cats but are much less common than in dogs. Cats can present with decreased vision, ataxia, paresis, circling, or altered consciousness. In two reports on feline intracranial neoplasia, 21% of cats had no specific neurologic signs but presented with lethargy and anorexia; 22% of cats with brain tumors had seizures. We have seen several geriatric cats in which cerebral meningioma was ultimately diagnosed that had normal neurologic findings and had presented to several veterinarians for the chief complaint of “just not being themselves” (i.e., behavior change and indolence). Headache, a common symptom in human patients, cannot be assessed in animals, but it may explain the large number of dogs and cats that present with lethargy or personality change.

Unlike dogs, which typically do have clinical signs, cats can have multiple tumors as well as asymptomatic meningiomas. In cats, intracranial meningioma is a common incidental finding on necropsy, as many do not display any clinical signs. In one retrospective review of feline intracranial neoplasia, 22.6% of meningiomas were considered to be incidental. Multiple meningiomas in cats can cause multifocal neurologic signs, depending on their location.

Pathologic Findings
Meningiomas are thought to arise from the arachnoid cap cells and arachnoid granulations, especially where they project into the dural venous sinuses. Grossly, canine and feline meningiomas are discrete, firm, rubbery, lobular, gray to pink, extramedullary masses. Meningiomas are typically well encapsulated (especially in cats) and attached to the underlying dura, displacing the brain without invading it. However, the edges of canine tumors can be hard to distinguish from edematous brain tissue, and meningiomas are invasive to normal brain tissue in almost 30% of canine cases. Hyperostosis, or proliferation of the overlying skull in response to pressure from the meningioma, is seen mostly in cats. Meningiomas can be attached to the dura in a broad, pedunculated, or sheet-like fashion (meningioma en plaque).

The World Health Organization (WHO) has established tumor categories and grades for meningiomas.

QuickNotes
Seizures are the most common clinical sign of intracranial meningioma in dogs but not in cats.

**World Health Organization Classification of Meningiomas**

<table>
<thead>
<tr>
<th>Grade I/Benign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only occasional mitotic figures</td>
</tr>
<tr>
<td>Most common</td>
</tr>
<tr>
<td>Ki-67 index: &lt;4%–5%</td>
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</tbody>
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<table>
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<tr>
<th>Grade II/Atypical</th>
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<tbody>
<tr>
<td>At least four mitotic figures per 10 high-power fields</td>
</tr>
<tr>
<td>Meets three of the following criteria:</td>
</tr>
<tr>
<td>Increased cellularity</td>
</tr>
<tr>
<td>Small cells with a high nucleus:cytoplasm ratio</td>
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<tr>
<td>Prominent nucleoli</td>
</tr>
<tr>
<td>Sheet-like growth pattern</td>
</tr>
<tr>
<td>Small foci of necrosis</td>
</tr>
<tr>
<td>Ki-67 index: 5%–10%</td>
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<tr>
<th>Grade III/Anaplastic (Malignant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obvious malignant cytology (resembles a sarcoma or carcinoma)</td>
</tr>
<tr>
<td>20 or more mitotic figures per 10 high-power fields</td>
</tr>
<tr>
<td>Brain invasion common</td>
</tr>
<tr>
<td>Ki-67 index: &gt;15%</td>
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Immunohistochemical staining of an anaplastic canine meningioma with Ki-67 staining of 19%. Ki-67–positive cells stain brown.
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human meningiomas (BOX 1). Ki-67, a nuclear protein found only in the proliferative phases of the cell cycle, is considered the most reliable proliferative marker for human brain tumors, and its presence is easily demonstrated with immunohistochemical staining (FIGURE 1). The Ki-67 index is useful in determining prognosis and likelihood of recurrence. WHO grade I tumors have a low Ki-67 index (<4% to 5%), grade II meningiomas have a moderately high index (5% to 10%), and grade III tumors have the highest index (frequently exceeding 15%). Ki-67 was previously reported in canine meningiomas, and we, along with another group, recently confirmed its presence in feline meningiomas.

Although the WHO staging system is not generally used in histologic grading of canine and feline meningiomas, malignant meningiomas have been reported in both species. Most intracranial meningiomas in cats are benign and relatively easy to remove surgically. By contrast, 18% to 27% of canine meningiomas are malignant and invade the Virchow–Robin space. In general, the term benign must be used cautiously when discussing meningiomas in dogs. Even though most canine meningiomas are cytologically benign, they can still be considered biologically malignant (likely to kill the animal) because of their increased growth rate and lack of demarcation from normal brain tissue and the difficulty in treating them with surgery alone.

Another pathologic variant of note in dogs is the cystic meningioma (FIGURE 2). Cysts within a tumor can be caused by tumor necrosis, isolation of CSF, or fluid production by the tumor itself. Although reports of canine cystic meningiomas are rare, we have presumptively diagnosed many cystic meningiomas in dogs. Interestingly, these tumors are almost always located in the olfactory lobe of the brain. The cyst is often much larger than the tumor mass, and most clinical signs are attributable to increased intracranial pressure secondary to the large quantity of fluid in the cyst.

In people, meningiomas occur twice as often in women as in men, leading many authors to investigate the role of estrogen and progesterone in their growth. Although most human meningiomas have progesterone receptors, and some have estrogen receptors, the function of these receptors is unclear. A high proportion of progesterone receptors has also been found in canine and feline meningioma cells. In both species, lower progesterone expression has been shown to correlate with early recurrence and a high proliferation index.

**QuickNotes**

In general, the term benign must be used cautiously when discussing meningiomas in dogs.

**FIGURE 2** T1-weighted postcontrast magnetic resonance imaging (MRI) scans of a canine cystic meningioma (arrows).

Coronal view. Axial view. Histologic confirmation was obtained via surgical biopsy. The inner black region is the cystic fluid inside the tumor.
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extraaxial (i.e., outside of the brain parenchyma), either with a dural attachment or confined strictly within a ventricle. However, definitive diagnosis requires collection of a tissue biopsy sample either during surgery or with a CT-guided stereotactic system. A thorough preanesthetic work-up, including a complete blood cell count, chemistry panel, urinalysis, thoracic radiography, and abdominal ultrasonography, is recommended before CT or MRI. A recent study of intracranial neoplasms in dogs found other, unrelated tumors in 23% of patients at necropsy. Therefore, it is crucial to rule out metastatic disease or an unrelated primary neoplasm before discussing prognosis and treatment options for a presumed meningioma.

CT is not as useful for demonstrating soft tissue detail as MRI, but it is usually adequate for identifying tumors in the rostral fossa. When imaging the caudal fossa, CT is much more prone to artifact production secondary to interference from the surrounding petrous temporal bone. Meningiomas are isodense to slightly hyperdense, homogenous, and brightly enhanced on CT. Calcification of the meningioma is best seen on CT, but if the entire tumor is densely calcified, no enhancement may be seen after intravenous administration of contrast medium (FIGURE 3). Hyperostosis of the overlying skull is easily visualized on CT.

On T1-weighted MRI, most meningiomas are isointense or hypointense compared with gray matter; their appearance on T2-weighted images is generally heterogeneously hyperintense. Postcontrast T1-weighted images display the tumor’s distinct margins with marked contrast enhancement because the capillaries of the meningioma do not pass through the blood–brain barrier (FIGURE 3). A dural “tail” enhancement has been described and is another characteristic that raises the index of suspicion for meningioma. However, it is impossible to differentiate reactive dural thickening from tumor extension along the dura. Cysts that may be associated with the tumor are best visualized on T2 weighted images.

CT and MRI are relatively accurate in providing a tentative diagnosis of meningioma in dogs and cats. One study in dogs showed 100% correlation with MRI diagnosis and histopathology for meningioma. Imaging diagnosis of meningioma included peripheral location, tissue displacement but not infiltration, increased or diffuse contrast enhancement, dural thickening, and close proximity to the meninges. This study also found that CT correctly identified the histologic tumor type in 86% of the cases evaluated. A similar study in cats reported correct identification of 96% of brain tumors as meningiomas based on MRI appearance alone. Advanced imaging, such as MRI or CT, has not been shown to determine which canine tumors are more invasive to normal brain tissue and, therefore, which tumors may be more difficult to treat with surgery alone.

CSF characteristics of canine intracranial meningiomas have been reported. The results

**QuickNotes**

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*Images of a feline meningioma (arrows).*

CT and MRI are relatively accurate in providing a tentative diagnosis of meningioma in dogs and cats.
are variable; an older study found that most CSF had pleocytosis with a predominance of neutrophils. Another author theorized that the neutrophils were secondary to focal necrosis of the meningioma with suppuration. A more recent report showed that most dogs (73%) did not have pleocytosis but instead had a nucleated cell count of <5/dL of fluid. Total protein levels were increased in the CSF of 61% of the dogs. Spinal fluid analysis can help rule out inflammatory disease as the cause of neurologic signs but is not definitive. We prefer not to collect CSF from animals with an intracranial mass consistent with meningioma on MRI, especially if there is significant peritumoral edema and mass effect. Increased intracranial pressure can put the patient at risk for brain herniation after CSF collection.

Definitive diagnosis of meningioma requires tissue biopsy. This can be performed intraoperatively at the time of tumor removal. A modified CT-guided stereotactic brain biopsy system has been described for use in dogs and is available at several veterinary teaching hospitals. Of 18 dogs with meningiomas, 100% were correctly diagnosed on histopathology using a specimen obtained with this system. Postoperative clinical complications were considered mild, and 72% of the dogs recovered from the biopsy procedure with no apparent complications. Biopsy is imperative to confirm the diagnosis of meningioma and provides vital information regarding prognosis and appropriate treatment options.

Treatment
Palliative Treatment
Palliative therapy targets the secondary effects of the tumor. Typically, an antiinflammatory dose of glucocorticoids is administered to decrease CSF production and tumor-associated brain edema; this therapy may be required for the lifetime of the patient, depending on what additional definitive therapy is selected by the owner. Steroids decrease the permeability of tumor capillaries as well as tumor blood volume. If the meningioma causes seizures, anticonvulsant therapy is also indicated. Phenobarbital and potassium bromide are the anticonvulsants most commonly used in dogs, but many options are available. Standard doses of phenobarbital given to dogs with rostral forebrain tumors tend to cause profound sedation; this and other side effects of phenobarbital and potassium bromide (e.g., polyuria, polydipsia, polyphagia) are likely to be compounded by concurrent steroid use. Cats do not commonly present with seizures, but anticonvulsants are also indicated if seizures develop in this species.

Palliation with steroids and anticonvulsants is recommended regardless of whether the owner opts for definitive therapy. Some animals respond significantly to palliative treatment alone; in one study, the median survival time was 3.8 months (range: 0.5 to 25.1 months) in dogs treated with anticonvulsants and steroids alone. There are no case reports of survival times for dogs in which no therapy was pursued for meningioma. In our experience, owners who decide against therapy choose to euthanize the dog immediately after diagnosis.

Surgery
Surgery is the preferred primary therapy for feline patients and is usually successful because most feline tumors can be excised completely. Surgery is the preferred primary therapy for feline patients and is usually successful because most feline tumors can be excised completely. Meningiomas in cats are firm, well-circumscribed masses that do not usually invade the neural parenchyma and are easily delineated from normal brain tissue. Postoperative mortality associated with craniotomy for meningioma removal in cats is reported to be approximately 19%, with anemia being the most common complication. In our clinical experience, however, the surgical mortality is close to 0% for cats. In one report, surgery as the sole treatment for...
intracranial meningiomas in cats yielded survival rates of 71% at 6 months, 66% at 1 year, and 50% at 2 years. Another report noted comparable results, with 78% of cats having no tumor recurrence for a median of 27 months. Similar survival times are reported in cats with multiple meningiomas.

The same is not true for surgical removal of intracranial meningiomas in dogs. Even tumors that are histologically benign are seldom well encapsulated and are therefore difficult to distinguish from the surrounding brain tissue. Canine meningiomas tend to be friable, and almost 33% infiltrate the brain parenchyma. In a study evaluating craniotomy in dogs and cats, the authors specifically commented on the differences between canine and feline tumors. The feline tumors were generally well defined and easily extracted, whereas the canine meningiomas lacked demarcation from normal brain tissue. Moreover, dogs treated with surgical removal alone had median survival times of 7 and 6.7 months, respectively, in two separate studies. Postcraniotomy radiation therapy can prolong survival significantly. These same studies reported mean survival times of 16.5 and 16.9 months for meningiomas in dogs treated with tumor resection followed by fractionated radiation. Another report found a mean progression-free survival interval of 30 months for incompletely resected canine meningiomas treated postoperatively with radiation.

A recent retrospective study found much longer survival times in dogs with intracranial meningiomas that underwent surgical resection with an ultrasonic aspirator. Surgical aspiration allows the surgeon to perform more complete tumor excision while reducing hemorrhage and iatrogenic brain damage. The aspirator has a tip that vibrates and fragments tissue while simultaneously providing lavage and suctioning matter from the surgical field. Median survival time in this study was approximately 42 months. Although ultrasonic aspiration is not yet widely available in veterinary medicine, greater use of this technique may increase survival times in canine patients with intracranial meningiomas treated with surgical removal alone.

The aspiration study was also the first to investigate the prognostic value of tumor histologic subtyping with regard to survival times. Patients with meningothelial, psammomatous, or transitional meningiomas had a much better prognosis, with median survival times exceeding 313, 523, and 1254 days, respectively. Patients with anaplastic and fibroblastic subtypes had the shortest survival times at 0 and 10 days, respectively. Histologic subtyping of meningiomas may eventually be used in dogs to determine prognosis and individualize treatment, possibly in conjunction with testing for Ki-67 levels. This subtyping may not be needed in cats because their tumors seem to be more benign in nature.

**Radiation**

The ultimate goal of radiation therapy is to administer the highest possible dose to the tumor while minimizing damage to surrounding healthy tissue. Radiation affects cells and their vasculature; 80% of the observed clinical effect is due to DNA damage resulting from the ionization of water and production of oxygen free radicals. This effect has a latent period and can take months to occur in slow-growing meningiomas. The acute adverse effects of radiation include cerebral edema and, possibly, a temporary increase in seizure activity. Brain edema, which may be due to transient demyelination, responds to steroid therapy. Late effects of radiation can be seen months to years after therapy and are due to brain necrosis. Late effects can mimic the original clinical signs of the treated tumor and cannot be effectively treated. In veterinary medicine, however, late effects of radiation therapy are rare because of the patients’ short life span.

Conventional radiotherapy consists of fractionated irradiation of the tumor and a 5- to 10-mm margin of surrounding tissue at approximately 3 Gy per session. In dogs and cats, the total dose is usually 46 to 48 Gy given over several weeks. Irradiation of canine and feline brain tumors is common in veterinary medicine, and reports in the literature describe using radiation therapy as the sole treatment for intracranial masses or after subtotal resection. The median survival time of dogs treated with fractionated radiotherapy alone for extraxial masses (mean total dose: 40.9 Gy) was 569 days in one study. Another study using hypofractionated radiation (38 Gy) as the sole therapy reported a mean survival time of 49.7 weeks for extraxial masses, but definitive histologic diagnosis was not obtained in each case. One cat with a suprasellar meningioma diagnosed with tumor resection followed by fractionated radiation alone had median survival times of 30 months after therapy and are due to brain necrosis. Late effects can mimic the original clinical signs of the treated tumor and cannot be effectively treated. In veterinary medicine, however, late effects of radiation therapy are rare because of the patients’ short life span.

**QuickNotes**

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Intracranial Meningioma in Dogs and Cats

Intracranial meningiomas are usually diagnosed via MRI. One dog, diagnosed with a meningioma on MRI, was treated with orthovoltage radiation and lived for 240 days before dying of an unrelated neoplasm.4 Again, several studies have shown that survival times are prolonged in dogs that received radiation therapy after surgical removal of their meningiomas.9,36,41

Radiosurgery

Within the past decade, stereotactic radiosurgery has gained popularity in human and veterinary medicine. Radiosurgery delivers a high dose of radiation to a well-defined intracranial target in a single treatment session and is accurate to within 1 mm.11 Multiple, noncoplanar radiation beams are stereotactically focused on the tumor using an image-based planning system and a rigid head fixation device. The steep dose gradient outside the edge of the target limits the exposure of normal tissue and decreases radiation side effects.

Radiosurgery can be performed with a specially adapted linear accelerator (LINAC) or Gamma Knife (Elekta, Norcross, GA). The procedure is typically conducted on an outpatient basis. At our facility, pretreatment volumetric MRI and stereotactic CT are conducted. The CT scan is performed with a bite plate securely fastened to the pet’s teeth; the same bite plate is used to facilitate stereotactic three-dimensional localization during the actual treatment (FIGURE 5). The MRI and CT images are fused during dose planning, using an automated program that generates multiple isocenters and an optimally conformed isodense line.49

Radiosurgery has been used to irradiate brain tumors in dogs and is very attractive to pet owners because it requires only one anesthetic event. Two dogs treated in this fashion with doses of 1250 and 1000 cGy had respective survival times of 4 years and 13 months.50 This treatment option is currently available at three veterinary academic centers and one private practice in the United States. We have treated several dogs and two cats with MRI-diagnosed cerebral meningiomas using a LINAC-based stereotactic radiosurgery unit to deliver an average dose of 1500 cGy. Several patients are still doing well clinically more than 1 year posttreatment, and the case series will be published soon.

Typically, we recommend radiosurgery as the primary mode of therapy for intracranial meningiomas that are relatively small (<2.5 cm in diameter) if the patient does not have severe clinical signs (i.e., normal neurologic examination with seizures as the only clinical sign) or the owner does not wish to pursue surgical excision. These treatment criteria reflect an increased risk of acute edema with larger meningiomas.51 Stereotactic radiotherapy has been shown to significantly decrease tumor volume, but this process is slow.52 Therefore, tumors that are in a surgically accessible location in animals displaying a significant mass effect and severe neurologic signs are best managed by conventional excision to quickly resolve clinical signs.

Chemotherapy

Historically, chemotherapy for brain tumors has been limited by the need for drugs that can cross the blood–brain barrier. However, several medications that may have a role in treating intracranial meningioma are now available. The nitrosourea drugs carmustine and

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lomustine are alkylating agents that are highly lipid soluble. They appear to act via induction of cross-linking of nucleic acid side chains in DNA and are not cell-cycle specific. Their most serious adverse effect is myelosuppression, which may interfere with treatment. While these agents are not typically recommended for use in patients with meningiomas, one report described the successful use of oral lomustine to treat an intracranial meningioma in a dog. In this particular case, lomustine was chosen for treatment because the tumor type could not be histologically confirmed (meningioma was diagnosed at necropsy). Lomustine was given every 6 weeks along with prednisolone, and the patient survived for 13 months.

One potentially promising treatment involves the antineoplastic agent hydroxyurea, which is used in human and veterinary medicine for long-term treatment of chronic myelogenous leukemia and polycythemia vera. This drug inhibits DNA synthesis without interfering with RNA or protein synthesis, and cell death occurs in the S phase of the cell cycle. Adverse effects are minimal and include myelosuppression, but this is reversible even after years of therapy.

Hydroxyurea was first demonstrated to arrest meningioma growth in cell culture and then to cause DNA fragmentation of tumors transplanted into nude mice. Favorable results have been achieved using hydroxyurea in human patients with meningioma, but no controlled studies exist in veterinary medicine. However, the drug is often used in veterinary neurology as a noninvasive, relatively inexpensive treatment option.

Hydroxyurea is often used in veterinary neurology as a noninvasive, relatively inexpensive treatment option. QuickNotes

Other Therapies
Gene therapy, brachytherapy, and immunotherapy have all been used in people for recurrent or malignant meningiomas, but their use is not widespread in veterinary patients. Gene therapy consists of transferring viral DNA or RNA into a tumor to render it susceptible to certain therapeutic agents. For example, in “suicide” gene therapy, a herpes simplex type I thymidine kinase gene is transferred into tumor cells, which sensitizes these cells to the antiviral drug gancyclovir. An adenovirus vector has been successfully transferred into a naturally occurring canine meningioma, but no further reports of gene therapy for this indication have been published in the veterinary literature.

Brachytherapy is a means of providing local radiation to a tumor via implantation of high-activity iodine-125 seeds during surgical resection. It has been used in human medicine as an adjunctive therapy for recurrent and primary skull-base meningiomas but has not been described as a treatment in the veterinary literature.

Immunotherapy involves modification of the immune system to slow the course of tumor progression, usually by culturing and stimulating autologous lymphocytes and returning them to the tumor. This mode of treatment is usually reserved for gliomas that do not respond to conventional therapies in humans, but it has been tried in dogs with meningiomas.

Conclusion
Surgery is the initial treatment of choice for intracranial meningiomas in cats and may be indicated in dogs. If the mass is in an accessible location, surgery provides a definitive diagnosis and immediate resolution of mass effect. Cats respond well to surgical resection of meningiomas, with a 50% survival rate at 2 years. Canine meningiomas are not as easily removed, with survival times of 7 months in dogs treated by conventional surgery alone.
However, canine patients that underwent ultrasonic aspiration of meningiomas had much longer survival times (median: 3.4 years).\(^2\)

Adjunctive therapy with radiation or hydroxyurea can prolong survival times in dogs.\(^36,40,53,57\)

Stereotactic radiosurgery may provide equivalent survival times to surgical resection in dogs and is less invasive. Ultimately, owners must be well informed about the cost, expectations, ease of therapy, and quality of life associated with each treatment option to make the best decisions for themselves and their pets.

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**References**

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1. Which is the most common clinical sign of an intracranial meningioma in dogs?
   a. tetraparesis
   b. seizures
   c. extreme lethargy
   d. blindness

2. Which statement is false with regard to most meningiomas in cats?
   a. They are extraxial.
   b. They arise from the arachnoid space.
   c. They are invasive to normal brain tissue.
   d. They are firm.

3. The nuclear protein Ki-67 is used
   a. as a proliferation marker for brain tumors.
   b. to determine the likelihood of recurrence and prognosis for meningiomas.
   c. to determine the WHO tumor grade.
   d. all of the above

4. Which grade of meningioma is associated with the highest Ki-67 levels?
   a. I
   b. II
   c. III
   d. IV

5. Lower progesterone expression in canine and feline meningiomas correlates with
   a. early recurrence.
   b. a lower recurrence risk.
   c. the presence of a secondary tumor.
   d. none of the above

6. Surgery for meningiomas in dogs
   a. can be difficult due to the invasive nature of the tumor.
   b. is not recommended.
   c. is as effective as surgery in cats.
   d. is only performed with a surgical aspirator.

7. Late effects of radiation are
   a. common in veterinary patients.
   b. due to vasogenic brain edema.
   c. irreversible.
   d. seen within days of treatment.

8. Which statement is false with regard to radiosurgery?
   a. It requires only one treatment session.
   b. It is used for malignant meningiomas in dogs.
   c. It is recommended for veterinary patients with severe neurologic signs.
   d. It can be used for skull-based meningiomas.

9. Which drug has been used to treat canine intracranial meningiomas with promising results?
   a. hydroxyurea
   b. tamoxifen
   c. mifepristone
   d. vincristine

10. Which postsurgical treatment option confers the greatest improvement in survival times in dogs?
    a. chemotherapy
    b. a second surgical procedure
    c. radiation
    d. immunotherapy