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Original Article

Meningiomas in dogs

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ABSTRACT

Background: Meningiomas and gliomas are the two most common types of human intracranial tumors. However, meningiomas are not exclusively human tumors and are often seen in dogs and cats.

Methods: To present meningioma surgery in dogs and compare the surgical possibilities, tumor location, and to show the differences between human and veterinary approaches to tumor profiling. Eleven dogs with meningiomas were treated surgically for 5 years. All tumors except one were resected radically (Simpson 2). Localization of tumors mirrored that of human meningiomas.

Results: Two dogs died in direct relation to surgery. One died 14 months after surgery due to tumor regrowth. Three dogs died of unrelated causes 10–36 months after tumor resection and five dogs are alive and tumor-free 2–42 months after surgery.

Conclusion: Radical surgery in dogs is as effective as in humans. Thus, we propose that it should be implemented as first-line treatment. The article is meant to please all those overly curious neurosurgeons in the world.

Keywords: Dog, Meningioma, Radicality, Surgery

INTRODUCTION

Meningiomas and gliomas are the two most common types of human intracranial tumors. However, meningiomas are not exclusively human tumors and are often seen in dogs and cats. In the treatment of dog meningiomas, there remains a lack of clarity about surgical treatment. Radiation, chemotherapy, and even stereotactic radiosurgery are often recommended while observation and euthanasia are viable options. Despite the same histological features as humans, dog meningiomas are always considered a malignant disease and treated as such.[5,8,10] In the past 5 years, we have had an opportunity to treat 11 dogs by surgery alone. We believe our experience might be of some interest not only to veterinary doctors but also to human neurosurgeons. We, therefore, feel it worthwhile to report our experiences in this surgical field.

MATERIALS AND METHODS

The veterinary clinic (owned by one of the authors of this paper, DV) operates its own computed tomography (CT) (Siemens Emotion Duo, Erlangen, Germany). Thus, the majority of diagnostic procedures were done by CT (9/11 cases). In only two dogs was magnetic resonance (MR) available (both were done elsewhere on Siemens Essenza, Erlangen, Germany). The clinic has a standard OR [Figure 1], which is equipped with a surgical microscope (Moller-Wedel VM 900, Wedel, Germany), microdrill (Mio NE116, Japan), Cavitron ultrasonic surgical aspirator (CUSA, which we never used), bipolar coagulation (Erbe ICC300, Tubingen, Germany), suction, and microinstruments. The anesthesia is done by one member of our surgical team (DV). Vital functions are monitored throughout surgery. Postoperative care consists of basic monitoring, eventual sedation and ventilation, as well as the possibility of hospitalization for a specified period postsurgery. As all procedures were performed in registered veterinary clinic, animals were treated according to international standards in veterinary medicine including Guide for the Care and Use of Laboratory Animals. As this is retrospective noninterventional study, IRB approval was not necessary.

Figure 1: Surgical setup. The surgeons (authors) consented to publication of their image.

CT was the diagnostic procedure in nine cases; in the remaining two cases, the dogs came to our attention through MR, which was performed elsewhere. Postoperative imaging was performed in only one case. Because the owners are required to pay the full service, most did not opt for postoperative imaging.

RESULTS

Basic data are given in [Table 1]. Of the 11 dogs (five males and six females), the median age was 9 years and the median weight 23 kg. The condition of the dogs was otherwise generally healthy. Of the 11 dogs, seven presented with epileptic seizures, two with ataxia, and two with behavioral changes.

Table 1: Characteristics of whole cohort.

Case no.	Age	Sex	Weight (kg)	Breed	Presentation	Diagnostics	Localization	Follow-up (months)	Outcome
1	7	M	43	German shepherd	Epileptic seizures	CT	Sphenoid wing	36	Abdominal neoplasia
2	9	F	39	German shepherd	ataxia	CT	Cerebellopontine angle	10	Renal failure
3	9	M	37	Golden retriever	Epileptic seizures	CT	Olfactory groove	24	Lost to follow-up 2 years after surgery
4	9	F	33	Flat-coated retriever	Epileptic seizures	CT	Parasagittal	24	Died of old age 2 years after surgery
5	7	F	10	Pug	Epileptic seizures	MR	Clinoid process/ planum sphenoidale	42	Alive and well
6	11	M	48	Golden retriever	Epileptic seizures	CT	Sphenoid wing/planum sphenoidale	14	Died of tumor regrowth
7	8	F	46	Crossbreed dog	Epileptic seizures	CT	Olfactory groove	8	Alive and well
8	12	F	33	Bohemian shepherd	behavioral changes	CT	Parasagittal	0	Cardiac failure
9	9	F	15	Crossbreed dog	Ataxia	CT	Cerebellopontine angle	0	Malignant hyperthermia
10	7	M	46	German shepherd	Epileptic seizures	MR	Olfactory groove	8	Alive and well
11	10	M	46	German shepherd	Behavioral changes	CT	Convexity	2	Alive and well

CT: Computed tomography, MR: Magnetic resonance

Tumor location

In general, meningiomas of dogs can be found in the same location as human meningiomas. The sites are given in [Table 1] and the tumors are presented in [Figures 2-13].

Surgery

The skull and brain of dogs are smaller than those in humans. The location of tumors mirrors that of human tumors (see images) but the dog skull differs and the orientation is rather difficult. The approach is usually an intricate part of the surgery. In supratentorial tumors, the landmarks are midline, both orbits and bone crest between the supratentorial and infratentorial compartment. The frontal sinus is enormous, virtually covering most of the supratentorial compartment. The craniotomy is performed with a drill, where the first cut leads to the sinus and only the second is true craniotomy. Olfactory tumors are found quite easily between the orbits. The most frequent craniotomy in humans, the pterional, is somewhat different in dogs. The wing is very shallow and any millimeter miss leads to difficult orientation. The shallow and nearly flush anterior and middle cerebral fossae may lead the surgeon astray from the wing and tumor. Retracting the frontal lobe is difficult: the structures are small, where even a tiny artery of <1 mm diameter may be a major trunk. The craniotomy should always lead directly to the tumor, which is immediately apparent after opening the dura. We could resect one small clinoid tumor [Figure 6], but we did not find the stamina to attack sellar meningioma [Figure 13]. Lately, we used CT and a drill or needle to mark the bone at the site of craniotomy.

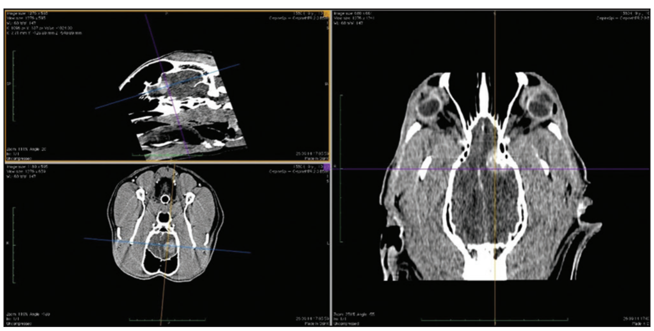

Figure 2: Left outer sphenoid wing meningioma.

The posterior fossa is even more difficult. The occipital bone is at the right angle to the spine's axis. It is usually overhung by the bone crest between the supra and infratentorial compartment where all the nuchal muscles are attached. The muscles need to be dissected free and the crest resected to gain good access to the CP angle. Except for the skin incision, whole surgery is performed under high magnification of the surgical microscope. The craniotomies are small, some 20–30 mm in diameter. The bone is not replaced, even when we entered the frontal sinus, where we encountered only one inflammatory complication.

The dura is nearly transparent and very delicate, especially in small dogs. It is opened in a regular fashion with the flap oriented towards the sinuses, which are carefully avoided. Again, the sinuses are not readily apparent and once injured the best defense to stop the bleeding is gentle tamponade with Surgicel. At the end of surgery, the dura is left opened and the DuraSeal covers the whole craniotomy.

In all but one case, we achieved radical Simpson 2 resection. We have experienced one postoperative wound infection necessitating drainage and antibiotic treatment. Two dogs died directly related to surgery: one was due to cardiac failure and the other to malignant hyperthermia (mortality 18%). Three dogs died of nonrelated causes at 10, 24, and 36 months after surgery. One died 1-year postsurgery due to a relapsing tumor. One dog was lost to follow-up at 24 months after surgery. Four dogs are alive and well 2, 8, 8, and 42 months after surgery [Table 1]. The median survival time in dogs surviving surgery was 18.7 months. Seven dogs presented with epileptic seizures; in three of these, the seizures reappeared after surgery and the dogs were put on antiepileptic drugs. All tumors proved to be meningiomas Grade I and the histological features were nearly identical to those found in human meningiomas [Figure 14].

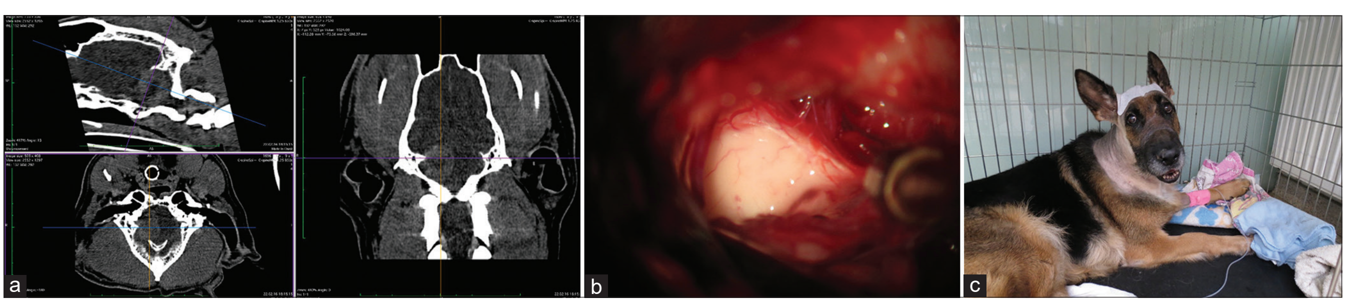

Figure 3: Right CP angle meningioma. (a) CT scan, (b) Lateral aspect of the pons after the tumor removal. (c) The patient after surgery Arachnoid well preserved. Owners consented to publication of dogs image.

(c) The patient after surgery

Figure 4: Olfactory groove meningioma.

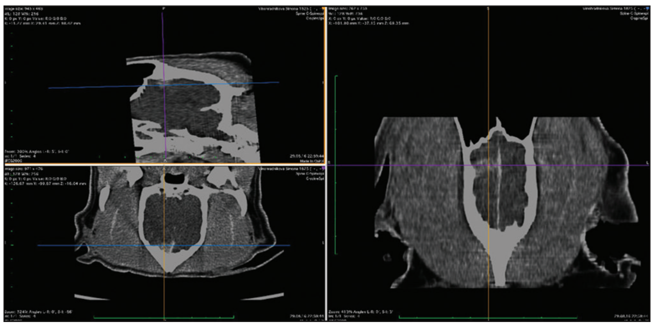

Figure 5: Parasagittal meningioma.

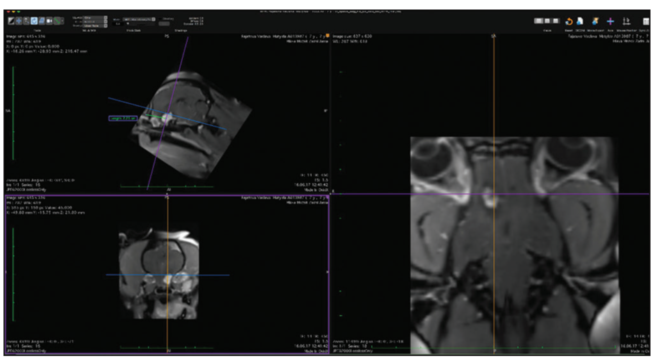

Figure 6: Right anterior clinoid/planum sphenoidale meningioma.

DISCUSSION

In the veterinary literature, meningiomas are not the trending topic as in human neurosurgery. In a systematic meta-analysis, Hu *et al*.[5] reviewed 22 studies with more than 10 patients in each study. They compiled 794 cases, of which only 109 were treated surgically and another 34 had surgery combined with radio- or chemotherapy. The majority (*n*= 449 patients) were treated by radiation.[5] Presumably, 197 of the reported tumors were meningiomas and 63 (32%) of these were treated surgically. The median survival time was given for the surgical group in four of the 22 studies (198–2014 days). However, early deaths after surgery were not reported. This period was longer than in the 134 meningioma cases treated by radiation.[5] In review articles by Axlund *et al*.[1] and Heidner *et al*.,[4] the meningiomas are from a human medicine perspective deemed and treated as a malignant disease. Surgery, if any, is followed by radio- and chemotherapy.[1,4] In some cases, where available, radiosurgery is performed.[10] These are the top veterinary clinics and hospitals' recommendations, which do not reflect the standard veterinary care where the most sophisticated techniques are usually not available. Even from the meta-analysis,[5] it is difficult to acquire precise and clear results to establish an optimal approach. Moreover, in veterinary medicine, observation and euthanasia are commonly used.

In our series, the median time that the dogs survived surgery was 18.7 months (range 2–42 months). Surgical mortality was 18%. Four dogs are alive and well 2, 8, 8, and 42 months after surgery. These results are similar to previously reported cases.[1,5,10]

Surgery for meningiomas is infrequent; the largest series we found in the literature was 39 cases (endoscopy assisted).[7] In contrast to other series, we used surgery as the only treatment, similarly to humans. All our meningiomas were nonmalignant Grade I tumors and, except for one subtotally resected case, we did not see any relapse of the disease. On the other hand, all our cases were invasive tumors, and always at least one part of the tumor grew invasively reaching brain tissue. However, this was most likely due to late diagnosis in dogs as opposed to humans. Veterinarians distinguish between dogs and cats. In cats, the meningiomas are often noninvasive, with a good plane of dissection, without attacking the arachnoid.[4] We have had an opportunity to operate on two cats with meningioma, where we observed a good plane of dissection with preserved arachnoid.

The surgical technique for dogs does not differ much from meningioma surgery in humans and entails dissection with cottonoids, breaking the tumor and piecemeal resection. Most of the tumors are soft and hence suckable.[3] They do not bleed much, and bleeding from the adjacent brain areas is usually managed by irrigation and Flo-Seal or Surgicel. Nevertheless, this does not mean that the surgery is easy and straightforward.

We always tried to achieve Simpson 2 resection with the coagulation of the tumor origin (the concept of human neurosurgery was never mentioned in the veterinary reports). Veterinarians have published, for instance, more prolonged survival with the implementation of CUSA,[3] endoscopic assistance,[7] and one even with intraoperative MR imaging (iMRI).[6] In all these techniques, survival was longer compared to other studies. This observation raises the question about the initial radicality of primary surgeries in other reports. We did not find sufficient data to evaluate surgical radicality. Postoperative imaging is not mentioned in the veterinary reports.[1,5,7,10] We also did not do routine

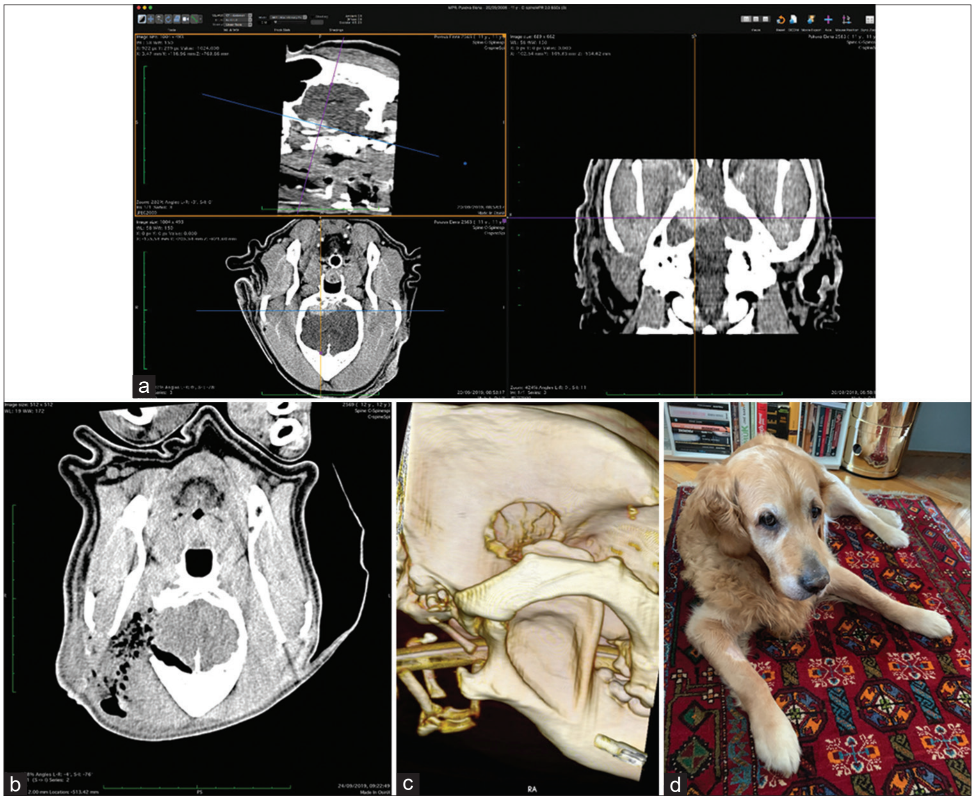

Figure 7: Right sphenoid wing meningioma. (a) Preoperative computed tomography (CT), (b) immediate postoperative CT, (c) CT reconstruction of pterional craniotomy. (d) The dog 3 months after the surgery. Owners consented to publication of dogs image.

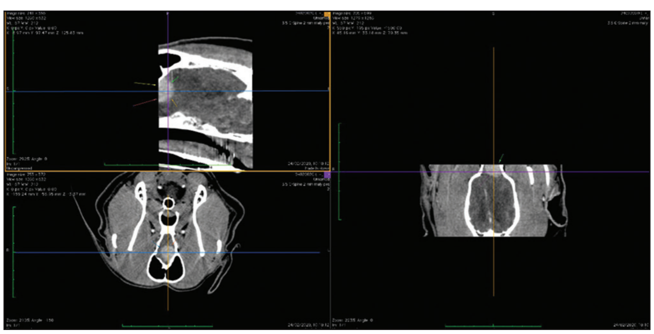

Figure 8: Olfactory groove meningioma.

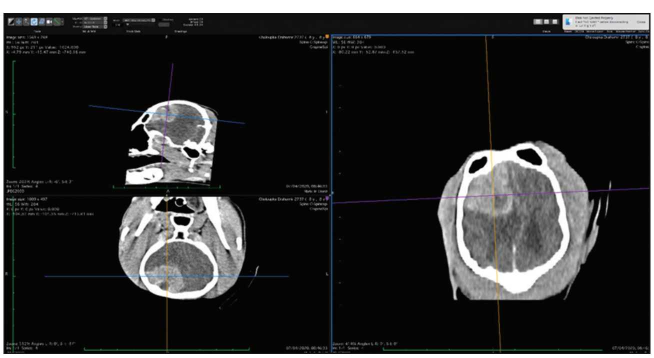

Figure 9: Parasagittal meningioma.

postoperative CT or MR but relying instead on the surgeon's experience (and instinct). Moreover, we did know about the only remnant we left behind [Figure 7].

Location-wise our tumors closely mirrored those of humans. We have seen olfactory, parasagittal, sphenoid wing, and cerebellopontine angle tumors. In the review of Motta *et al.*,[10] the tumors are divided basically into two groups: forebrain and caudal brain. The significant bulk of reported surgically treated tumors seem to be olfactory bulb and forebrain (convexity and parasagittal) tumors.[5,10] Our team has found only two case reports on surgical treatment of posterior fossa tumors.[2,9] We have operated on two dogs with cerebellopontine meningioma [Figures 3 and 10]. One dog died immediately after surgery due to cardiac failure; the other survived without any deficit but succumbed 10 months later due to renal failure. In both cases, we achieved Simpson 2 resection.

In the veterinary literature, survival is prolonged by radiation and chemotherapy.[1,4,5,8,10] Unfortunately, the radicality of surgery was not given in any veterinary report and one may hypothesize that radical surgeries were not likely performed. Given the longer survival for CUSA, endoscopic assistance, and iMRI techniques,[5-7] it seems that the surgeries were most likely not radical in

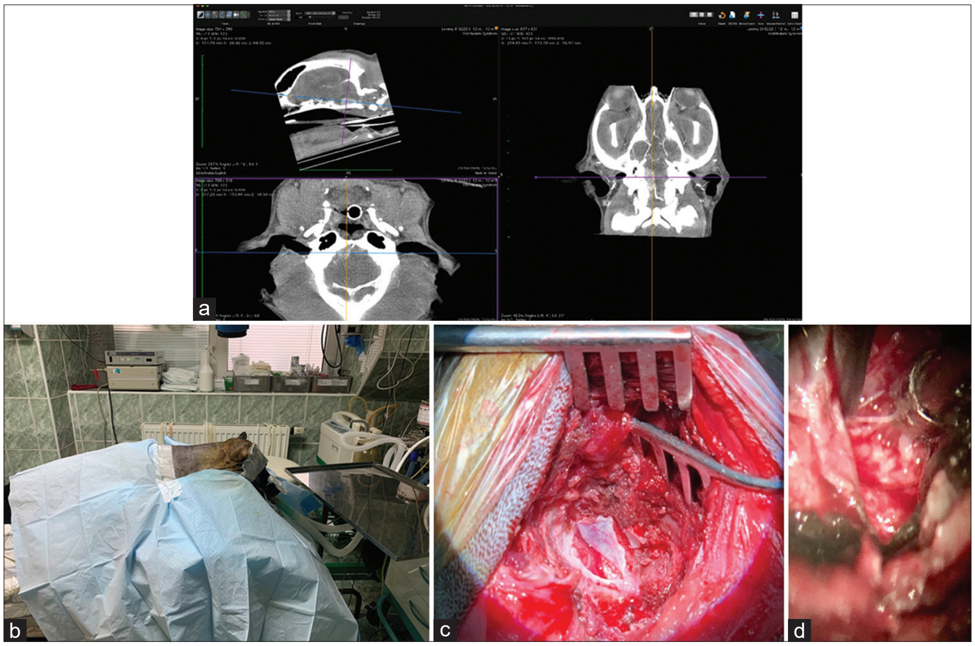

Figure 10: CP angle meningioma. (a) Computed tomography, (b) patient positioning, (c) craniotomy and durotomy, (d) the tumor is seen in front of IXth–XIth nerves.

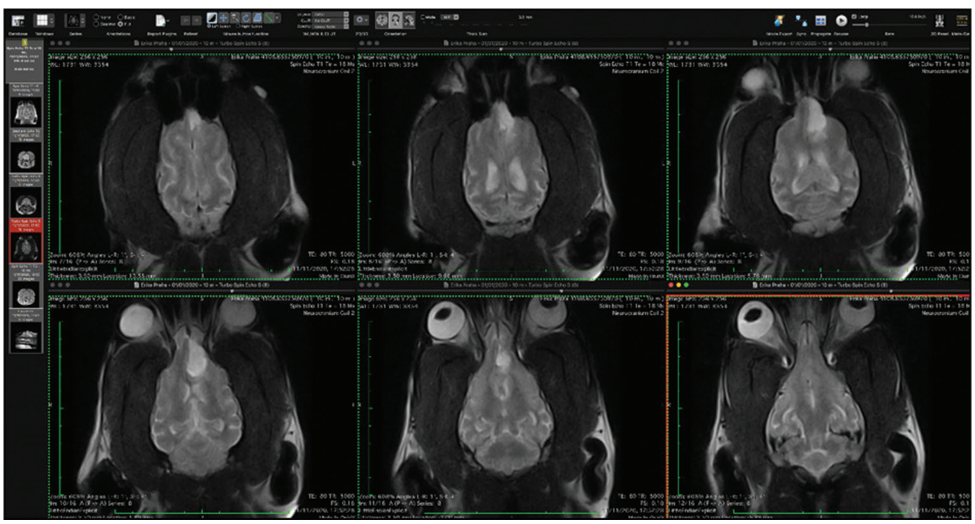

Figure 11: Olfactory groove meningioma, magnetic resonance scan.

the other reports. With the usual fragility of the tumor, difficult access, and restricted view of the surgical field, it may be easy to overlook some remnants. In addition, the treatment of the tumor origin was not mentioned. We always coagulate the dura of the tumor origin. The survival times shown in [Table 1] correspond to the range of survival times reported by the veterinarian literature when radiation is used.[11,12] We can conclude that radical surgery provides sufficient results and radio- and chemotherapy are not needed as is the case in human tumors.[12]

Survival is not long considering human time perception. However, the equivalent of 1 year for a human is 7 for a dog, which is 1/12–1/15th of the animal's life span. This information must be conveyed to the dog owners and they must be advised of alternatives (most probable would be euthanasia). The treatment cost also needs to be taken into account, as pets do not have health insurance. It might be worthwhile to speculate on the speed of growth in dog meningiomas. Do they grow proportionally faster than human meningiomas given that the life span of the dog is shorter or do they grow slower? The latter option does not seem plausible. Thus,

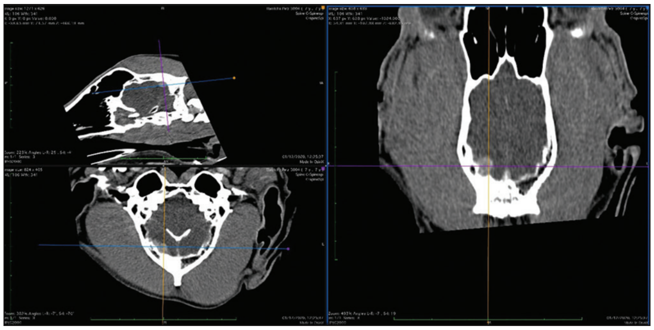

Figure 12: Small convexity meningioma.

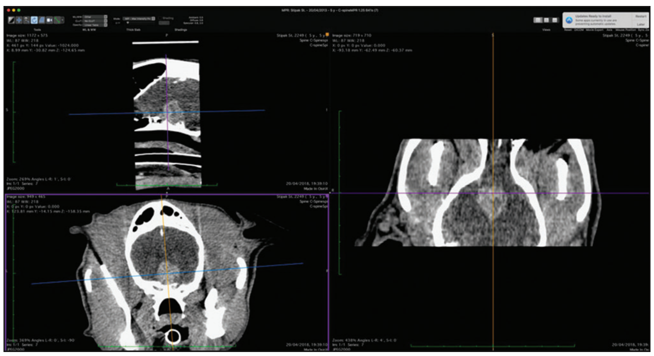

Figure 13: Sellar meningioma. Not indicated for surgery.

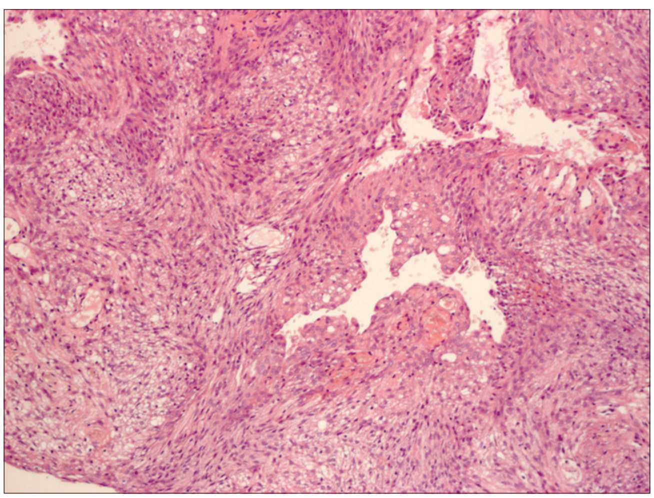

Figure 14: Meningioma Grade I. There is a difference from human tumors.

the relapse of the disease or the growth of the remnant 1 year after the initial treatment seems a more reasonable outcome.

CONCLUSION

For a neurosurgeon with extensive experience with meningiomas, the dog meningiomas pose an "amusing challenge." Given the size of the dog's brain, it is a true form of microneurosurgery. The authors hope the article can lighten up the mood from the technical and heavy science literature we usually encounter in our medical journals and that it will fall in with the perpetual and insatiable curiosity inherent in those professionals working in the field of neurosurgery.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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