Subjective Evaluation of Computed Tomography and Magnetic Resonance Imaging for Detecting Intracalvarial Changes in Canine Nasal Neoplasia

Ravinder S. Dhaliwal, DVM, MS, DACVIM (Oncology), DABVP[a]
Barbara E. Kitchell, DVM, PhD, DACVIM (Internal/Oncology)
John M. Losonsky, DVM, MS, DACVR
Igor V. Kuriashkin MD, PhD
Robert B. Clarkson, DVM, PhD

Department of Veterinary Clinical Medicine
College of Veterinary Medicine
University of Illinois, Urbana, IL 61802

[a]*Present address: South Bay Veterinary Specialists, 5440 Thornwood Drive, San Jose, CA 95123.*

KEY WORDS: canine, canine nasal malignancy, computed tomography, magnetic resonance imaging

ABSTRACT

Paired imaging studies consisting of computed tomography (CT) and magnetic resonance imaging (MRI) were performed in eight dogs to evaluate subjectively whether MRI is superior to CT in detecting intracalvarial changes associated with canine nasal neoplasia. Imaging in four anatomical regions (caudal ethmoturbinates, cribriform plate, frontal sinuses, and the olfactory peduncle of the frontal lobes of the brain) were compared. The region of the olfactory peduncle of the frontal lobes was the only region with an observed difference between the paired images. Although a difference between the imaging methods was noted in only three of the eight cases studied, it appeared that the soft tissue contrast was better with MRI than that acquired by CT in all three cases. It was concluded that there was no difference noted in detecting intracalvarial changes in the specified structures between CT and MRI. If MRI is not available, CT images provide valuable clinical information.

INTRODUCTION

Neoplasms involving the nasal and paranasal sinuses are rare in dogs. Intranasal neoplasia accounts for 1% to 2% of all reported canine neoplasms.[1,2] Of these neoplasms, 80% are malignant, and 60% to 75% of malignant intranasal neoplasms are epithelial in origin.[3,4] Large-breed male dogs more than 7 years of age have been overrepresented in clinical studies. Commonly reported canine intranasal neoplasms include adenocarcinoma, squamous cell carcinoma, undifferentiated carcinoma, chon-

drosarcoma, fibrosarcoma, osteosarcoma, and lymphosarcoma. Less commonly seen tumors include mast cell tumor, transmissible venereal tumor, melanoma, histiocytoma, and hemangiosarcoma.[3] Most canine nasal malignancies are locally aggressive and rare to metastasize. The majority of nasal neoplasms in dogs and cats are located at or near the cribriform plate at the time of presentation. Extension through the nasal cavity to adjacent tissue is common in advanced cases.[5] Approximately one-half of the nasal tumors in dogs have bilateral involvement at the time of diagnosis.[6]

Magnetic resonance imaging (MRI) and computed tomography (CT) were compared to detect changes associated with intranasal neoplasia in dogs. The purpose of the present study was to determine whether MRI is superior or complementary to CT in detecting intracranial changes associated with canine nasal malignancies. The significance of intracranial invasion by the nasal neoplasia as a prognostic factor is not known at the present time, but this information is critical to radiation treatment planning.

Past studies have suggested that the extent of canine intranasal neoplasia is often difficult to define accurately by survey radiographs as compared with CT imaging because they are limited to the transverse plane, or in nasal imaging, the dorsal plane.[7–9] Additional image planes are available using computer reformation, which compromises resolution because sagittal, dorsal, and oblique planes are not primary acquisitions. MRI can be acquired in any plane desired by the operator. Superior soft tissue contrast and no superimposition of overlying structure make CT and MRI advantageous over conventional radiography. CT has proven to be superior to conventional radiography for detecting changes within the nasal cavity, defining the extent and severity of disease processes, and in differentiating infectious rhinitis from nasal neoplasia.[8] CT provides vital information to assist in radiation treatment planning and to provide prognostic information.[9] Advantages of MRI relative to CT include the superior ability of MRI to detect subtle changes within the brain parenchyma and to provide superior contrast within soft tissue structures.[10,11] Additionally, CT lacks ionizing radiation. One report suggests that MRI could be the imaging modality of choice in dogs and cats when an intracranial or extracranial tumor invasion is suspected.[12]

The purpose of this study was to evaluate subjectively whether MRI is superior to CT in detecting intracalvarial changes associated with canine nasal neoplasia.

MATERIALS AND METHODS

Eligibility Criteria

Selection of dogs for participation in this study was based on histologically confirmed diagnosis of nasal malignancy, having paired MRI and CT studies completed within the previous 3-week period, and no prior cytoreductive surgery or neoadjuvant chemotherapy. The rationale for allowing a maximum 3-week delay in paired studies included concern for prolonged anesthesia and to allow for technical difficulties with the scanning equipment. Initially, 13 dogs were enrolled. Five of the 13 dogs did not meet the 3-week time criteria and were subsequently excluded from the evaluation. One of the five dogs excluded from participation had a tumor located in the maxillofacial region, and CT evaluation failed to reveal nasal involvement. Complete evaluations were performed at the University of Illinois, Veterinary Medical Teaching Hospital. Imaging with both instruments was completed for six of the eight dogs on the same day. CT imaging was done 3 weeks after the MRI for one dog, and CT imaging was done 3 days after MRI for another dog.

All dogs had clinical signs consistent with nasal malignancy, including chronic sneezing, tenacious mucoid nasal discharge, progressive unilateral to bilateral epistaxis, and facial deformity. No dog in this group was presented with any neurologic signs. Clinical laboratory tests performed on all dogs before CT or MRI imaging included a

Table 1. Results of Changes Noted in Dogs with Intranasal Neoplasia Evaluated by Computed Tomography (CT) and Magnetic Resonance Imaging (MRI)

Case No.	Time Interval Between CT and MRI Study (days)	Cribriform Plate		Caudal Ethmoturbinates		Frontal Sinus		Olfactory Peduncle	
		CT	MRI	CT	MRI	CT	MRI	CT	MRI
1	0	+	+	+	+	–	–	–	–
2	0	+	+	+	+	+	+	–	+
3	0	+	+	+	+	–	–	–	–
4	17	+	+	+	+	–	–	–	–
5	0	+	+	+	+	+	+	–	–
6	0	+	+	+	+	+	+	+	–
7	0	+	+	+	+	–	–	–	–
8	3	+	+	+	+	+	+	+	–
Total Positive Cases		8	8	8	8	4	4	2	1

+ = pathologic changes present; – = pathologic changes absent.

complete blood count, biochemical profile, and three views of thoracic radiographs (right and left lateral and ventro-dorsal).

Computed Tomography and Magnetic Resonance Imaging

Computed tomography (GE 8800 CT scanner; GE Healthcare) and magnetic resonance imaging (0.15 Tesla; Teslacon Technicare) scanners were used. Sagittal and dorsal reformations of CT images were made of the primary-acquisition transverse slices at 2-mm intervals. Sagittal, transverse, and dorsal plane images were obtained as primary acquisitions for MRI studies. Imaging with both instruments was performed with dogs under general anesthesia. The time required was approximately 30 to 40 minutes for each imaging study. Paired CT and MRI images were reviewed jointly by three experienced investigators.

Identical anatomical regions (i.e., caudal ethmoturbinates, cribriform plate, frontal sinuses, and the olfactory peduncle of the frontal lobes of the brain) were compared in both imaging studies. Criteria for pathologic change included abnormal shape or displacement of structure in the four anatomic structures studied. Any evidence of contrast enhancement, bony destruction, or soft tissue invasion by the neoplastic process was considered a positive pathologic change. CT scans were evaluated independently from the MRI scans.

Iothalamate meglumine (Conray, Mallinkrodt Medical) was administered IV at 880 mg per kg of body weight (3.12 ml per kg) for the CT studies. This solution provides 282 mg organically bound iodine per ml. The contrast media was a bolus injection delivered as rapidly as possible by hand. For T1-weighted MRI studies, gadoteridol (ProHance, Bracco Diagnostics) was administered IV at 0.4 ml per kg of body weight.

T1-weighted images were obtained before and after administration of contrast media with a repetition time of 650 milliseconds and an echo time of 30 milliseconds. T2-weighted images were obtained using a repetition time of 2,500 milliseconds and an echo time of 120 milliseconds. MRI images were obtained in sagittal, transverse, and dorsal planes before and after contrast media administration. T2-weighted transverse images also were obtained. The most sensitive image acquisition to detect fluids, such as peritumoral edema, is the T2-weighted sequence, which more precisely defines the total margins of the lesion. Although T2-weighted sequences are more sensitive, they offer less resolution. For MRI, the slice thickness was 5 mm, whereas the slice thickness for sagittal and dorsal

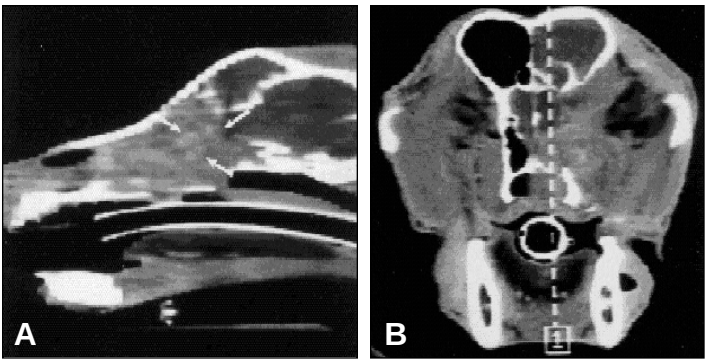

Figure 1. CT image from a dog (Case 6), illustrating a 2-mm parasagittal reformation at level of right olfactory peduncle (**A**). The arrow indicates suspect involvement in area of contrast enhancement. The dotted line (**B**) indicates the angle of acquisition of the sagittal reformation seen in **A**.

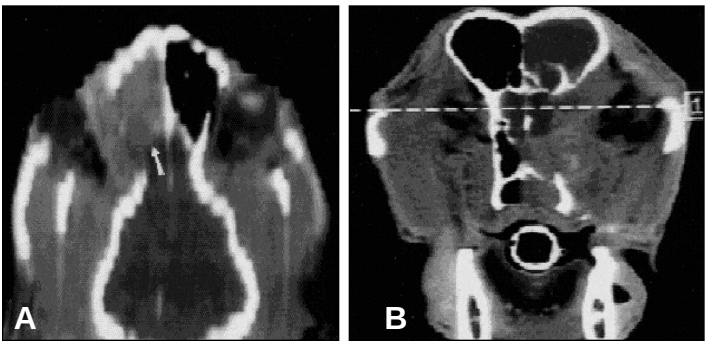

Figure 2. CT image from a dog (Case 6), illustrating a 2-mm dorsal level reformation from the midlevel of the olfactory peduncle (**A**). The arrow shows suspect area of post-contrast enhancement in rostral right brain. The dotted line (**B**) indicates the angle of acquisition of dorsal reformation seen in **A**.

images was 4 mm. The image matrix for all images was 192 × 192, and the slice interspacing was 0.6 mm for all image slices. The window for T1 images before and after contrast administration was 800 with a level of 300. For T2 images, the window was 1024 with a level of 385.

CT was performed of the nasal passages with a 3rd generation GE (9800 and 8800) CT/T scanner with the animal under general anesthesia. The nasal and cranial regions were imaged in a transverse plane using a 5-mm slice thickness with a 2-second acquisition time. The settings for small, medium, and large dogs were 80 kVp/70 mA; 80 kVp/120 mA; and 80 kVp/120 mA, respectively.

RESULTS

Findings and conclusions regarding changes noted were consistent among all three investigators. Four of the eight dogs evaluated had nasal adenocarcinoma, two had nasal chondrosarcoma, and two had nasal carcinoma. Findings of paired CT and MRI images obtained at the levels of cribriform plate, caudal ethmoturbinates, frontal sinuses, and the olfactory peduncle of the rostral brain are presented in Table 1.

No differences were observed at the level of cribriform plate, caudal ethmoturbinates, or frontal sinuses in all eight cases. The olfactory peduncle of the rostral brain showed pathologic involvement in two cases (Cases 6 and 8) based on CT findings, whereas MRI revealed no anatomic abnormalities. Similarly, olfactory peduncle of the rostral brain showed pathologic involvement in one case (Case 2) based on the MRI scan, but CT image on the same case revealed no abnormality.

Invasion of tumor into the brain was thus equivocal in three of the eight cases (Cases 2 ,6, 8). For Case 8, a CT sagittal reformation suggested a neoplastic lesion encircling the brain, whereas the MRI revealed no brain involvement. Differences noted between the CT and MRI results for Case 6 are illustrated in Figures 1 to 4. In the remaining five cases, CT was diagnostic and ruled out any soft tissue extension into the brain.

DISCUSSION

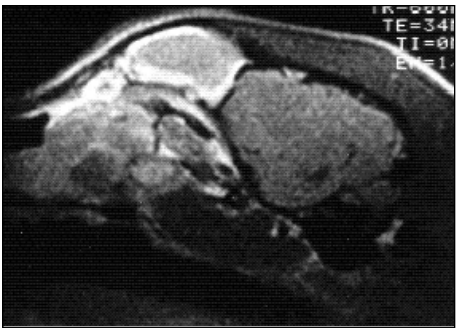

Figure 3. Right parasagittal MRI image from a dog (Case 6), taken after contrast approximately 3 mm lateral to the midsagittal plane, reveals no enhancement of brain parenchyma.

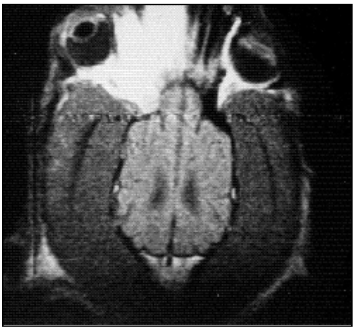

Figure 4. Dorsal MRI image from a dog (Case 6) taken after contrast at level of orbits reveals no brain parenchyma involvement. The straight line coursing through the MRI image is a linear artifact.

Broadly speaking, the results reported are identical for CT and MRI, except for the perceived brain invasion. The word "equivocal" has been used in the presentation of results for CT and MRI in their ability to detect intracranial invasion by canine nasal malignancy. This statement is supported by results for Case 6. In this particular case, the CT image shows mild enhancement adjacent to the brain parenchyma and may not be invading the brain tissue. Some clinicians and radiologists believe that brain invasion by nasal neoplasm results in moderate to intense uptake of contrast material within the brain parenchyma.

The authors initiated this study in general agreement with other investigators that MRI is superior to CT in detecting soft tissue changes, but results of this study did not support that hypothesis.[13] More prospective studies with greater numbers of cases must be performed to compare MRI and CT for detection of intracranial invasion by canine nasal malignancy.

Nasal tumors are infrequently diagnosed early in the course of the disease, primarily because early clinical signs are not recognized by the owners. Nasal disorders are presented with very similar clinical signs, regardless of the underlying pathology. The median duration of signs prior to diagnosis reported in one study was 3 months.[3] With the increased availability of CT, MRI, and rhinoscopy, an early diagnosis of a nasal neoplasia is possible. The cost of these diagnostic procedures and the necessity of general anesthesia are still the limiting factors to the widespread use of such advanced imaging modalities in veterinary medicine. Most nasal tumors are locally aggressive, and distant metastasis is rare, although reports indicating regional lymph node and pulmonary metastasis from the primary nasal neoplasm do exist in the literature.[6,14] Distant metastases (pulmonary and regional lymph nodes) were found at necropsy in 41% of dogs that had been treated with radiotherapy for nasal neoplasia.[14] Metastasis rate appears to be lowest among sarcomas.[6] Megavoltage external beam-radiation therapy is the treatment of choice for canine intranasal malignancies. However, it must be noted that nasal cavity nonkeratinizing squamous cell carcinoma in dogs responds poorly to radiotherapy.[15]

Clinical signs for nasal neoplasia may vary and are dependent on the extent of local tumor involvement in the nasal cavity and the surrounding anatomic structures. Initially, nasal discharge (bloody, mucopurulent, or serous), sneezing, facial deformity, and a temporary response to antibiotics are noted. In advanced disease, there is destruction of the nasal septum with bilateral involvement, deformation of the nasal bones, proptosis, and invasion of the tumor into the olfactory lobe of the brain through the cribriform plate.[4] In all eight cases described in the present report, the cribriform plate was invaded by the nasal neoplasia, which was evident on both CT and MRI images. CT

and MRI both provide more detailed diagnostic and prognostic information than does conventional radiography. These cross-sectional imaging modalities have proven to be much more sensitive to early changes observed with intranasal tumors than is conventional skull radiography.[9,13] Standard skull radiographs can provide valuable information in diagnosing nasal tumors with loss of fine trabecular pattern. These changes are better delineated with an open-mouth ventrodorsal view. As the disease progresses, deviation or lysis of the nasal septum and invasion of the frontal sinuses can be noted on conventional radiography.[16] Radiography was considered a reliable means for diagnosing nasal neoplasia in dogs when an external mass and erosion of the bony nasal septum were evident.[17] Radiographic criteria used to evaluate the aggressiveness of a nasal cavity lesion on skull radiographs include loss of bone margination (confinement), bone destruction, and periosteal new bone production.[4] It is suggested that radiographs be performed prior to rhinoscopy to prevent loss of radiographic detail due to rhinoscopy-induced hemorrhage.[4] A detail (fine) rare-earth intensifying screen-film combination should be used.[18] Excellent clinical information to diagnosis nasal disease in dogs can be aided by nasal radiographs, CT, and MRI, but a nasal biopsy with cytologic and histologic evaluation of tissue specimens is essential to confirm the diagnosis.

This is strictly an observational study and suggests that MRI is complementary to CT in detecting changes in the brain parenchyma secondary to nasal neoplasia. Findings in this study were not consistent with Moore et al,[13] whose study of four dogs demonstrated that MRI images were superior to CT images for detection of cribriform plate involvement and provided better anatomic detail both of the tumor and of secondary changes, such as edema and compression of the adjacent tissue.

CT provides better detail for detecting bony changes in the nasal and skull region secondary to nasal neoplasia. Compact bone has insufficient hydrogen protons due to low water content and thus low signal is generated for MRI scans. Because of the low number and characteristics of the hydrogen protons in bone, MRI is not considered useful in bone evaluation, whereas CT provides excellent detail of the bony structure.[10,19] CT or MRI both provide information important for radiation therapy planning. MRI provides much more detailed information about the brain and surrounding soft tissue structures. Although a difference was noted in only three of the eight cases studied, it appeared that the soft tissue contrast was better imaged with MRI than that acquired by CT in all eight cases. From the results of this study, it is suggested that MRI (if available) should be performed to evaluate the intracalvarial changes associated with intranasal neoplasia in dogs.

Multiple sagittal and dorsal reformations at 2-mm intervals were made from the original transverse CT slices. No difference in diagnostic information was noted when CT and MRI scans were compared at the levels of cribriform plate, frontal sinuses, and caudal ethmoturbinates. This indicates that CT is equivalent to MRI in detecting changes, and reformation images provide the same information at those levels. The transverse CT images suggested involvement of the olfactory peduncle in three cases. Sagittal and dorsal reformations of the acquired transverse images refuted intracranial invasion in one of these three cases. In one other case, CT revealed no abnormalities at the level of olfactory peduncle, but MRI showed involvement of the olfactory peduncle by nasal neoplasia. Multiple 2-mm reformations from the originally acquired transverse CT acquisition, while laborious, do provide additional information regarding intracalvarial invasion by canine intranasal neoplasia. Accurate determination of destruction or minor invasion into the cribriform plate is often difficult to detect using CT imaging unless the invasion is pronounced. This is because the cribriform plate is a dome-shaped structure.

Quantitative value could have been obtained by measuring the houndsfield units both before and after contrast, which would have provided more information regarding whether or not contrast enhancement did occur. This quantification was not done in this study because a normal reference range for the dog skull was not available.

Human literature review reveals that CT is the examination of choice in staging sinonasal tumors. However, MRI yields valuable information in cases where the neoplasm has invaded the surrounding muscle and soft tissue.[20] CT and MRI are also important in effective radiotherapy planning, enabling more accurate radiation dose delivery to the tumor bed.[14] A previous study[13] also showed that MRI images were superior to CT images in identifying changes with nasal tumors involving the rostral brain. That study revealed MRI was a better indicator of peritumoral edema, displacement of normal brain tissue by the tumor mass, and collapse of the lateral ventricles. These three abnormalities were not as easily recognized with CT images. All four dogs in that study demonstrated clinical signs of nasal tumor invasion into the central nervous system and neurologic abnormalities. None of the eight dogs in the present study displayed clinical signs of central nervous system involvement.

Although a statistical evaluation can be performed on the present data to calculate the numerical significance of the results, such analyses were not performed because changes noted in MRI versus CT images were clinically significant, which was considered sufficient for determination of methodology superiority. A small number of cases are reported here because of financial limitations imposed by CT and MRI. Extended anesthesia time in acquiring images of geriatric patients was also a consideration.

CONCLUSIONS

From this study, it was concluded that there was no difference noted in detecting changes in the specified structures between MRI and CT. MRI was complementary to CT in detecting subtle changes in the region of the olfactory peduncle of the frontal lobes of brain. It was also concluded that MRI offers the advantage of multiplanar image acquisition, but if MRI is not available, multiple reformations of CT images may provide valuable diagnostic information.

ACKNOWLEDGMENTS

This study was supported by a grant form the Companion Animal Memorial Fund. The authors thank Shawn Lynn and Richard Keen for technical assistance.

REFERENCES

1. Brodey RS: Canine and feline neoplasia. *Adv Vet Sci Comp Med* 1970; 14:309–354.
2. Confer AW, DePaoki: Primary neoplasms of the nasal cavity, paranasal sinuses and nasopharynx in the dog. *Vet Pathol* 1978; 15:18–30.
3. Madewell BR, Priester WA, Gillette EL, et al: Neoplasms of the nasal passages and paranasal sinuses in domesticated animals as reported by 13 veterinary colleges. *Am J Vet Res* 1976; 37:851–856.
4. Legendre AM, Spaulding K, Krahwinkel DJ Jr: Canine nasal and paranasal sinus tumors. *J Am Anim Hosp Assoc* 1983; 19:115–123.
5. Ogilvie GK, LaRue SM: Canine and feline nasal and paranasal sinus tumors. *Vet Clin North Am Small Anim Pract* 1992; 22:1133–1144.
6. Patnaik AK: Canine sinonasal neoplasms: Clinicopathological study of 285 cases. *J Am Anim Hosp Assoc* 1989; 25:103–114.
7. Thrall DE, Robertson ID, McLeod DA, Heidner GL, Hoopes JP, Page RL: A comparison of radiographic and computed tomographic findings in 31 dogs with malignant nasal cavity tumors. *Vet Radiol* 1989; 30:59–66.
8. Codner EC, Lurus AG, Miller JB, et al: Comparison of computed tomography with radiography as a noninvasive diagnostic technique for chronic nasal disease in dogs. *JAVMA* 1993; 202:1106–1110.
9. Park RD, Beck ER, LeCouter RA: Comparison of computed tomography and radiography for detecting changes induced by malignant nasal neoplasia in dogs. *JAVMA* 1992; 201:1720–1724.
10. Shores A: Magnetic resonance imaging. *Vet Clin North Am Small Anim Pract* 1993; 23:437–459.
11. Tucker RL, Gavin PR: Brain imaging. *Vet Clin North Am Small Anim Pract* 1996; 26:735–757.
12. Voges AK, Ackerman N: MR evaluation of intra and extracranial extension of nasal adenocarcino-

ma in a dog and cat. *Vet Radiol Ultrasound* 1995; 36:196–200.

13. Moore MP, Gavin PR, Kraft SL, et al: MR, CT and clinical features from four dogs with nasal tumors involving the rostral cerebrum. *Vet Radiol* 1991; 32:19–25.
14. Adams WM, Withrow SJ, Walshaw R, et al: Radiotherapy of malignant nasal tumors in 67 dogs. *JAVMA* 1987; 191:311–315.
15. Correa SS, Mauldin GN, Mauldin GE, Patnaik AK: Efficacy of cobalt-60 radiation therapy for the treatment of nasal cavity nonkeratinizing squamous cell carcinoma in the dog. *J Am Anim Hosp Assoc* 2003; 39:86–89
16. Bright RM, Bojrab MJ: Intranasal neoplasia in the dog and cat. *J Am Anim Hosp Assoc* 1976; 12:806–812.
17. Harvey CE, Biery DN, Morello J, et al: Chronic nasal disease in the dog: Its radiographic diagnosis. *Vet Radiol* 1979; 20:91–98.
18. Miyabayashi T, Biller DS, Haider PR, et al: Radiographic appearances of the nasal conchae in dogs using different screen-film systems: A postmortem study. *J Am Anim Hosp Assoc* 1994; 30:382–388.
19. Thomson CE, Kornegay JN, Burn RA, et al: Magnetic resonance imaging—a general overview of principles and examples in veterinary neurodiagnosis. *Vet Radiol Ultrasound* 1993; 34:2–17.
20. Krengli M, Avataneo T, Orecchia R, et al: Definition of the T parameter in nasosinusal neoplasms: a CT-MR comparison. *Radiol Med (Torino)* 1993; 86:89–94.