Original Article

The effectiveness of computed tomography in differentiating nasal neoplastic disease from non-neoplastic disease in dogs

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Abstract

Seventy-eight dogs with symptoms of rhinitis were evaluated by computed tomography (CT) to differentiate nasal neoplastic diseases (neoplastic group) from non-neoplastic diseases (non-neoplastic group). The age distribution was significantly higher in the neoplastic group ($p < 0.001$). Miniature Dachshunds were seen significantly more in the non-neoplastic group ($p < 0.001$). The CT findings of osteolysis (nasal septum, hard palate, cribriform plate) and tumor infiltration (nasopharyngeal, orbit and surrounding subcutaneous tissues) were significantly more frequent in the neoplastic group ($p < 0.001$). The median CT number was 50.8 HU in the neoplastic group and 38.0 HU in the non-neoplastic group ($p < 0.001$), and the median standard deviation for each case was 9.3 HU in the neoplastic group and 24.1 HU in the non-neoplastic group ($p < 0.001$). These results suggest that the CT numbers in neoplastic lesions are uniform compared to the numbers in non-neoplastic lesions. In conclusion, a neoplastic lesion can be suggested when CT images reveal osteolysis, aggressive invasiveness and homogeneous CT numbers.

Key word : Canine, Computed tomography, Miniature Dachshund, Nasal tumor, Rhinitis

Introduction

There are numerous causes of canine nasal diseases, including infectious diseases (viral, bacterial, and fungal), allergic diseases and neoplastic diseases [2, 15]. Nasal neoplasia accounts for most of the tumors in the category of respiratory diseases in the World Health Organization (WHO) TNM classification of malignant tumors [13]. Differentiating neoplastic from non-neoplastic diseases in dogs with nasal symptoms is very important because the two types of disease present similar clinical signs. Improvement in clinical signs after administration of antibiotics, non-steroidal anti-inflammatory drugs and steroids does not exclude the possibility of neoplastic disease [15], and histopathology is considered to be necessary for a definitive diagnosis. Sampling tumor tissue, however, is difficult because the tumor lesion is surrounded by bony structures, and the collection of a biopsy specimen becomes difficult when inflammatory tissue coexists with the tumor.

Both computed tomography (CT) and magnetic resonance imaging (MRI) are coming into wider use as diagnostic tools in veterinary medicine. Because they enable the imaging of soft tissues despite overlying bony structures, they have become important tools in diagnosing nasal diseases [3, 5, 6]. The MRI is useful in evaluating soft tissues, but this method is still difficult to use routinely in veterinary clinics because few facilities have the equipment. On the other hand, CT has been introduced in more facilities, making it easier to use it as a diagnostic tool for nasal disease [3, 16].

Dogs that were referred to Azabu University with nasal symptoms and underwent CT examination were included in this retrospective evaluation of the reliability of CT images for differentiating neoplastic and non-neoplastic diseases.

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Materials and Methods

Dogs that were referred to the Diagnostic Radiology Department and Oncology Department at Azabu University Veterinary Teaching Hospital during a period from April 2002 to January 2007 with nasal symptoms and underwent CT examinations were included in this study. Those that had already had surgical or radiation therapy were excluded from this study.

Dogs in which malignant tumors had been histopathologically diagnosed from biopsy specimens taken at the time of CT examination at this hospital or at the referring veterinary hospital were categorized in the neoplastic disease group. Dogs with bacterial and mycological culture evaluations, CT examination, follow-up of clinical signs, and those that had non-neoplastic disease histopathologically diagnosed were categorized in the non-neoplastic disease group. A total of 78 dogs were included in this study: 50 in the neoplastic group and 28 in the non-neoplastic group. The median follow-up period of the non-neoplastic group after the CT examination was 28 months (range, 0.5–61 months) and all dogs were still alive at follow-up.

Data collected from the medical records included breed, sex, age, body weight, and duration of clinical signs (sneezing, nasal discharge, epistaxis and facial deformity) from the onset of clinical signs to the first visit. Tumors were staged using a modification of the WHO TNM system [1]. CT images were evaluated for the presence or absence of lesions, location of the lesion (unilateral or bilateral), osteolysis (incisive bone, nasal septum, bone above the hard palate, cribriform plate and frontal sinus), and invasiveness (nasopharynx, frontal sinus, orbit and surrounding subcutaneous tissue).

The CT scans were obtained using a single-slice scanner (Xvision/GX, Toshiba, Tokyo, Japan). Scans were taken at 120kVp and 75mA, with 1–5mm thickness. In this study, contrast medium was not used to distinguish neoplastic and non-neoplastic disease at the nasal cavity and frontal sinus. The CT numbers within the nasal cavity and the frontal sinus for a 10×10 pixel area were measured at the center of the lesions (Hounsfield Units, HU). Median and standard deviation of CT numbers were then calculated and compared between the two groups.

The Mann-Whitney U test was used to analyze age distribution, body weight and CT numbers. The chi-square test was used to analyze CT findings, and Yates calibration was used as needed. Breed distribution was a multiple comparison; therefore, a Bonferroni correction was applied in the statistical adjustment. *P* values <0.05 were considered significant for all of the statistical analyses.

Results

The common breeds in the neoplastic group were Golden Retriever (*n*=9), Shetland Sheepdog (*n*=6), Beagle and Shiba Inu (*n*=4 each), and Labrador Retriever (*n*=3). The other breeds were Siberian Husky, Papillon, Maltese (*n*=2 each), Miniature Dachshund, Collie, Bull Terrier, Toy Poodle, Alaskan Malamute, Pug, and Border Collie (*n*=1 each) and mixed breed (*n*=9). The common breeds in the non-neoplastic group were Miniature Dachshund (*n*=14) and Golden Retriever (*n*=3). The other breeds were Shetland Sheepdog, Labrador Retriever (*n*=2 each), Yorkshire Terrier, Beagle, Shih Tzu, Old English Sheep Dog, Welsh Corgi, Toy Poodle, and mixed breed (*n*=1 each). Miniature Dachshunds were seen significantly more often in the non-neoplastic group (*p*<0.001). In the neoplastic group, 34 dogs were male (13 neutered) and 16 were female (seven spayed), and in the non-neoplastic group, 20 were male (six neutered) and eight were female (five spayed). No significant difference was seen in the sex distribution between the groups. The mean and the median ages of dogs in the neoplastic group were 10.2 and 10.0 years (range, 5–15 years), respectively, and those of dogs in the non-neoplastic group were 7.1 and 7.0 years (range, 2–13 years), respectively. The mean age of the neoplastic group was significantly higher than that of the non-neoplastic group (*p*<0.001). The median weight of the dogs in the neoplastic group was 14.2 kg (range, 2.5–46.6 kg) and that of dogs in the non-neoplastic group was 6.8 kg (range, 2.6–42.0 kg). The weight of the neoplastic group was significantly higher than that of the non-neoplastic group (*p*<0.001). The duration of clinical signs from onset of the disease to the first visit to Azabu University was evaluated. The number of cases and duration of clinical signs are summarized in Table 1. A modified WHO TNM stage was T1 (*n*=4), T2 (*n*=3), T3 (*n*=2), and T4 (*n*=41). The histopathological diagnoses within the neoplastic group were adenocarcinoma (*n*=

Table 1. Number and duration of clinical signs for neoplastic and non-neoplastic groups.

Clinical sign	Neoplastic group		Non-neoplastic group	
	Cases	Median durations* (range)	Cases	Median durations* (range)
Sneezing	23 (46.0%)	5 (1-35)	12 (42.9%)	5 (1-24)
Nasal discharge	23 (46.0%)	2 (1-24)	22 (78.6%)	3 (1-33)
Epistaxis	36 (72.0%)	3 (1-35)	10 (35.7%)	2 (0-7)
Facial deformity	17 (34.0%)	2 (1-6)	1 (3.6%)	2

*month

Table 2. Comparison of computed tomography findings between neoplastic and non-neoplastic groups.

	Neoplastic group (n=50)		Non-neoplastic group (n=28)		Significant difference
	Positive	Negative	Positive	Negative	
Lesion in nasal cavity	49 (98.0%)	1 (2.0%)	24 (85.7%)	4 (14.3%)	NS*
Destruction of incisive bone	3 (6.0%)	47 (94.0%)	2 (7.1%)	26 (92.9%)	NS*
Destruction of nasal septum	39 (78.0%)	11 (22.0%)	9 (32.1%)	19 (67.9%)	$p<0.001$
Destruction of hard palate	26 (52.0%)	24 (48.0%)	3 (10.7%)	25 (89.3%)	$p<0.001^*$
Destruction of cribriform plate	31 (62.0%)	19 (38.0%)	2 (7.1%)	26 (92.9%)	$p<0.001^*$
Osteolysis of frontal sinus area	21 (42.0%)	29 (58.0%)	2 (7.1%)	26 (92.9%)	$p=0.003^*$
Nasopharyngeal lesion	32 (64.0%)	18 (36.0%)	7 (25.0%)	21 (75.0%)	$p<0.001$
Lesion in frontal sinus area	39 (78.0%)	11 (22.0%)	14 (50.0%)	14 (50.0%)	$p=0.011$
Invasion into orbit	27 (54.0%)	23 (46.0%)	1 (3.6%)	27 (96.4%)	$p<0.001^*$
Invasion into subcutaneous tissue	28 (56.0%)	22 (44.0%)	3 (10.7%)	25 (89.3%)	$p<0.001^*$

*Yates calibration was performed.

NS, no significant difference

Fig. 1. Transverse CT image at the level of the maxillary first molar in a neoplastic group case. Tumor extended the bilateral nasal cavity and destroyed the nasal turbinate. Asterisk (*) shows the point of measurement of CT numbers, where the median CT number and SD were 42.9 and 6.1, respectively.

Fig. 2. Transverse CT image at the level of the maxillary first molar in a non-neoplastic group case. The lesion was in the left nasal cavity. Asterisk (*) shows the point of measurement of CT values, where the median CT number and SD were 42.9 and 13.8, respectively.

21), squamous cell carcinoma (n=7), osteosarcoma (n=5), undifferentiated carcinoma (n=4), carcinoma (n=3), chondrosarcoma (n=2), sarcoma (n=2), transitional cell carcinoma (n=2), mast cell tumor (n=2), undifferentiated transitional cell carcinoma (n=1), and lymphoma (n=1). The diagnoses within the non-neoplastic group were oral nasal fistula from dental disease (n=7), purulent rhinitis (n=3), lymphoplasmacytic rhinitis (n=2), and unknown (n=16). There was no fungal rhinitis found in this study.

Bilateral involvement of the lesion, found on CT images, was seen in 41 of 50 cases (82.0%) in the neoplastic group and

Fig. 3. Boxplot of median CT number

Horizontal line, median ; small square, mean ; box, 25–75% ; whisker, 5–95% ; cross, minimum and maximum data. The maximum number of frontal sinus in the neoplastic group was 234 and is not shown in this graph.

Fig. 4. Boxplot of standard deviation of CT number

Horizontal line, median ; small square, mean ; box, 25–75% ; whisker, 5–95% ; cross, minimum and maximum data. The maximum CT number of frontal sinus in the neoplastic group was 138 and is not shown in this graph.

19 of 28 cases (67.9%) in the non-neoplastic group. Other relevant findings on the CT images are listed in Table 2. Examples of CT images from the neoplastic and non-neoplastic groups are shown in Fig. 1 and Fig. 2, respectively. Osteolysis of the nasal septum, hard palate, cribriform plate, and frontal sinus, lesion in the frontal sinus and nasopharyngeal area, invasion to the orbit, and surrounding subcutaneous tissue were seen significantly more often in the neoplastic group.

The CT numbers of the nasal cavity were evaluated in 47 cases in the neoplastic group and 23 cases in the non-neoplastic group, and the CT numbers of the frontal sinus were evaluated in 36 cases in the neoplastic group and eight cases in the non-neoplastic group. The CT numbers of lesions in the nasal cavity and frontal sinus were not evaluated for all of

the dogs in this report. This is because some dogs in the neoplastic group had lesions in one or the other of the two locations, and some dogs in the non-neoplastic group had no lesion at all. The median CT number of the nasal cavity was significantly higher in the neoplastic group (50.8 HU) than in the non-neoplastic group (38.0 HU) ($p < 0.001$) (Fig. 3). The median CT number of the frontal sinus area was 48.5 HU in the neoplastic group and 28.3 HU in the non-neoplastic group. The neoplastic group had significantly higher CT numbers than those of the non-neoplastic group ($p < 0.0001$) (Fig. 3).

The median standard deviation of the CT numbers in the nasal cavity was 9.3 HU in the neoplastic group and 24.8 HU in the non-neoplastic group, indicating a significant statistical dispersion in the non-neoplastic group ($p < 0.001$) (Fig. 4). The median standard deviation of the CT numbers in the frontal sinus was 8.6 HU in the neoplastic group and 9.9 HU in the non-neoplastic group, with no significant difference between the groups (Fig. 4).

Discussion

The sex distribution [3, 10], age distribution [3, 7, 9], the duration of clinical signs [2, 6], and pathological diagnosis [7, 9, 10, 14] of dogs in this study showed similar results to those in previous reports. The breed distribution in the previous reports stated that mixed or large-breed dogs were common breeds in both groups [3, 10], while Miniature Dachshunds significantly overrepresented in the non-neoplastic nasal disease group in the present study. Dogs in the non-neoplastic group weighed significantly less ($p < 0.001$), but the median weight was 14.3 kg in the neoplastic group and 16.8 kg in the non-neoplastic group without significant difference when the Miniature Dachshunds were excluded from the statistical analysis.

There were many dogs without a definitive diagnosis in the non-neoplastic group. Tissue samples were taken from some but a histopathological diagnosis of neoplasia could not be made, although it may have been hidden. The survival time for untreated canine nasal neoplastic diseases is reported to be about 3 months (95 days) [8]. The dogs in the non-neoplastic group in this study had a median follow-up period of 30 months, and all were still alive. This suggested that the possibility of hidden neoplastic disease was low. In the non-neoplastic group with definitive diagnoses, rhinitis of an oral nasal fistula from dental disease was diagnosed most frequently ($n=7$). Small breed dogs, such as Miniature Dachshund ($n=5$), Shih Tzu ($n=1$), and Yorkshire Terrier ($n=1$), were affected. The canine tooth was the affected area for all of the dogs. Previous reports on the differential diagnosis of rhinitis had no description of rhinitis caused by dental disease [4, 9, 10]. Small breed and toy breed dogs are more likely to be affected by periodontal diseases [5]. When examining small breed dogs with signs of nasal disease, examination of the oral cavity along with the nasal cavity is recommended.

The CT images revealed significant osteolysis (septum, hard palate, cribriform plate and frontal sinus) and invasiveness (nasopharynx, frontal sinus, orbit and surrounding subcutaneous tissue) in the neoplastic group. In contrast, osteolysis, excluding septum destruction, was detected in less than 15% of the dogs in the non-neoplastic group. From this result, the likelihood of the lesion being neoplastic is considered to be high when osteolysis or invasion into the surrounding subcutaneous tissues is detected on CT images. These results were markedly different from those in a previous report [3]. On CT images, the characteristics of fungal rhinitis such as Aspergillosis are hyperostosis [11, 12] and osteolysis [11]. In this study, Aspergillosis was not detected; therefore, the non-neoplastic group may have had less osteolysis detected on CT images. In Japan, fungal rhinitis is diagnosed to a lesser extent than in Western countries though caution is needed when making the differentiation. Also, the characteristics of neoplastic lesions mentioned in this study may not be detected when the tumor is not in the advanced stage of the disease. Therefore, even when CT images do not reveal osteolysis and severe invasiveness, the lesion may still be neoplastic. Aggressive osteolysis in the neoplastic group was detected in this study. The time to referral to our institution may have had some influence on that result. In the early stage of the neoplastic disease, osteolysis may not be detected. On the other hand, however, osteolysis and invasion to the surrounding subcutaneous tissues may occur in the late stage of non-neoplastic disease or fungal rhinitis.

The CT numbers revealed significant differences between the two groups. Since the differentiation of liquid from tumor tissues by histopathology or other diagnostic imaging tools such as MRI were not performed in this study, CT numbers alone are not considered distinguishing the components. However, the CT numbers measured in the nasal cavity and fron-

tal sinus of the neoplastic group were significantly higher than those of the non-neoplastic group. Lesions in the non-neoplastic group were bodies of liquid with inflammatory substances, revealing CT numbers that were higher than that of water (0 HU) but lower than that of a tumor. The CT numbers of neoplastic tissues, on the other hand, are close to those of normal solid organs, which are much higher than that of water. It should be noted, however, that high viscosity liquid accumulation in the frontal sinus may reveal high accumulated CT numbers. This may cause further difficulties in distinguishing liquid accumulation from tumor tissue.

The standard deviation of the CT numbers in the nasal cavity for the non-neoplastic group showed significant statistical dispersion. The components that appear on the CT images of the nasal cavity are air, soft tissue, cartilage and bone. The CT numbers range from -1,000 HU of air to >1,000 HU of bone. The nasal cavity lesion in the non-neoplastic group contains bone and cartilage of the turbinate and nasal septum, as well as air and inflammatory substances, making the CT numbers vary widely. The standard deviation of the CT number in the nasal cavity for the neoplastic group was low and uniform. This may be due to tumor destruction of the components within the nasal cavity and substitution with tumor tissue within the area. The reason for the high standard deviation in the non-neoplastic group in this study was diversity in the frontal sinus. Because of the gross resolution of the device, we may have included a wider area for measurement of CT numbers. Therefore, for the small lesions, air and bone surrounding the lesion may have been measured within the area. This suggests that measurement of CT numbers alone might become a tool for distinguishing neoplastic tissue from non-neoplastic tissue in the nasal cavity.

Plane CT images were used in this report, though angiography is performed in making diagnoses most of the time. In this case, a tumor creates more contrast compared to benign lesions. Therefore, comparing the CT numbers of plane CT images to contrast CT images may make differentiation easier.

In the diagnosis of nasal diseases, the degrees of osteolysis and tumor invasiveness on CT images and the dispersion of CT numbers may distinguish neoplastic disease from non-neoplastic disease. The usefulness of CT images for diagnosing nasal disease is suggested.

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犬の鼻腔腫瘍疾患と非腫瘍疾患の鑑別における CT 画像の有用性について

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■ 和文要約

鼻腔症状を呈し、CT を撮影した78頭について腫瘍疾患と非腫瘍疾患での臨床所見と CT 所見を比較した。年齢は腫瘍疾患で高齢であり、ミニチュア・ダックスフントに非腫瘍性疾患を多く認めた。CT では、腫瘍群に有意に多い所見として、骨溶解（鼻中隔、硬口蓋、篩骨）と周囲浸潤（鼻咽頭、眼窩、皮下組織）があった。鼻腔の CT 値の比較では、中央値（標準偏差）が、腫瘍疾患が50.8HU（9.3HU）、非腫瘍疾患が38.0HU（24.1HU）と非腫瘍疾患で有意に低く、ばらつきが多い結果となった。

Key word : Canine, Computed tomography, Miniature Dachshund, Nasal tumor, Rhinitis

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