



# MRI findings, including diffusion-weighted imaging and apparent diffusion coefficient value, in two cats with nasopharyngeal polyps and one cat with lymphoma

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## Abstract

**Objectives** Most nasopharyngeal masses in cats are lymphomas or polyps. To our knowledge, there is no report of MRI findings, including diffusion-weighted imaging (DWI) or apparent diffusion coefficient (ADC) values, of nasopharyngeal lymphomas and nasopharyngeal polyps in cats. This study aimed to evaluate the MRI findings of nasopharyngeal lymphomas and nasopharyngeal polyps, including DWI and ADC values.

**Methods** MRI examination was performed on two cats with a histologically confirmed nasopharyngeal polyp and one cat with lymphoma. The magnetic resonance scanning protocol included T2-weighted imaging (T2WI), T1-weighted imaging (T1WI) and DWI. An ADC map was created based on DWI. ADC values were then calculated.

**Results** MRI of the nasopharyngeal polyps revealed well-defined masses with strong rim enhancement, mass-associated stalk-like structures and asymmetric tympanic bulla lesions. The polyps appeared hyperintense on T2WI, hypo- to isointense on T1WI, and of mixed intensity or hypointense on DWI. On the ADC map, the masses appeared hyperintense. The ADC values of the polyps were  $2.07 \times 10^{-3} \text{ mm}^2/\text{s}$  and  $2.28 \times 10^{-3} \text{ mm}^2/\text{s}$ . MRI examination of the nasopharyngeal lymphoma revealed a strongly enhancing heterogeneous lesion. The mass appeared mildly hyperintense on T2WI, isointense on T1WI and hyperintense on DWI. On the ADC map, the mass appeared hypointense. The ADC value of the mass was  $0.46 \times 10^{-3} \text{ mm}^2/\text{s}$ . The ADC values of the nasopharyngeal polyps were higher than the ADC value of the nasopharyngeal lymphoma.

**Conclusions and relevance** Measurement of ADC values may be useful for differentiating between nasopharyngeal polyps and nasopharyngeal lymphomas.

**Keywords:** ADC; DWI; lymphoma; MRI; nasopharyngeal polyp; T2 shine-through

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## Introduction

The most common nasopharyngeal masses in cats are lymphomas, found primarily in older animals, and polyps, found primarily in younger animals.<sup>1</sup> Lymphoma is the most common nasopharyngeal neoplasia, comprising 25–49% of cats with nasopharyngeal disease.<sup>1,2</sup> Nasopharyngeal polyps account for 28% of cats with nasopharyngeal disease.<sup>1</sup> Many previous studies have reported that nasopharyngeal polyps

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occur in cats younger than 3 years of age, whereas others have reported a wider range, including cats aged 6–7 years and cats aged 17.5 years.<sup>3</sup> Definitive diagnosis of a nasopharyngeal lesion is made via microscopic examination of cytological or histological representative samples.<sup>4</sup> Many biopsy techniques, including fine-needle aspiration, antegrade flushing, specialised nasopharyngeal forceps and endoscopy, are available.<sup>1,5</sup> Occasionally, these methods result in an inaccurate or missed diagnosis, depending on the site of the mass, the presence of necrotic debris and scattered neutrophils and blood.<sup>1,4</sup>

CT findings of nasopharyngeal polyps and conventional MRI findings of nasopharyngeal polyps and nasopharyngeal lymphomas have been reported.<sup>2,3,6</sup> Recently, we reported that diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) values are useful for diagnosing feline central nervous system lymphomas.<sup>7</sup> To our knowledge, there is no report about MRI findings, including DWI or ADC values, of nasopharyngeal lymphomas and nasopharyngeal polyps in cats. In this study, we evaluated the MRI findings, including DWI and ADC values, of a nasopharyngeal lymphoma and nasopharyngeal polyps.

## Materials and methods

Case records from the Kinki Animal Medical Training Institute between 2015 and 2018 were reviewed. Cats with sneezing, stertor or nasal discharge were included in this study. Two cats with a histologically confirmed nasopharyngeal polyp and one cat with lymphoma that had undergone MRI examination of the head were identified.

For the MRI procedure, the cats were anaesthetised with intravenous propofol (Intervet) and maintained with isoflurane and oxygen. MRI examination was performed using a 1.5 Tesla system (Brivo MR355; GE Health Care Japan) with the cat in the prone position. A flex coil was used for signal reception. The magnetic resonance scanning protocol included transverse fast-spin echo T2-weighted imaging (T2WI), transverse spin echo (SE) T1-weighted imaging (T1WI) and transverse diffusion-weighted imaging (DWI).

Transverse DWI was performed using single-shot SE-type echoplanar imaging. T2WI was performed using the following parameters: repetition time (TR)/echo time (TE) 4600/120 ms; thickness 3.5 mm; spacing 0.7 mm; number of excitations (NEX) 3; field of view (FOV) 140 mm; matrix 480 × 480. T1WI was performed using the following parameters: TR/TE 350/13 ms; thickness 3.5 mm; spacing 0.7 mm; NEX 4; FOV 140 mm; matrix 320 × 320; flip angle (FA) 90°. DWI was performed using the following parameters: TR/TE 3700/88 ms; thickness 3.5 mm; spacing 0.7 mm; b-value 1000 s/mm<sup>2</sup>; NEX 4; FOV 150 mm; matrix 64 × 64. Diffusion-weighted gradients were applied in three directions (x, y and z). Transverse SE post-contrast T1WI was performed after

administration of gadolinium-diethylenetriamine pentaacetic acid (DTPA) 0.2 ml/kg (Magnevist; Bayer).

The ADC distribution was demonstrated on an ADC map created with a workstation using commercially available DICOM image viewing software (OsiriX 6.5.2, 64 bit; Pixmeo). All MRI findings were reviewed by one experienced radiologist (TT). ADC values were calculated and obtained at multiple regions of interest and values were obtained. Measurement of ADC values from cystic or necrotic areas of a mass was avoided. The ADC values were measured in random order at three different times with at least a 2 week interval to avoid potential bias and the mean ADC values were calculated.

## Results

### Case 1

A 6-month-old neutered female Selkirk Rex presented with a 1 month history of sneezing and stertor. Clinical examination was normal, as were haematological and serum biochemical analyses. Lateral radiography of the head revealed a regular circular mass of soft tissue opacity in the caudal portion of the nasopharynx.

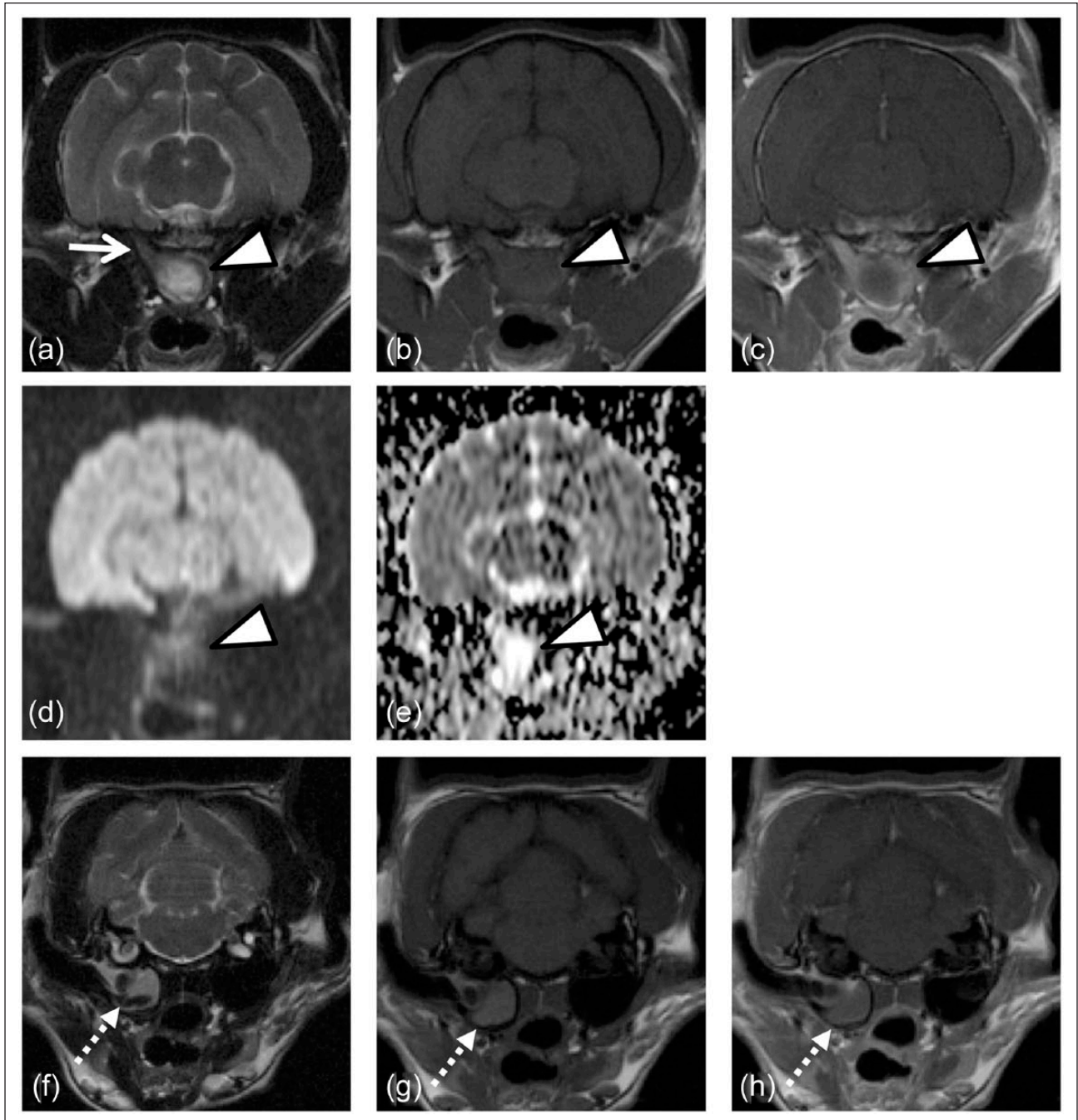
MRI examination revealed a nasopharyngeal mass located caudal to the hard palate (Figure 1a–e). The mass was connected to the right auditory tube by a stalk-like structure (Figure 1a, arrow). Comparing it with grey matter, the mass appeared hyperintense on T2WI (Figure 1a, arrowhead), hypo- to isointense on T1WI (Figure 1b, arrowhead), heterogenous rim-enhancing on post-contrast T1WI (Figure 1c, arrowhead) and of mixed intensity on DWI (Figure 1d, arrowhead). On the ADC map, the mass appeared as hyperintense (Figure 1e, arrowhead). The ADC value of the mass was  $2.07 \times 10^{-3}$  mm<sup>2</sup>/s. A non-enhancing lesion filling the right tympanic bulla appeared as mildly hyperintense compared with grey matter on T2WI and isointense on the T1WI (Figure 1f–h).

There were no abnormal findings in regional lymph nodes, palatine tonsils, the nasal cavities and sinonasal sinuses. The mass was grasped with Allis forceps and traction was applied until the mass detached at its stalk-like structure. The histopathological examination of the mass confirmed a nasopharyngeal polyp.

### Case 2

A 1-year-old neutered male mixed-breed cat presented with a 2 month history of intermittent sneezing and nasal discharge. The cat appeared normal on clinical examination, and haematological and serum biochemical analyses were also normal. Lateral radiography of the head revealed ill-defined mass with of soft tissue opacity in the caudal portion of the nasopharynx.

MRI examination revealed a nasopharyngeal mass located caudal to the hard palate (Figure 2a–e). The mass was connected to the right auditory tube by a stalk-like structure (Figure 2a, arrow). Compared with the grey



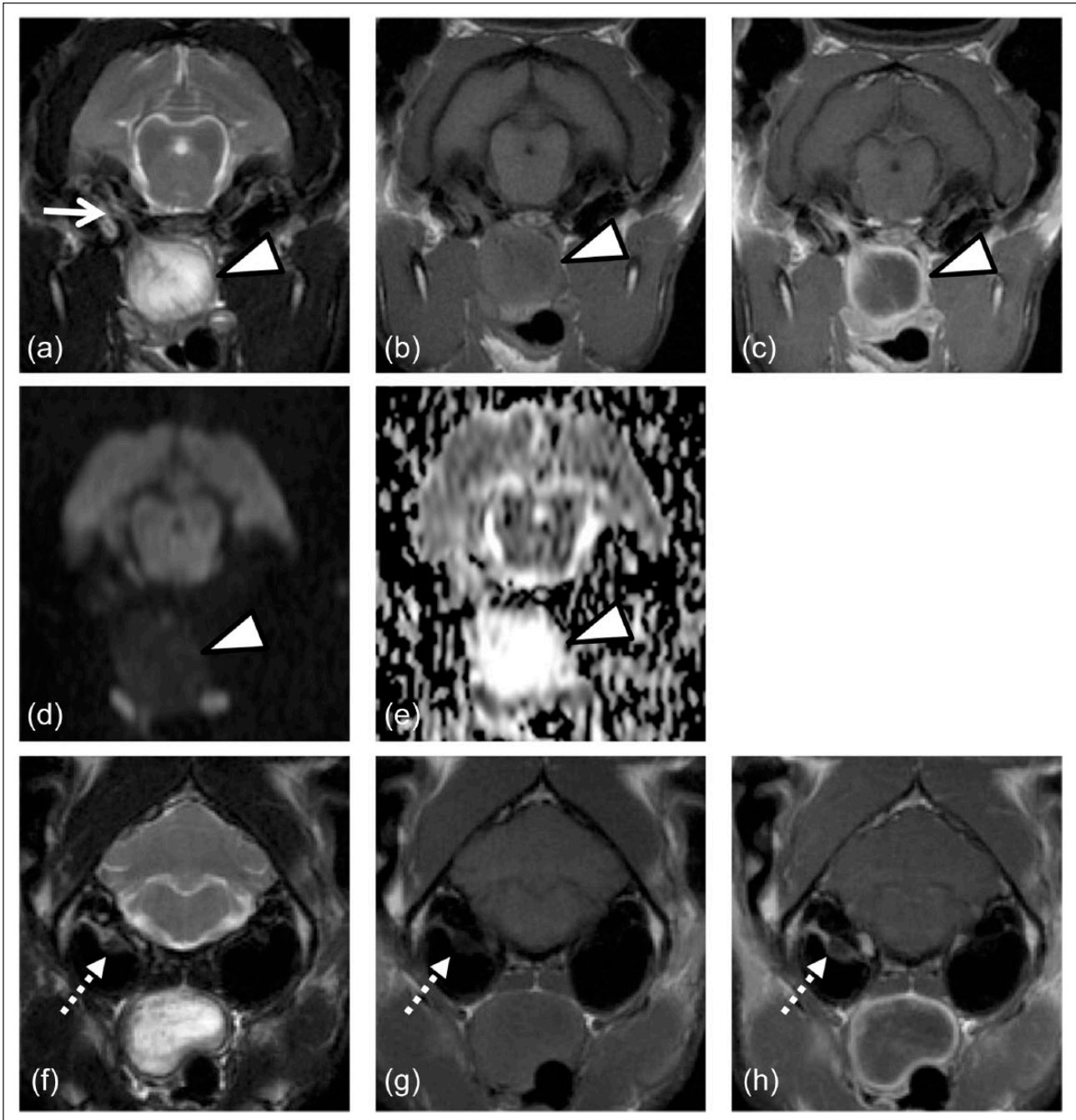
**Figure 1** MRI findings of a nasopharyngeal polyp with (a–e) right stalk-like structure and (f–h) a lesion in the tympanic bulla (dotted arrow) in case 1. (a,f) T2-weighted imaging, (b,g) T1-weighted imaging (T1WI), (c,h) contrast-enhanced T1WI, (d) diffusion-weighted imaging and (e) apparent diffusion coefficient map. The nasopharyngeal polyp (arrowhead) was seen as a well-defined mass with strong rim enhancement and mass-associated right stalk-like structure (arrow) and a lesion in the right tympanic bulla

matter, the mass appeared hyperintense on T2WI (Figure 2a, arrowhead), hypo- to isointense on T1WI (Figure 2b, arrowhead), rim enhancement on post-contrast T1WI (Figure 2c, arrowhead) and hypointense on DWI (Figure 2d, arrowhead). On the ADC map, the mass appeared as hyperintense (Figure 2e, arrowhead). The ADC value of

the mass was  $2.28 \times 10^{-3} \text{ mm}^2/\text{s}$ . In the right tympanic bulla, a rim-enhancing small lesion was detected, which was hyperintense compared with grey matter on T2WI and isointense on T1WI (Figure 2f–h).

There were no abnormal findings in regional lymph nodes, palatine tonsils, the nasal cavities and sinonasal





**Figure 2** MRI findings of a nasopharyngeal polyp with (a–e) right stalk-like structure and (f–h) a lesion in the tympanic bulla (dotted arrow) in case 2. (a,f) T2-weighted imaging, (b,g) T1-weighted imaging (T1WI), (c,h) contrast-enhanced T1WI, (d) diffusion-weighted imaging and (e) apparent diffusion coefficient map. The nasopharyngeal polyp (arrowhead) was seen as a well-defined mass with strong rim enhancement and mass-associated right stalk-like structure (arrow) and a lesion in the right tympanic bulla

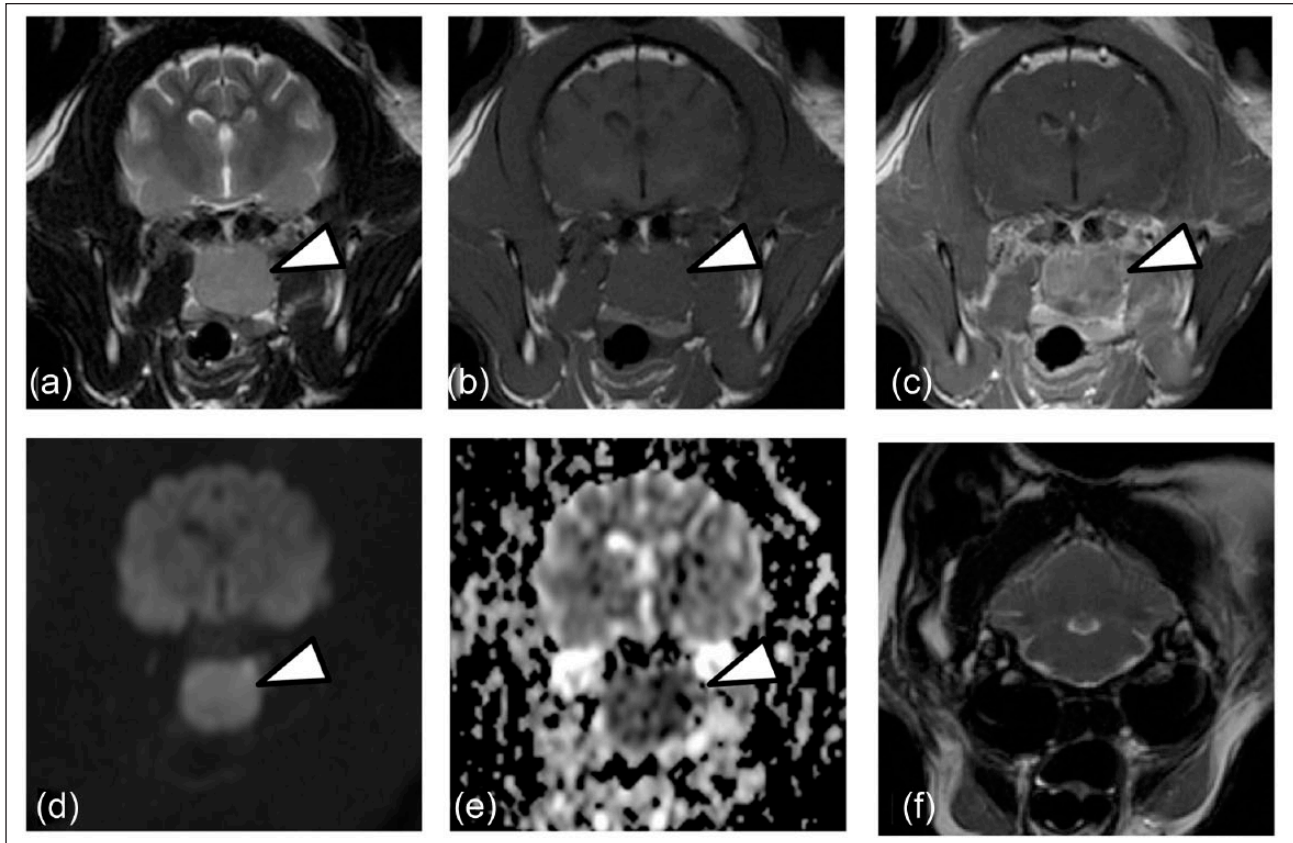
sinuses. The mass was extracted by traction, and the histopathological examination of the mass confirmed that the mass was a nasopharyngeal polyp.

### Case 3

A 6-year-old neutered male mixed-breed cat presented with a 1 month history of intermittent sneezing and

epistaxis. Clinical examination was normal, and haematological and serum biochemical analyses were also normal. This cat had undergone a CT examination, which revealed a soft tissue-attenuating lesion without contrast enhancement in the nasal cavity.

MRI revealed a nasopharyngeal mass located caudal to the hard palate (Figure 3a–e). Compared with the



**Figure 3** MRI findings of (a–e) a nasopharyngeal lymphoma in case 3. (f) No mass-associated stalk-like structure or lesion in the right tympanic bulla was detected. (a,f) T2-weighted imaging, (b) T1-weighted imaging (T1WI), (c) contrast-enhanced T1WI, (d) diffusion-weighted imaging and (e) apparent diffusion coefficient map. The nasopharyngeal lymphoma (arrowhead) showed strong heterogeneous enhancement

grey matter, the mass appeared as mildly hyperintense on T2WI (Figure 3a, arrowhead), isointense on T1WI (Figure 3b, arrowhead), showed heterogeneous strong enhancement on post-contrast T1WI (Figure 3c, arrowhead) and was hyperintense on DWI (Figure 3d, arrowhead). On the ADC map, the mass appeared as hypointense (Figure 3e, arrowhead). The ADC value of the mass was  $0.46 \times 10^{-3} \text{ mm}^2/\text{s}$ . There was no stalk-like structure through the auditory tube and no lesion was detected in the tympanic bulla (Figure 3f). Fine-needle aspiration was performed and the mass was diagnosed as lymphoma based on cytology.

## Discussion

In this study, nasopharyngeal polyps were characterised by the following MRI findings: a well-defined mass hyperintense on T2WI, hypo- to isointense on T1WI, strong rim enhancement, mass-associated stalk-like structure and an asymmetric tympanic bulla lesion. The tympanic bulla lesion showed several different intensities on T2WI, T1WI and enhanced T1WI. The CT features of nasopharyngeal polyps have previously been reported to include a well-defined mass with strong rim enhancement, mass-associated stalk-like structure and

asymmetric tympanic bulla wall thickening with pathological expansion of the tympanic bullae.<sup>3</sup> MRI findings of nasopharyngeal polyps in this study were similar to previously reported MRI findings of nasopharyngeal polyps.<sup>6</sup> In contrast, the nasopharyngeal lymphoma in this study appeared as mildly hyperintense on T2WI, heterogeneous and strongly enhancing, with no stalk-like structure or tympanic bulla lesion. However, on examination of nasopharyngeal lymphomas in a previous study,<sup>2</sup> fluid accumulation in the ipsilateral or both tympanic bullae was reported.

Auditory tubes help equilibrate air pressure between the middle ear and pharynx when middle-ear pressure is less than atmospheric.<sup>8</sup> Dysfunction of the auditory tube, including obstruction of the nasopharynx and soft palate abnormalities, causes development of fluid accumulation in the tympanic bulla.<sup>8,9</sup> Therefore, a tympanic bulla lesion in a cat with nasopharyngeal polyps or the lack of a tympanic bulla lesion in a cat with nasopharyngeal lymphoma may not be a specific finding.

Differences of diffusion caused by disease can be shown with DWI or an ADC map.<sup>10</sup> DWI reflects the macromolecular motion of intra- and extracellular water.<sup>11</sup> On DWI, tissues with restricted mobility of water molecules

(diffusion-restricted tissue) will exhibit a high signal, whereas those with free mobility of water molecules (non-restricted tissue) will exhibit a low signal.<sup>12</sup> An ADC map is proportional to the measured ADC values obtained using DWI. ADC values permit quantitative evaluation of images according to the microstructure and pathophysiological state of the tissues being examined.<sup>13</sup> On the ADC map, diffusion-restricted tissues have a lower ADC value, whereas non-restricted tissue have a higher ADC value.<sup>12</sup> DWI reflects contrast from two sources: tissue diffusion and T2WI. In some circumstances, the regional elevation in T2WI leads to a signal augmentation, which dominates any diffusion-related signal loss. This phenomenon is termed 'T2 shine-through'.<sup>14</sup> The misleading effect of T2 shine-through is checked by referring to the ADC map, which is a graphic representation of the ratio of the diffusion-weighted signal intensities.<sup>15</sup>

In humans, DWI allows for the differentiation between malignant and benign lesions. Malignant lesions show lower ADC values compared to benign solid or cystic lesions.<sup>16</sup> In head and neck lesions, the reported mean ADC values of malignant lymphomas, carcinomas and benign solid lesions are  $0.66 \times 10^{-3} \text{ mm}^2/\text{s}$ ,  $1.13 \times 10^{-3} \text{ mm}^2/\text{s}$  and  $1.56 \times 10^{-3} \text{ mm}^2/\text{s}$ , respectively.<sup>16</sup> In nasopharyngeal disease, DWI/ADC can be used to differentiate carcinomas from lymphomas (lymphomas show lower ADC values than carcinomas).<sup>17</sup>

As lymphomas are highly cellular, water diffusion is often restricted.<sup>18</sup> Therefore, the nasopharyngeal lymphoma appeared hyperintense on DWI. On the ADC map, the lymphoma appeared hypointense. The ADC value of nasopharyngeal lymphomas is similar to that of central nervous system lymphomas.<sup>7</sup>

In contrast, the nasopharyngeal polyp in case 1 appeared as mixed intensity, including hyperintensity, on DWI. On the ADC map, the nasopharyngeal polyp appeared as hyperintense. Hyperintensity on DWI may be a result of the T2 shine-through phenomenon. Histologically, nasopharyngeal polyps consist of a core of loosely arranged fibrovascular tissue covered by a stratified squamous-to-ciliated columnar epithelial layer. Lymphoplasmacytic variation, lymphoid aggregates or follicles, and pleocellular inflammation are often present throughout the stromal tissues.<sup>3,19</sup> This inflammation may lead to hyperintensity on T2WI of nasopharyngeal polyps. We observed an increase in signal intensity on DWI of nasopharyngeal polyp in case 1, which was a result of T2 shine-through. The ADC value of nasopharyngeal polyps was higher than that of nasopharyngeal lymphoma. Therefore, ADC value measurement may be helpful to differentiate nasopharyngeal polyps from nasopharyngeal lymphomas.

In humans, the ADC value varies according to imaging parameters, including TE, TR and b-value applied to DWI.<sup>20,21</sup> The term of b-value refers to the strength of

the diffusion-sensitising gradient.<sup>15</sup> A high b-value emphasises diffusion.<sup>22</sup> A higher b-value in DWI can produce increases distortion and decreases of signal:noise ratio.<sup>15,22</sup> DWI in combination with conventional MRI found that a b-value of  $1500 \text{ s}/\text{mm}^2$  significantly improved the specificity but not the sensitivity vs a b-value of  $500 \text{ s}/\text{mm}^2$ .<sup>23</sup> b-Values can significantly affect the diagnostic accuracy of DWI detection of malignant lesions; however, there is no clear trend favouring high or low b-values across different tissue and tumour types.<sup>22</sup> This study included a small number of cats with nasopharyngeal polyps and a nasopharyngeal lymphoma. Further studies are needed to evaluate the MRI findings, including DWI and ADC values, in a large population of cats with nasopharyngeal masses.

## Conclusions

ADC value measurement could be helpful for differentiating between nasopharyngeal polyps and nasopharyngeal lymphomas. Because of the small number of cats included in this study, further studies are needed to evaluate the MRI findings of nasopharyngeal masses, including DWI and ADC values.

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