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Computed tomography and magnetic resonance diagnosis of variations in the anatomical location of the major salivary glands in 1680 dogs and 187 cats

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ABSTRACT

During assessment of routine clinical magnetic resonance imaging (MRI) of the heads of dogs, variations in the location of mandibular and zygomatic salivary glands (SGs) were observed incidentally. The aims of this retrospective study were to describe anatomical variations of the major SGs found on MRI and computed tomography (CT) studies of the head in dogs and cats and to investigate possible clinical relevancy.

No anatomical variation of the SGs was seen in cats, but in dogs, although variation of the parotid SG was not identified, that of the mandibular SG was found in 33/1680 animals (2%), either unilaterally (6/33 right-sided, 13/33 left-sided) or bilaterally (14/33). The Border terrier breed (19/33, 58%) was over-represented. Each atypically located mandibular SG was positioned medial to the digastric muscle and rostral to the retropharyngeal lymph node. The sublingual glands were difficult to delineate from the mandibular glands. Anatomical variation of one zygomatic gland (3/4 left-sided) was identified in four small-breed dogs (0.2%). Each atypically located zygomatic gland was tilted at the ventrorostral aspect of the masseter muscle underneath the skin surface. MRI and CT characteristics were not different between typically and atypically located SGs. None of the dogs had clinical signs related with SG disease. It was concluded that, with suspected breed predispositions, incidental unilateral or bilateral anatomical variations of mandibular and zygomatic SGs can be encountered in dogs and an awareness of these possible variations may be important in pre-surgical planning.

Introduction

The major salivary glands (SGs), being well-delineated and organised tissue structures, can be readily identified on advanced imaging studies of the head in dogs and cats. Recent studies have described the appearance and anatomical location of the normal canine major SGs on computed tomography (CT) sialography (Kneissl et al., 2011) and low-field magnetic resonance imaging (MRI) (Weidner et al., 2012), in which consistent landmarks were described and compared to anatomical slices. Furthermore, while plain radiographs are of limited usefulness in SG assessment, advanced imaging techniques have led to improvement in diagnosis of SG diseases and further management (Burke et al., 2011).

Cross-sectional imaging eliminates organ superimposition, improving visibility and differentiation of soft tissue and bone structures, provides detailed anatomical location and soft tissue characterization, and allows assessment of local and regional extension and infiltration of lesions (Dennis, 2000). The advantages of CT and MRI in characterisation, diagnosis and assessment of extension of SG lesions, aiding pre-operative planning, have been reported (Pownder et al., 2006; Bartoe et al., 2007; McGill et al., 2009; Atkins et al., 2010; Cannon et al., 2011; Philp et al., 2012; Boland et al., 2013; Goldsworthy et al., 2013).

During the routine MRI assessment of dogs, for which advanced imaging of the head was necessary as part of an investigation for pathology unrelated to SG disease, variations in the location of the mandibular and zygomatic SGs were occasionally noted. The anatomical variants were located at distinct positions in the musculature layers of the head, with new neighbouring anatomical structures. The latter has a clinical implication for disease recognition and accurate pre-surgical planning. The aims of this study were to describe variations in location of the major SGs in dogs and cats on cross-sectional images, to estimate their prevalence, and to assess their possible clinical significance (including signalment, history, and clinical signs). We hypothesised that anatomical variations of the major SGs would be an infrequent finding in dogs and cats without obvious associated clinical presentation.

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Materials and methods

Selection criteria

All MR and CT images of the heads of dogs and cats, acquired over a 5 year period at the Small Animal Hospital, School of Veterinary Medicine, University of Glasgow, were retrospectively evaluated on a workstation, using DICOM software (Visbion PACS System) to assess the anatomical location of the parotid, sublingual, mandibular and zygomatic SGs. All MRI and CT examinations, including post-contrast studies, were performed as part of the animal's diagnostic work-up for an array of clinical presentations. All animals with clearly identified SGs on transverse images were included. Those where the entire SGs did not appear in the field of view (FOV), but with clearly visible anatomical locations (i.e. typical vs. atypical), were included.

This study was considered as sub-threshold for specific ethical approval by the convenor of the School of Veterinary Medicine Ethics Committee, as the work involved only analysis of data routinely recorded from normal and necessary clinical procedures and was with owner's consent.

Imaging studies

MR images were obtained under general anaesthesia, using a 1.5 Tesla unit (Siemens Magnetom Essenza) with a head/neck coil (for most patients) or an extremity coil for cats and some toy dogs. Dorsal and sternal recumbencies were used for positioning in the head/neck coil and extremity coil, respectively. Transverse T2-weighted (T2w) (range TR: 3810-5230/TE: 85–97 ms) turbo spin echo sequences were assessed first to evaluate the location of the SGs. Dorsal and sagittal T2w, and transverse T1-weighted (T1w) (range TR: 464-618/TE: 13–14 ms) pre- and post-intravenous (IV) injection of contrast medium (0.1 mmol/kg of gadopentetate dimeglumine; Magnevist, Bayer HealthCare Pharmaceuticals) turbo spin echo sequences were also reviewed (if available) to help determine the anatomical location and to assess the MRI characteristics of the SGs. In all MRI studies, transverse images were orientated perpendicular to the palatine bone. The slice thickness varied from 3 to 4 mm (transverse plane) and from 3 to 3.5 mm (sagittal and dorsal planes) with an interslice interval of 0.7–0.9 mm.

CT images of the head were obtained using a dual slice CT scanner (Siemens Somatom Spirit). Animals were positioned under general anaesthesia in sternal or dorsal recumbency, with extended head and neck. Acquisition scan mode was helical or axial depending on the region of interest. Acquisition variables and display FOV were dependent on patient size and region of interest (tube voltage, 130 kVp; tube current, 50–240 mAs; tube rotation time, 1–1.5 s; beam pitch [if helical], 1–1.5; slice thickness, 2–5 mm; matrix size, 512 × 512). Images were reformatted with bone and soft tissue filters and window viewings could be adjusted for each patient. Post-contrast images, acquired after IV injection of 2 mL/kg of ioversol (Optiray 300, Mallinckrodt Pharmaceuticals) using a pressure injector (Injektron 82M, Medtron) at a rate of 5 mL/s, were reviewed, if available.

Imaging features

MR and CT images of animals with variation in location from previously described normal anatomy of any major SGs were reviewed using a DICOM image viewer (OsiriX version 5.0 Imaging Software) to assess the position, laterality, interface with surrounding structures, homogeneity of the parenchyma, signal intensity or attenuation, contrast enhancement pattern, shape and size of atypically located glands. The above characteristics were compared to the typically located contralateral SG, in cases of unilateral anatomical variation.

The gland interface with surrounding structures was characterised as clearly defined or indistinct, and smooth or irregular. The parenchyma was defined as homogeneous or heterogeneous. Signal intensity was assessed on T2w and T1w sequences and classified as hypointense, isointense, hyperintense or mixed relative to surrounding musculature. Attenuation was assessed on pre-contrast CT images (soft tissue window) and classified as hypoattenuating, isoattenuating, hyperattenuating or mixed relative to surrounding soft tissue. If present, any contrast enhancement pattern was characterised as homogeneous, heterogeneous or ring-like. The shape was described if it differed from typical SGs. Atypical glands were subjectively described as smaller, similar or bigger than typical ones. Signalment, history, clinical signs and presumptive diagnosis at the time of imaging work-up of animals showing anatomical variation of any major SGs were recorded.

Statistical analysis

Statistical analyses were performed using commercially available software (Minitab16 Statistical Software; IBM SPSS Statistics, v22). Animals with both MRI and CT studies were counted only once in the statistical analysis. Normality of data was assessed with the Anderson–Darling test. Descriptive statistics were reported as mean, range, and standard deviation (SD) or median and range depending on the normality of data. The prevalence of variations in location was calculated for each major SG in dogs and cats. Associations between variations in the location of the major SGs and a particular breed (when at least one patient from this breed showed variation) were tested using Fisher's exact test. The χ^2 test was used to determine any association with gender. Associations with weight and age were not tested due to incomplete data records and independence of age and anatomical variation, respectively. For all analyses, a value of $P < 0.05$ was considered statistically significant.

Results

Variations in cats

No variation in the location of any major SGs was found in 121 MRI and 74 CT studies (total 195) that met the inclusion criteria (eight cats had both MRI and CT studies).

Variations in dogs

All presumptive or definitive diagnoses at the time of imaging of dogs with atypical SG location were unrelated to SG disease. No variation in location of the parotid glands was found in 1248 MRI and 473 CT studies (total 1721) that met the inclusion criteria (41 dogs had both MRI and CT studies).

Thirty-three dogs (prevalence 2.0%) showed a unique variation in the location of at least one mandibular gland (21 males, 12 females; median weight 11.6 kg, range 5.7–32.4 kg). Twenty-six were found on MRI and eight on CT, with one dog having both scans. Prevalence and laterality of variations are summarised in Table 1. A variety of breeds were represented with Border terriers (19/33, 57.6%), crossbreeds (4/33, 12.1%) and Basset hounds (3/33, 9.1%) most common. Variation in the location of mandibular SGs was statistically significantly associated with Border terriers ($P < 0.001$) and Basset hounds ($P < 0.001$). No statistically significant association was found with any other breeds (Table 2) or gender ($P = 0.459$).

Atypical mandibular SGs were all positioned between the oropharynx medially and the digastric muscle laterally, and were generally located slightly more rostral than the expected location (Figs. 1–3). The shape appeared more triangular or tear-dropped in

Table 1
Prevalence and laterality of the variations in location of mandibular and zygomatic salivary glands in dogs.

	Mandibular gland variation	Zygomatic gland variation
Prevalence	33/1680 (2%)	4/1680 (0.2%)
Unilateral		
Left	13 (39.4%)	3 (75%)
Right	6 (18.2%)	1 (25%)
Bilateral	14 (42.4%)	–

Table 2
Number of dogs per breed showing anatomical variation of mandibular salivary glands.

	Number of dogs per breed showing mandibular salivary gland variation (%)	Total number of dogs included per breed (%)	Frequency of mandibular salivary gland variation among the breed
Border terrier	19 (57.6%)	27 (1.6%)	70.4%*
Basset hound	3 (9.1%)	8 (0.5%)	37.5%*
Crossbreed	4 (12.1%)	140 (8.3%)	2.8%
Labrador Retriever	2 (6.1%)	169 (10.1%)	1.2%
Cocker Spaniel	1 (3.0%)	76 (4.5%)	1.3%
German Shepherd	1 (3.0%)	50 (3.0%)	2.0%
Hungarian Vizsla	1 (3.0%)	17 (1.0%)	5.9%
Patterdale terrier	1 (3.0%)	5 (0.3%)	20.0%
Old English Sheepdog	1 (3.0%)	3 (0.2%)	33.3%
Cavalier King Charles spaniel	0 (0%)	135 (8.0%)	–
Boxer	0 (0%)	130 (7.7%)	–
Border Collie	0 (0%)	92 (5.5%)	–

* Statistical significant associations between the presence of mandibular salivary gland anatomical variation and breed, tested with Fisher's exact test.