Kafkas Universitesi Veteriner Fakultesi Dergisi
ISSN: 1300-6045 e-ISSN: 1309-2251
Journal Home-Page: http://vetdergikafkas.org

Kafkas Univ Vet Fak Derg
27 (5): 617-624, 2021
DOI: 10.9775/kvfd.2021.25972

RESEARCH ARTICLE

Computed Tomographic Imaging Characteristics of the Thyroid Glands in Clinically Normal Van Cats

Osman YILMAZ [1,a (*)]

[1] Department of Anatomy, Faculty of Veterinary Medicine, Van Yüzüncü Yıl University, TR-65080 Van - TURKEY
[a] ORCID: 0000-0003-2013-9213

Article ID: KVFD-2021-25972 Received: 03.05.2021 Accepted: 24.08.2021 Published Online: 27.08.2021

Abstract

This study was performed to obtain morphometric and volumetric measurements of thyroid glands of Van Cats, and to determine homotypical variations and biometric differences between the genders. Thyroid gland computed tomography (CT) images obtained from a total of 16 clinically healthy adult Van Cats (8 males, 8 females) were used in the study. Measurements were made on the transverse, sagittal, and dorsal sections of both right and left thyroid gland CT images. Volumes of the thyroid lobes were estimated using transverse ellipse, maximum ellipse, and planimetry methods. Statistical analyses were then performed on the obtained morphometric and volumetric values. In terms of sexual dimorphism in Van Cats, morphometric and volumetric measurement values of the thyroid gland were found to be larger in male cats than in females ($P<0.05$). When the parameters were inspected in terms of homotypical variations, measured values for the right thyroid lobes were found to be larger compared to the left thyroid lobe values in both male and female cats. Average length, width, height values for male thyroid glands were 25.41±1.63 mm, 2.49±0.09 mm, and 4.54±0.21 mm, respectively, while the same values were 19.57±0.92 mm, 2.06±0.17 mm, and 4.19±0.21 for female cats, respectively. Average thyroid gland volumes calculated through transverse ellipse, maximum ellipse, and planimetry values were 149.46±19.71 mm^3, 154.80±19.70 mm^3, and 166.86±19.04 mm^3 for males, respectively. The female counterparts for these values were 89.52±11.82 mm^3, 92.31±11.90 mm^3, 109.40±6.02 mm^3, respectively. As a result, various parameters on CT images of thyroid glands in clinically healthy Van Cats were measured and the results were statistically evaluated between the genders. It is thought that the results will be useful in the evaluation of abnormal thyroid glands in Van Cats CT images in clinical practices.

Keywords: *Computer tomography, Morphometry, Thyroid gland, Van Cat, Volumetric measurement*

Klinik Olarak Normal Van Kedilerinde Thyroid Bezinin Bilgisayarlı Tomografi Görüntülerinin Özellikleri

Öz

Bu çalışma, Van Kedilerinde thyroid bezinin morfometrik ve volümetrik ölçülerini elde etmek ve bu ölçüm değerlerinin hem homotipik varyasyonlar hem de cinsiyetler arasındaki biyometrik farklılıklarını ortaya koymak amacıyla yapıldı. Çalışmada klinik olarak sağlıklı 16 adet erişkin Van Kedisi (8 erkek, 8 dişi) thyroid bezine ait bilgisayarlı tomografi (BT) görüntüsü kullanıldı. Sağ ve sol thyroid bezine ait transversal, sagital ve dorsal kesitlerden morfometrik ölçümler alındı. Thyroid loblarının hacimleri transversal elips, maximum elips ve planimetri yöntemleri kullanılarak tahmin edildi. Morfometrik ve volümetrik değerlerin istatistiki analizi yapıldı. Van Kedilerinde seksüel dimorfizm bakımından, thyroid bezine ait morfometrik ve volümetrik ölçüm değerlerinin erkek kedilerde dişilere göre daha yüksek olduğu görüldü ($P<0.05$). Ayrıca, ölçüm parametrelerine homotipik varyasyonlar bakımından bakıldığında ise hem erkek hem de dişi kedilerde sağ loptaki ölçüm değerlerinin sol loba oranla daha yüksek olduğu tespit edildi. Thyroid bezine ait ortalama uzunluk, genişlik ve yükseklik değerleri erkeklerde sırasıyla 25.41±1.63 mm, 2.49±0.09 mm ve 4.54±0.21 mm, dişilerde ise bu değerler sırasıyla 19.57±0.92 mm, 2.06±0.17 mm ve 4.19±0.21 mm olarak belirlendi. Transversal elips, maximum elips ve planimetri yöntemleriyle hesaplanan thyroid bezine ait ortalama volüm değerleri erkeklerde sırasıyla 149.46±19.71 mm^3, 154.80±19.70 mm^3 ve 166.86±19.04 mm^3, dişilerde ise ortalama sırasıyla 89.52±11.82 mm^3, 92.31±11.90 mm^3 ve 109.40±6.02 mm^3 olarak hesaplandı. Sonuç olarak, klinik olarak sağlıklı Van Kedilerinde thyroid bezine ait ölçüm parametrelerinin istatistiksel olarak cinsiyetler arasındaki farklılıkları BT görüntüleri kullanılarak değerlendirildi. Elde edilen verilerin Van Kedilerinde anormal thyroid bezine ait BT görüntülerinin değerlendirilmesinde faydalı olacağı düşünülmektedir.

Anahtar sözcükler: *Bilgisayarlı tomografi, Morfometri, Thyroid bezi, Van Kedisi, Volümetrik ölçüm*

How to cite this article?

Yılmaz O: Computed tomographic imaging characteristics of the thyroid glands in clinically normal Van cats. *Kafkas Univ Vet Fak Derg,* 27 (5): 617-624, 2021.
DOI: 10.9775/kvfd.2021.25972

(*) **Corresponding Author**

Tel: +90 432 225 1128/21537 Fax: +90 432 225 1127
E-mail: osman_40_5@hotmail.com

Introduction

Living in the Van province region of Turkey and taking their names from it, Van Cats are an endemic species with a soft and furry body, occasional heterochromia (both eyes can be yellow or blue, or one eye can be blue while the other one is yellow), erect ears, round face, a triangular head shape. Van Cats enjoy playing in and around water, are capable hunters, and are quite intelligent. Due to these outstanding properties, Van Cats have long gained the attraction and affection of humans throughout history [1,2]. It has been reported that the average body length (centimeter: cm), tail length (cm), withers height (cm), breast girth (cm), and body weight (grams: g) measurement values of adult Van Cats are 38 cm, 27 cm, 31 cm, 30 cm, and 3992 g in males, and 36 cm, 26 cm, 27 cm, 31 cm, and 3132 g in females, respectively [3].

The thyroid glands are often bilaterally located on the ventral surface of the cranial section of the trachea, while occasionally they reach above the larynx [4]. The morphology of the thyroid gland varies between species. In cats and dogs, thyroid glands consist of two flat lobes right below the caudal of the larynx and on the lateral surface of the trachea, stretching alongside each other [4,5]. While cats usually lack an isthmus that connects these two lobes [6,7], occasionally a narrow and thin isthmus has been reported which connects the caudal ends of the lobes [4,8]. In dogs, usually in larger breeds, a thin isthmus can be found, albeit inconsistently and infrequently [9]. Hormones synthesized by this endocrine gland play role in sexual development, various metabolic activities, and other basic cellular activities [8].

Medical imaging processes like ultrasonography, thyroid scintigraphy, CT, and magnetic resonance imaging (MRI) are widely used in small pet animals like cats and dogs when attempting to inspect the thyroid gland anatomy and to identify, diagnose, stage, and manage thyroid gland diseases [7,9,10-12]. Additionally, CT and MRI methods, in particular, are being frequently employed to evaluate pathological conditions that influence the thyroid gland, like congenital, idiopathic, and spontaneous hypothyroidism and hyper-thyroidism cases, unilateral or bilateral diffuse or localized hyperplastic masses, or neoplasia, tumor, carcinoma, thyroid nodules and lesions that may occur due to a wide range of causes. These methods also allow for more detailed inspection and evaluation of the normal structure of the thyroid gland [7,11,13]. These imaging methods can also be used to obtain transverse, sagittal, and dorsal sections of the thyroid gland, which in turn help understand the anatomic structure of the gland more accurately [7,13].

Numerous studies have been performed to use the CT images to examine the anatomic structure of the cats' thyroid gland, determine its morphological and morphometric properties, and evaluate various pathologic alterations that may occur in the gland [6,7,13,14]. The present study was performed to obtain morphometric and volumetric measurements of thyroid glands of Van Cats, and to determine homotypical variations and biometric differences between the genders.

Material and Methods

Animals

A total of 16 adults and clinically healthy Van Cats (8 males and 8 females) obtained from the Van Yüzüncü Yıl University (YYU) Van Cat Research and Application Center in this study were used as the live material of the study. The cats were aged between 3 and 8 years old (the average ages of male and female cats were the same, 5±2 years), and their body weights (kilograms: kg) varied between 4.81 kg and 7.05 kg (the average body weights for male and female cats were 6.08±0.70 kg and 5.28±0.28 kg, respectively). Only cats without thyroid gland pathology history which were clinically healthy in terms of complete blood count, serum thyroid hormone levels, serum T4 concentration, serum biochemistry, and urine analysis results were included in the study. Thyroid glands on both sides of the cats were evaluated. The study was performed with the Van YYU Animal Experiments Local Ethics Committee (VAN YUHADYEK) decision (Approval no: 2020/09-07, date: 24.09.2020).

Anesthesia

Dissociative agents were used to place the cats under anesthesia. A combination of Ketamine (15 mg/kg, 10% injectable, IM) and Xylazine (1-2 mg/kg, 2% injectable, IM) was used to this end.

Computed Tomography Imaging

Van Cats were placed into the tray of a 16-detector multi-section CT device (Siemens, Somatom Sensation 16, Erlangen, Germany) in the symmetrical sternal recumbency position to obtain the CT images of their glandula thryoidea (gl. thryoidea). The imaging para-meters of the device were set as follows: resolution: 512×512 pixels, physical detector collimation: 16×0.6 mm, section thickness: 0.5 mm, kernel: U90u, gantry rotation period: 420 ms, rotation time(sec)/ effective mAs/KV: 0.75/120/120, final section collimation: 32×0.63 mm; feed/rotation: 6 mm, and increment: 0.5 mm. The applied CT doses and scans were performed considering the standard protocols, based on the literature [15,16]. Obtained CT images were saved in DICOM (Digital Imaging and Communication in Medicine) format, which were then transferred to CD.

Obtaining Thyroid Gland Measurements From Computed Tomography Images

Measurements on images were performed in the computer environment using RadiAnt DICOM Viewer (64 Bit) software. Electronic calipers were used on the transverse, sagittal, and dorsal section images of the Van Cats' right and left

thyroid glands to obtain the measurements. During the measurements, the maximum length and height of each thyroid lobe in each section view (transverse, sagittal, and dorsal) were considered valid. Transverse images were used to determine the thyroid lobe length, where the number of image slices containing thyroid tissue was multiplied by the slice thickness (0.5 mm). Measurements were recorded in millimeter (mm) units.

The volumes of the thyroid lobes were calculated using three different methods. The first method was the planimetry method, which is a stereological approach where the edges of the gland were traced out by hand over the transverse section image in each slice to determine the corresponding area. The total volume of the thyroid gland was then calculated multiplying the area with the slice thickness, and adding all of the results together. The second method was the transverse ellipse volume method, where the transverse section images alone were used to obtain length, width, and height values placed into the ellipse volume formula (Volume = length x width x height x 0.524). The third method was the maximum ellipse volume method, which is similar to the second method but considers the linear measurement values for length, width, and height parameters in each slice. The total thyroid gland volume for each cat was obtained by adding the right and left thyroid lobe volumes together. To evaluate the repeatability of the values, each of the measurements was made three times by the same anatomist and the average of these values was used.

Statistical Analysis

In the present study, each of the sexes was represented by 8 cats, and the sampling size power (test strength) was calculated as 90%. Definitive statistics were continuous variables in the study were expressed as mean, standard deviation, minimum, and maximum values. Shapiro-Wilk (n<50) and Skewness-Kurtosis tests were used to control if the continuous measurement averages displayed a normal distribution, and since the variables were found to have nominal distribution, the parametric tests were used. Comparison of the measurements based on the genders was performed using the independent t-test. Comparison of right and left thyroid glands (separately for each gender) was performed using paired t-test. Pearson correlation coefficients were calculated to determine potential correlations between the measurements (separately for each gender). Statistical significance level was considered as 5% for the calculations, which were performed using SPSS (IBM SPSS for Windows, ver.24) statistical package software.

Results

In the present study, morphometric measurements of the Van Cat thyroid glands were taken from the transverse (length, height, width), dorsal (length, width) and sagittal (length, height) sections of CT images *(Fig. 1, Fig. 2, Fig. 3)*. Volumetric values for the thyroid glands were also obtained using three different methods of planimetry, transverse, and maximum ellipse volume methods. The measurements obtained were evaluated in terms of sexual dimorphism and homotypical variations, and the results are provided in *Table 1, Table 2,* and *Table 3*. Any statistically significant correlations between the measurements were noted (P<0.05).

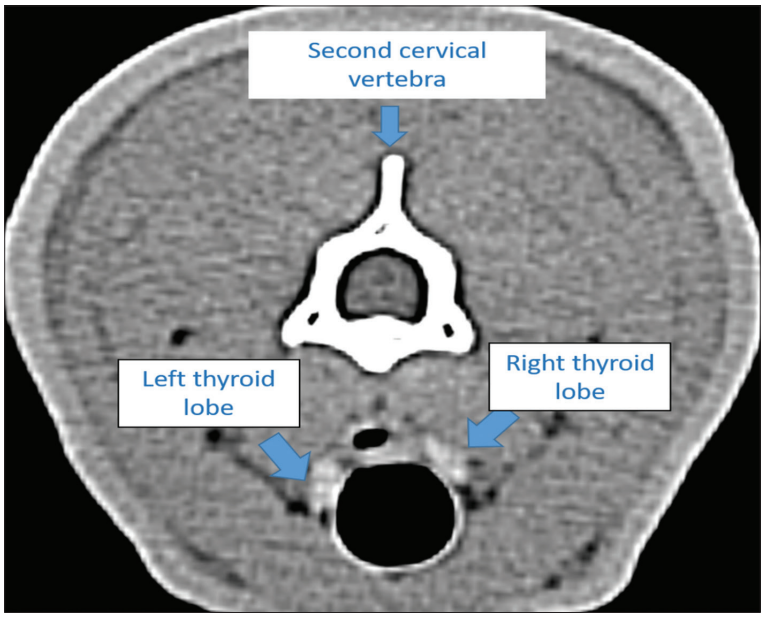

Fig 1. Transverse CT image of the right and left thyroid glands at the middle aspect of the second cervical vertebra in a clinically normal Van Cat. CT images were viewed at a window width (WW) of 300 Hounsfield Unit (HU) and a window level (WL) of 50 HU

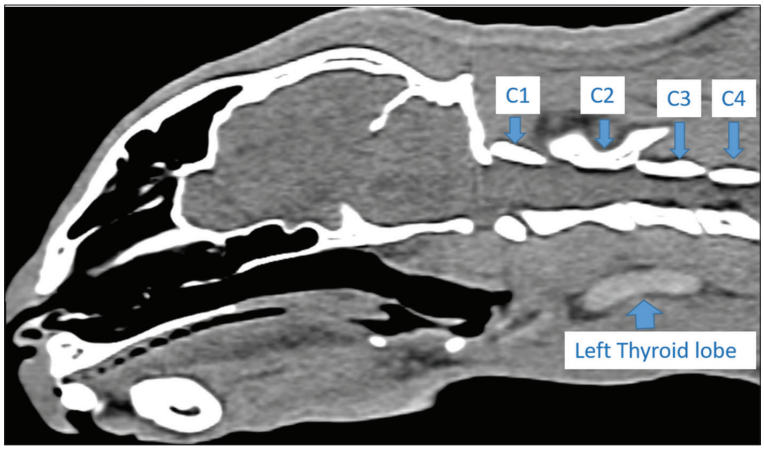

Fig 2. Sagittal CT image of the left thyroid gland in a clinically normal Van Cat. CT images were viewed at a window width (WW) of 400 Hounsfield Unit (HU) and a window level (WL) of 50 HU

Table 1 represents to definitive statistics for the transverse, sagittal, and dorsal section morphometric measurement values between the right and left lobes, and per gender. Accordingly, right and left transverse length, right and left transverse height, right and left width, right and left sagittal length, right and left sagittal height, right and left dorsal length, and right and left dorsal width measurements were found to be higher in male cats, compared to females (P<0.05). Furthermore, evaluation of the definitive statistics for the right and left thyroid lobes for the genders have shown that both male and female cats had higher values for their right thyroid lobe, compared to their left counterparts. On that note, female cats were found to have statistically higher right-side lobe transverse length and width, sagittal length, and dorsal length and width values compared to their left-side lobe, while male cats were found to have statistically higher right-side lobe transverse length and height, sagittal length and height, and dorsal length and width values compared to their left-side lobe (P<0.05). Average length, width, height values for all the sections (taking into consideration both right and left side thyroid lobes) were found as 25.41±1.63 mm, 2.49±0.09 mm, and 4.54±0.21 mm for males, and as 19.57±0.92 mm, 2.06±0.17 mm, and 4.19±0.21 mm for females, respectively.

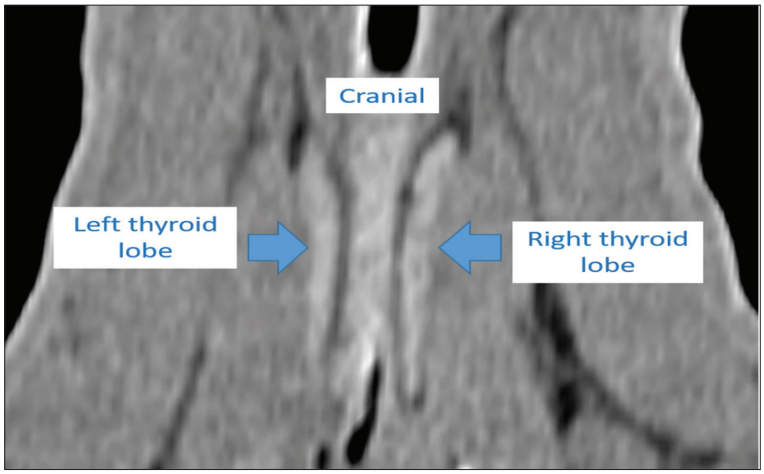

Fig 3. Dorsal CT image of the right and left thyroid glands in a clinically normal Van Cat. CT images were viewed at a window width (WW) of 400 Hounsfield Unit (HU) and a window level (WL) of 50 HU

Definitive statistics and right and left side comparisons for the Van Cat thyroid gland volumetric measurements based on gender are provided in *Table 2*. When the thyroid gland volumes obtained using transverse ellipse, maximum ellipse, and planimetry methods are evaluated, it was noticed that all three methods agreed on the result that male cats had statistically larger glands compared to females (P<0.05).

Table 1. *Descriptive statistics and homotypic variations of the morphometric measurement values obtained using CT images of the thyroid gland in Van Cats by gender*

Imaging Plane			Female			Male			P
			Mean±SD	Min.	Max.	Mean±SD	Min.	Max.	
Transverse	Length	Right	20.25±0.91#	18.40	21.20	25.80±1.71#	24.00	28.80	0.001*
		Left	19.40±1.00	17.60	20.80	25.35±1.60	23.60	27.60	0.002*
	Width	Right	2.07±0.14#	1.91	2.33	2.47±0.07	2.41	2.61	0.001*
		Left	1.99±0.19	1.68	2.28	2.45±0.08	2.37	2.60	0.002*
	Height	Right	4.26±0.14	4.09	4.43	4.56±0.20#	4.36	4.94	0.004*
		Left	4.19±0.20	3.88	4.46	4.49±0.22	4.25	4.91	0.012*
Sagittal	Length	Right	19.90±0.82#	18.30	20.70	25.55±1.69#	23.60	28.50	0.001*
		Left	19.01±0.93	17.20	20.30	25.13±1.55	23.20	27.30	0.002*
	Width	Right	NA						
		Left							
	Height	Right	4.18±0.23	3.97	4.57	4.60±0.21#	4.39	4.97	0.002*
		Left	4.11±0.25	3.80	4.42	4.51±0.21	4.28	4.93	0.004*
Dorsal	Length	Right	19.88±0.88#	18.20	20.70	25.49±1.68#	23.60	28.40	0.001*
		Left	18.98±0.96	17.10	20.30	25.15±1.54	23.40	27.50	0.002*
	Width	Right	2.13±0.15#	2.00	2.41	2.54±0.09#	2.44	2.68	0.001*
		Left	2.04±0.20	1.77	2.40	2.49±0.11	2.35	2.65	0.002*
	Height	Right	NA						
		Left							

** Shows the difference between the female-male (*P<0.05: Independent T-test); # Shows the difference between right and left separately in genders (#P<0.05: Paired T-test); NA = Not applicable*

Table 2. *Descriptive statistics and homotypic variations of the volumetric measurement values obtained using CT images of the thyroid gland in Van Cats by gender*

Method		Female			Male			P
		Mean±SD	Min.	Max.	Mean±SD	Min.	Max.	
Transverse ellipse	Right	93.92±9.77#	78.45	106.46	152.51±20.18#	135.13	186.47	0.001*
	Left	85.11±14.11	60.12	104.44	146.40±19.48	127.78	184.63	0.002*
	Both	89.52±11.82	69.28	105.45	149.46±19.71	131.46	185.55	
	Total	179.04±23.64	138.57	210.90	298.91±39.42	262.91	371.10	
Maximum ellipse	Right	97.03±9.74#	82.15	110.12	158.86±19.88#	138.03	192.63	0.001*
	Left	87.58±14.35	63.34	109.93	150.74±19.68	129.50	188.94	0.002*
	Both	92.31±11.90	72.74	110.03	154.80±19.70	133.77	190.79	
	Total	184.61±23.79	145.48	220.05	309.61±39.39	267.54	381.58	
Planimetry	Right	112.05±5.09#	106.25	122.63	170.24±19.03#	152.64	199.80	0.001*
	Left	106.75±7.19	100.94	120.51	163.48±19.16	144.74	195.21	0.002*
	Both	109.40±6.02	103.85	121.57	166.86±19.04	149.76	196.70	
	Total	218.80±12.04	207.70	243.14	333.72±38.09	299.53	393.40	

** Shows the difference between the female-male (*P<0.05: Independent T-test); # Shows the difference between right and left separately in genders (#P<0.05: Paired T-test); Both=Mean volume of left and right thyroid lobes. Total=Mean volume of thyroid tissue in each cat*

Table 3. *The correlation between morphometric and volumetric measurement values of the thyroid gland with age and body weight in Van Cats by gender*

Measurement Parameters			Female		Male	
			Age (5±2 years)	Body Weight (5.28±0.28 kg)	Age (5±2 years)	Body Weight (6.08±0.70 kg)
Transverse length	Right	r	0.473	0.106	0.919**	0.908**
	Left	r	0.598	0.455	0.929**	0.920**
Transverse width	Right	r	0.877**	0.440	0.871**	0.825*
	Left	r	0.836**	0.179	0.710*	0.682*
Transverse height	Right	r	0.347	0.185	0.894**	0.756*
	Left	r	0.752*	0.413	0.864**	0.720*
Sagittal length	Right	r	0.234	0.013	0.909**	0.912**
	Left	r	0.443	0.388	0.906**	0.908**
Sagittal height	Right	r	0.311	0.120	0.908**	0.924**
	Left	r	0.669	0.249	0.875**	0.881**
Dorsal length	Right	r	0.106	-0.171	0.908**	0.910**
	Left	r	0.355	0.333	0.921**	0.912**
Dorsal width	Right	r	0.741*	0.362	0.522	0.503
	Left	r	0.847**	0.246	0.590	0.586
Transverse ellipse volume	Right	r	0.902**	0.401	0.970**	0.906**
	Left	r	0.892**	0.378	0.952**	0.885**
Maximum ellipse volume	Right	r	0.844**	0.377	0.960**	0.929**
	Left	r	0.906**	0.423	0.938**	0.901**
Planimetry volume	Right	r	0.883**	0.539	0.967**	0.934**
	Left	r	0.895**	0.570	0.967**	0.945**

*** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, r: Pearson correlation coefficients*

Average volume values that calculated using transverse ellipse, maximum ellipse, and planimetry methods for male cats were found as 149.46±19.71 mm^3; 154.80±19.70 mm^3; 166.86±19.04 mm^3, while the same values were found as 89.52±11.82 mm^3, 92.31±11.90 mm^3, 109.40±6.02 mm^3 for female cats, respectively.

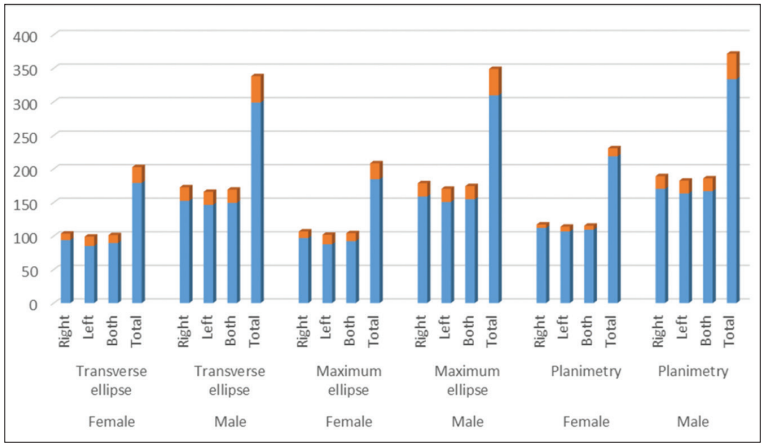

Fig 4. Distribution of the thyroid glands volumetric measurements in Van Cats by gender

Distribution of the thyroid glands volumetric measurements by gender has been given in *Fig. 4*. Generally, according to the graph in the figure, it was seen that male Van Cats were higher volumetric measurement of thyroid gland compared to female Van Cats.

Table 3 displays the correlation between the morphometric and volumetric measurement values for thyroid glands for each gender with other parameters like age and body weight. Accordingly, a positive correlation was observed between the female cats' age with right - left transverse width, left transverse height, right - left dorsal width, right - left transverse ellipse volume, right - left maximum ellipse volume, and right - left planimetry volume values ($P<0.05$). A further and generally positive correlation was determined between female cats' body weights with thyroid gland morphometric and volumetric values (except for right - side dorsal length), but the correlation was not statistically significant ($P>0.05$). In male cats, on the other hand, both age and body weight were found to have a positive and statistically significant correlation with right - left transverse length, right - left transverse width, right - left transverse height, right - left sagittal length, right - left sagittal height, right - left dorsal length, right - left transverse ellipse volume, right - left maximum ellipse volume, and right - left planimetry volume values ($P<0.05$).

Discussion

While methods like high-resolution ultrasonography and scintigraphy imaging are effective in determining primary thyroid and parathyroid disorders, CT and MRI methods are becoming more widely and effectively used in determining a variety of cases that influence the thyroid gland. These situations particularly include determination of the size and operative conditions of masses in thyroid glands like ectopic thyroid, thyroidal masses, or aggressive thyroid neoplasia, and MRI and CT imaging are also capable of providing aid detailed inspection of the normal structure of the thyroid gland [11,13]. Furthermore, morphometric and volumetric measurement values for small pet animals like cats and dogs obtained using imaging methods like CT and MRI scans provide valuable information for Veterinary clinicians in the diagnosis and treatment of various pathological conditions concerning the thyroid gland and neighboring anatomical structures [7,11,13,14,17]. The present study is a study that determines the morphometric and volumetric values for right and left-side of thyroid lobes in Van Cats using computed tomography, and that reveals the biometric differences between male and female cats in these values.

In general, measurement values for the thyroid gland obtained using medical imaging methods have been studied in humans, dogs, and cats in terms of homotypical variations and sexual dimorphism [7,9,18-20]. In terms of sexual dimorphism, it has been determined with the present study that morphometric and volumetric measurement values for male cats are larger compared to female cats. Evaluation of the homotypical variations in the parameters, on the other hand, has shown that right-side of thyroid gland measurement values are higher compared to the left-side of counterpart. These findings lead us to conclude that in Van Cats, the right lobe of the thyroid gland is larger compared to the left lobe, and male cats have larger thyroid glands compared to females.

Dyce et al.[5] have reported that the thyroid lobes in medium-sized dogs are approximately 5 cm in length and 1.5 cm in width, and that immature and brachiocephalic species had larger glands, while in cats each thyroid gland lobe is approximately 2 cm in length and 0.3 cm in width. Drost et al.[7] have used helical computed tomography to perform a clinical study on 8 female cats to obtain transverse, sagittal and dorsal sections on both right and left thyroid lobes, and reported the average length, height, and width values as 16.78±2.48 mm, 4.19±0.93 mm, and 2.28±0.76 mm, respectively. In the present study, the average length, width, and height values in all sections for right and left thyroid glands were found as 25.41±1.63 mm, 2.49±0.09 mm, and 4.54±0.21 mm for male cats respectively, and as 19.57±0.92 mm, 2.06±0.17 mm, and 4.19±0.21 mm for female cats, respectively. These values and the literature in general, and any small variations are attributed to age, length, body weight, and racial properties of the studied cats. Meanwhile, various studies have reported that these sizes change significantly in cats with hyperthyroidism. For instance, Volckaert et al.[21] performed a study where they reported the length, height, and width of the thyroid glands of cats with hyperthyroidism as 26.7 mm, 10.5 mm, and 13.3 mm respectively with ultrasonography, and as 20.7 mm, 13.2 mm, and 13.1 mm respectively with

scintigraphy. Besides, Wisner et al.[22] reported right and left side length, height, and width values in hyperthyroid cats as 21.9±4.4 mm, 20.2±3.6 mm; 8.1±3.0 mm, 5.5±2.4 mm; 7.7±2.4 mm, 5.7±2.1 mm, respectively. These literature results can be interpreted as cats having a large variation in scale in terms of hyperthyroidism.

Certain studies performed on humans have reported a generally positive correlation between the size of the thyroid gland with age and body weight [19,23]. On the other hand, Lee et al.[18] have reported that humans have a strong negative correlation between thyroid measurements and age, but have a positive correlation between body weight and thyroid gland size. Furthermore, Taeymans et al.[9] used CT images to determine the normal canine thyroid gland sizes and reported a negative yet insignificant correlation between age and gland size. The same researchers also reported that no meaningful correlations existed between body weight and thyroid gland size. Despite that, Taeymans et al.[10] performed another study using MRI and reported a correlation between normal canine thyroid gland size and body weight. In the present study, however, a generally positive correlation was determined between male cats' thyroid measurements and their age and body weights. While female cats were found to have a mostly positive correlation between age and thyroid measurements, no correlation was determined between their body weight and thyroid sizes. Based on these results it can be concluded that correlations between age and body weight and thyroid gland measurements can vary between species, and even within the same species variations may emerge due to factors like length, racial properties, measurement methods, and iodine intake.

Many studies were performed on cats and dogs to determine volumetric measurements of thyroid glands using medical imaging methods like ultrasonography, scintigraphy, and computed tomography [7,9,21,22]. The average thyroid gland volume of clinically healthy dogs was determined as 1148.04 mm^3 in the precontrast period, while it was determined as 1188.88 mm^3 in the postcontrast stage [9]. In healthy cats, ultrasonography was used to determine the lobar volume value of the thyroid gland in cats as 85 mm^3, and total volume as 169 mm^3 [22]. In another study, computed tomography images were used in conjunction with a transverse ellipse, maximum ellipse, and sum of areas methods to obtain average thyroid gland volume, which was reported as 75.06±31.52 mm^3, 115.63±50.80 mm^3, and 113.75±49.46 mm^3 for the methods, respectively [7]. In the present study, transverse ellipse, maximum ellipse, and planimetry methods were used to calculate the thyroid gland average volumes, which were found as 149.46±19.71 mm^3, 154.80±19.70 mm^3, and 166.86±19.04 mm^3 for the methods respectively in male cats, and as 89.52±11.82 mm^3, 92.31±11.90 mm^3, and 109.40±6.02 mm^3 in female cats, respectively. This variation between the measurements was attributed primarily to gender, followed by age, length, body weight, racial properties, and the differences between measurement methods.

There were a few limitations to this study. (1) The morphometric and volumetric measurement values of the thyroid gland of Van Cats in the study were obtained under general anesthesia and using a CT device. CT application has some disadvantages such as the harmful effects of ionizing radiation applied on the body in CT scans. However, medical imaging methods such as 2D and 3D ultrasound, which provide the opportunity to obtain images for morphometric and volumetric measurements of the thyroid gland of Van Cats, without putting the cats under general anesthesia and exposing them to ionizing radiation, were not used in the study. (2) It would be optimal to compare CT measurements of the thyroid gland of Van Cats with in situ measurements obtained using calipers. However, all of the Van Cats used in the presented study were healthy and alive. CT images of the study were obtained only under general anesthesia without any damage to the vitality of these cats, and measurements were taken from these images using electronic calipers through the RadiAnt DICOM Viewer (64 Bit) software program. For these reasons, it was not possible to dissect the thyroid gland of Van Cats, which is an endemic species, to obtain measurement values by using a caliper or to examine histologically.

As a result, the morphometric and volumetric parameters of thyroid glands of clinically healthy Van Cats were measured using computed tomography images, and the sexual dimorphism and homotypical variations between the measurements were statistically determined. We humbly believe the results will be useful in the evaluation of thyroid gland pathologies in Van Cats for Veterinary clinicians.

References

1. Yılmaz O: Van Kedilerinde glandula lacrimalis'in bilgisayarlı tomografi görüntülerinden morfometrik incelenmesi. *Atatürk Üniv Vet Bil Derg*, 16 (1): 16-24, 2021. DOI: 10.17094/ataunivbd.835268

2. Yılmaz O, Demircioğlu İ: Computed tomography-based morphometric analysis of the hip bones *(Ossa coxae)* in Turkish Van Cats. *Kafkas Univ Vet Fak Derg,* 27 (1): 7-14, 2021. DOI: 10.9775/kvfd.2020.24449

3. Cak B: 2017. Turkish Van Cat and Turkish Angora Cat: A review. *J Agric Sci Technol A,* 7 (3): 151-159, 2017. DOI: 10.17265/2161-6256/2017.03.002

4. König HE, Liebich HG: Endocrine glands (glandulae endocrinae). **In,** König HE, Liebich HG (Eds): Veterinary Anatomy of Domestic Mammals: Text Book and Colour Atlas. 3rd ed., 561-570, Schattauer, Germany, 2007.

5. Dyce KM, Sack WO, Wensing CJG: Textbook of Veterinary Anatomy, 4th ed., 268-331, Saunders, Elsevier Inc, Missouri, United States, 2010.

6. Drost WT, Mattoon JS, Samii VF, Weisbrode SE, Hoshaw-Woodard SL: Computed tomographic densitometry of normal feline thyroid glands. *Vet Radiol Ultrasound,* 45 (2): 112-116, 2004. DOI: 10.1111/j.1740-8261.2004.04018.x

7. Drost WT, Mattoon JS, Weisbrode SE: Use of helical computed tomography for measurement of thyroid glands in clinically normal cats. *Am J Vet Res,* 67 (3): 467-471, 2006. DOI: 10.2460/ajvr.67.3.467

8. Sebastiani AM, Fishbeck DW: Mammalian Anatomy: The Cat. 2nd ed., 184, Publishing Company, Colorado, Morto, 2005.

9. Taeymans O, Schwarz T, Duchateau L, Barberet V, Gielen I, Haskins M, Van Bree H, Saunders JH: Computed tomographic features of the normal canine thyroid gland. *Vet Radiol Ultrasound*, 49 (1): 13-19, 2008. DOI: 10.1111/j.1740-8261.2007.00310.x

10. Taeymans O, Dennis R, Saunders JH: Magnetic resonance imaging of the normal canine thyroid gland. *Vet Radiol Ultrasound*, 49 (3): 238-242, 2008. DOI: 10.1111/j.1740-8261.2008.00357.x

11. Taeymans O, Penninck DG, Peters RM: Comparison between clinical, ultrasound, CT, MRI, and pathology findings in dogs presented for suspected thyroid carcinoma. *Vet Radiol Ultrasound*, 54 (1): 61-70, 2013. DOI: 10.1111/j.1740-8261.2012.01966.x

12. Peterson ME, Broome MR: Thyroid scintigraphy findings in 2096 cats with hyperthyroidism. *Vet Radiol Ultrasound*, 56 (1): 84-95, 2015. DOI: 10.1111/vru.12165

13. Wisner ER, Zwingenberger AL: Thyroid and parathyroid. **In,** Atlas of Small Animal CT and MRI. 141-152, Willey- Blackwell Publishing, USA, 2015.

14. Bush J, Nemanic S, Gordon J, Bobe G: Computed tomographic characteristics of the thyroid glands in eight hyperthyroid cats pre- and postmethimazole treatment compared with seven euthyroid cats. *Vet Radiol Ultrasound,* 58, 176-185, 2017. DOI: 10.1111/vru.12458

15. Prokop M: General principles of MDCT. *Eur J Radiol,* 45, S4-S10, 2003. DOI: 10.1016/s0720-048x(02)00358-3

16. Kalra MK, Maher MM, Toth TL, Hamberg LM, Blake MA, Shepard J, Saini S: Strategies for CT radiation dose optimization. *Radiology*, 230, 619-628, 2004. DOI: 10.1148/radiol.2303021726

17. **Lautscham E, Von Klopmann C, Schaub S, Stengel C, Hartmann A:** CT imaging features of the normal parathyroid gland in the dog. *Tierarztl Prax Ausg K Kleintiere Heimtiere*, 48 (5): 313-320, 2020. DOI: 10.1055/a-1236-4542

18. Lee DH, Cho KJ, Sun DI, Hwang SJ, Kim DK, Kim MS, Cho SH: Thyroid dimensions of Korean adults on routine neck computed tomography and its relationship to age, sex, and body size. *Surg Radiol Anat,* 28 (1): 25-32, 2006. DOI: 10.1007/s00276-005-0042-3

19. Arioz Habibi H, Memis Durmaz ES, Qarayeva V, Kandemirli SG, Kalyoncu Ucar A, Aslan M, Apaydin G, Kurugoglu S, Adaletli I: Quantitative assessment of thyroid, submandibular, and parotid glands elasticity with shear-wave elastography in children. *Ultrasound Q*, 34 (2): 58-61, 2018. DOI: 10.1097/RUQ.0000000000000352

20. Binar M, Serindere M, Bozlar U, Karahatay S, Demirkapi S, Aydin U, Gokgoz M, Tasar M, Gerek M: Determining the thyroid gland volume causing tracheal compression: A semiautomated 3D CT volumetry study. *Medicina,* 55 (5): 143, 2019. DOI: 10.3390/medicina55050143

21. Volckaert V, Vandermeulen E, Saunders JH, Combes A, Duchateau L, Peremans K: Scintigraphic thyroid volume calculation in hyperthyroid cats. *J Feline Med Surg*, 14 (12): 889-894, 2012. DOI: 10.1177/1098612X12458427

22. Wisner ER, Théon AP, Nyland TG, Hornof WJ: Ultrasonographic examination of the thyroid gland of hyperthyroid cats: Comparison TO $^{99m}TcO^{-}_{4}$ scintigraphy. *Vet Radiol Ultrasound*, 35, 53-58, 1994. DOI: 10.1111/j.1740-8261.1994.tb00178.x

23. Hegedüs L, Perrild H, Poulsen LR, Andersen JR, Holm B, Schnohr P, Jensen G, Hansen JM: The determination of thyroid volume by ultrasound and its relationship to body weight, age, and sex in normal subjects. *J Clin Endocrinol Metab,* 56 (2): 260-263, 1983. DOI: 10.1210/jcem-56-2-260