

Normal Values of the Kidney in Persian Cats by MRI

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ABSTRACT

Renal diseases are common in cats. Different imaging techniques are available for the detection of kidney disorders. However, there is currently no data available for the normal kidney size of Persian cats measured by magnetic resonance imaging (MRI) technique. In the present study, the kidney size of 10 healthy male and female Persian cats was analyzed. MRI was used to measure healthy Persian cats' kidneys and the results were compared by gender and location (left vs. right). The length, width, depth, and volume of the kidneys were measured from images taken using MRI. The data of kidney from male cats was larger than that of females. The length and width of the right kidney were larger than the left kidney, especially the volumes of the right kidney were significantly greater than the left kidney ($P < 0.01$). In males, the length of the right kidney was significantly larger than the left ($P < 0.05$). In females, the mid width ($P < 0.05$) and volume ($P < 0.05$) of the right kidney were significantly larger than the left. This is the first report describing the kidney size of healthy Persian cats by MRI. These data regarding the feline kidney may help to establish reference values and provide information regarding renal pathology and surgery in practice.

Keywords: Renal Size; MRI; Imaging Techniques; Gender Differences.

INTRODUCTION

One of the most common disorders in cats is renal disease (1-5). In particular, Persian cats have a hereditary predisposition to chronic renal failure (5, 6). Several imaging techniques are available for the detection of kidney disorders (7-9). Among these methods, ultrasonography (US), radiography, computer tomography (CT), and magnetic resonance imaging (MRI) are included. Computer tomography (CT) and magnetic resonance imaging (MRI) are detailed and comparative imaging techniques. MRI is the most accurate imaging method, especially, in soft tissue investigation. However, US and radiography are more accessible and less expensive than MRI and CT. Moreover, the US does not require general anesthesia (7).

Only a few studies have been reported in association with normal renal dimensions in cats (10-12). Although

kidney dimensions may vary between cat breeds, most of the cat populations enrolled in previous studies include a wide range of cat breeds (10, 12-14). It was reported that Persian cats have a high incidence of inherited polycystic kidney disease (5, 6). The reference values for Persian cats' kidney morphometry, to the best of the author's knowledge, based on MRI, have not been reported. Therefore, in this study, we limited our research to a single breed of cat (Persian cat) using MRI, which is considered the most accurate imaging technique.

In this study, the aim was to determine the kidney size in 20 healthy Persian cats by MRI (10 males and 10 females). The length, width, depth, and volume of Persian cats' kidneys were measured. Using statistical methods, these data were compared according to gender and position (left and right).

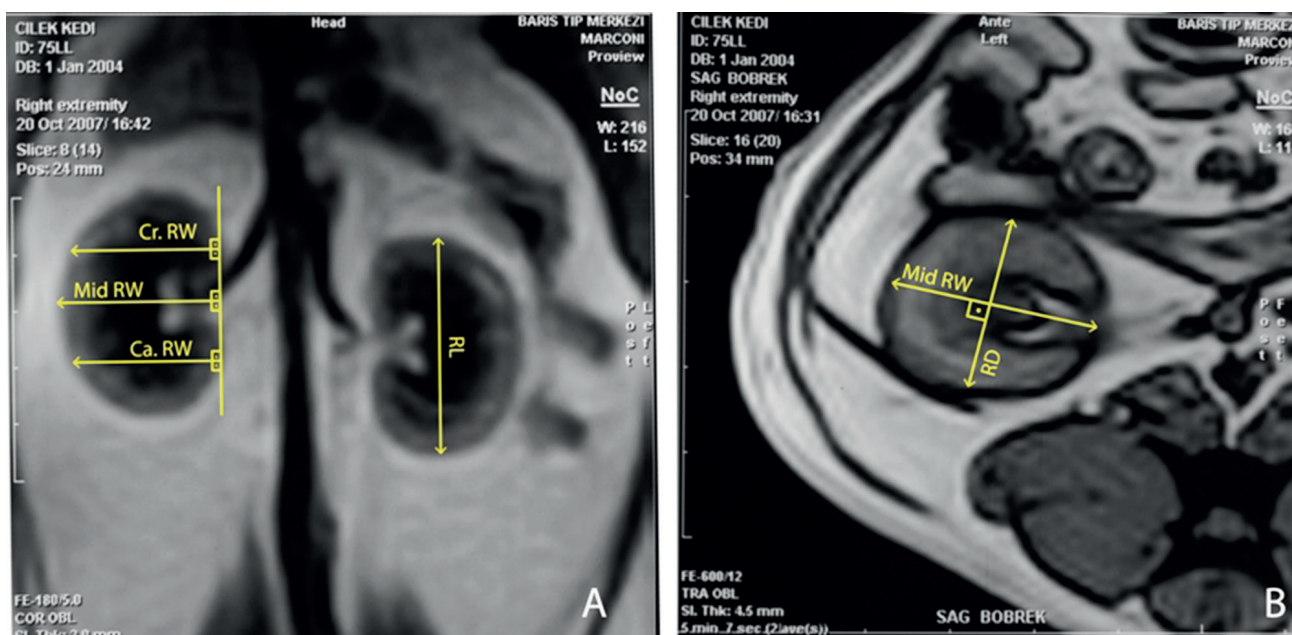


Figure 1. The renal length and renal width of Persian cats' kidneys were measured from dorsal sections of magnetic resonance imaging (A). The renal depth of the kidney was measured from transverse sections of magnetic resonance imaging (B). Cr. RW; Cranial Renal Width, Ca. RW; Caudal Renal Width, Mid RW; Mid Renal Width, RL; Renal Length RD; Renal Depth

MATERIALS AND METHODS

Cats used in the study

A total of 20 (6 intact and 4 neutered males, and 2 intact and 8 spayed females) healthy Persian cats with an average age of 2.49 ± 1.18 years (mature) and a weight of 3.65 ± 0.75 kg were examined. In the study, cats registered in a private veterinary clinic and whose parents were registered as Persian cats, approved by a veterinarian were used. These animals were Persian cats, whose health checks had been carried out regularly. Written informed consent was obtained from each owner and their local veterinary surgeon before enrollment. The cats were considered healthy on the basis of physical examination, serum biochemistry (involving blood urea nitrogen and creatinine levels) and complete urinalysis.

Measurements and calculation using MRI

The determination of the kidney morphometry of the Persian cats was carried out by the use of the MRI technique. The study was performed by a single blinded researcher. For MRI, cats were anesthetized intramuscularly with a combination of medetomidin HCl 0.08 ml/kg (Domitor®, Pfizer, Orion-Farmos, Espoo, Finland) and ketamine 6 mg/kg (Ketasol®, Interhas, Richter Pharma, Wels, Austria). After anesthesia,

the cats were placed in dorsal recumbency and stabilized on the table. Afterwards, the images of the kidney were recorded. MRI was performed with a commercially available 0.23 Tesla open configuration MRI system (Philips Panorama, Marconi Medical System-outlook proview interface VIA 2.0.4.0.23 Tesla, The Netherlands). The data of the setting device was TR-350, TE 10, Flip angle-90, Number of average-2, FOW-380, Matrix-216 x 216 up 256 x 256.

The measurements for the MRI sections were taken in sagittal and transverse planes (Figure 1). To measure the length and width of the kidneys, dorsal sections were taken in a sagittal plane by MRI were used. The renal length was measured in the sagittal plane from the cranial to caudal poles of the kidney in the cranio-caudal direction along the longitudinal axis of the kidney (Figure 1A) (10-13). The cranial renal width was measured on an axis perpendicular to the longitudinal axis of the kidney from the cranio-medial pole to the lateral margin (Figure 1A). The caudal renal width was measured on an axis perpendicular to the longitudinal axis of the kidney from the caudo-medial pole to the lateral margin (Figure 1A).

Following the measurements, the average of the cranial and caudal renal widths was calculated. For determination of the mid-renal width in the sagittal plane, the bar was

Table 1. The measurements of Persian cats' kidneys by magnetic resonance imaging (MRI).

Renal dimensions	Right Kidney (Mean ± S.D.) (N=20)	Left Kidney (Mean ± S.D.) (N=20)
RL (cm)	3.74±0.69	3.52±0.44
Mid RW (cm)	2.58±0.42	2.52±0.39
Av. RW (cm)	2.37±0.43	2.28±0.40
RD (cm)	2.21±0.30	2.21±0.32
V 1 (cm ³)	11.84±6.20 ^a	10.71±4.65 ^a
V 2 (cm ³)	10.92±6.01 ^b	9.72±4.39 ^b

^{a,b} In Persian cats, the volumes 1 and 2 of the right kidneys were larger than those of the left kidneys (a; $P < 0.01$, b; $P < 0.01$). RL; Renal Length, Mid RW; Mid Renal Width, Av. RW; Average of Cranial Renal Width and Caudal Renal Width, RD; Renal Depth, V 1; Volume 1=0.523 x RL x Mid RW x RD, V 2: Volume 2=0.523 x RL x Av. RW x RD

formed parallel to the longitudinal axis and by crossing the cranio-medial pole to the caudo-medial pole of the kidney. The mid-renal width was measured on an axis perpendicular to the longitudinal axis of the kidney from the level of the renal hilum on the bar to the lateral margin (Figure 1A) (10-13). Transverse sections were taken at 3-4.5 mm intervals. In these sections, the renal depth was measured on an axis perpendicular to the mid-renal width (Figure 1B). The depth of the kidney was measured in a ventro-dorsal direction from the dorsal pole to the ventral pole of the kidney in a transverse plane (Figure 1B) (10-13). From MRI images, the renal volumes were calculated using the ellipsoid formula: Volume (cm³ or ml) = 0.523 x length (cm) x width (cm) x depth (cm) (13, 15, 16). Two volumes were calculated, according to two different widths:

- Volume 1 = 0.523 x length x width (mid renal width) x depth.
- Volume 2 = 0.523 x length x width (average of cranial and caudal renal width) x depth

Statistical Methods

Statistical analyses were carried out using the SPSS 15.0 software package. The normality of distributions of data was analyzed using the Shapiro-Wilk test. A comparison of the measurements from the kidneys of male and female cats was performed by the Student's t test. The presence of significant statistical differences in abnormal distribution was checked using the Mann-Whitney U test. A comparison of

Table 2. The renal measurements of male and female Persian cats by magnetic resonance imaging (MRI).

Renal Dimensions	Male (Mean ± S.D.) (N=10)	Female (Mean ± S.D.) (N=10)	
Right Kidney	RL (cm)	3.90±0.86 ^a	3.58±0.44
	Mid RW (cm)	2.69±0.55	2.47±0.23 ^b
	Av. RW (cm)	2.49±0.55	2.25±0.21
	RD (cm)	2.29±0.31	2.12±0.27
	V 1 (cm ³)	13.69±8.07	9.99±2.91 ^c
Left Kidney	V 2 (cm ³)	12.77±7.86	9.07±2.63 ^d
	RL (cm)	3.62±0.55 ^a	3.42±0.31
	Mid RW (cm)	2.67±0.45	2.36±0.25 ^b
	Av. RW (cm)	2.44±0.44	2.12±0.30
	RD (cm)	2.28±0.36	2.13±0.28
	V 1 (cm ³)	12.25±5.80	9.18±2.61 ^c
	V 2 (cm ³)	11.19±5.44	8.26±2.52 ^d

^a The length of the right kidney was longer ($P < 0.05$) than the left kidney in male Persian cats.

^{b,c,d} The mid width, volumes 1 and volume 2 of the right kidney were larger than the left kidney in female Persian cats (b; $P < 0.05$, c; $P < 0.05$, d; $P < 0.05$). RL; Renal Length, Mid RW; Mid Renal Width, Av. RW; Average of Cranial Renal Width and Caudal Renal Width, RD; Renal Depth, V 1; Volume 1=0.523 x RL x Mid RW x RD, V 2; Volume 2=0.523 x RL x Av. RW x RD

MRI data from the right and left kidneys was performed by a Paired Student's t test. The presence of significance in abnormal distribution was analyzed using the Wilcoxon test. The Pearson correlation test was used in order to assess the correlation between all the parameters. A P -value of less than or equal to 0.05 was deemed statistically significant.

RESULTS

The data from MRI was examined and the dimensions of the kidneys were calculated (Table 1 and 2). In Persian cats, while the length and width of the right kidney were larger than the left (Statistically not significant, $P > 0.05$), the depths of the right and left kidneys were equal. The volumes 1 and 2 of the right kidney were significantly larger ($P < 0.01$ and $P < 0.01$, respectively) than the volumes 1 and 2 of the left kidney (Table 1).

When the results from both genders were compared to each other, the length, width, depth, and volume measurements of both kidneys were larger in males than in females (Table 2). When the data from males and females was con-

sidered separately, significant differences were found between the right and left kidneys (Table 2). The length of the right kidney was significantly longer ($P < 0.05$) than the left kidney in males. The mid-width, volume 1 and volume 2 of the right kidney were significantly larger ($P < 0.05$, $P < 0.05$, $P < 0.05$, respectively) than the left kidney in female cats (Table 2).

There was no statistically significant correlation between these kidney measurements and age, or weight. Furthermore, when comparing kidney measurements between neutered and intact animals, no statistical significance was detected in this study.

DISCUSSION

Although the size of the kidney is an important parameter in order to distinguish between normal and abnormal (7), there is, to the best knowledge of the authors, no standard for the size of the Persian cat kidney measured by the MRI method. We were unable to compare the results obtained by MRI with previous results because of the dearth of literature regarding kidney measurements obtained by MRI in cats.

Anatomically, the normal renal length has been reported as 38–44 mm in cats by the US (14). Debruyne *et al.* (7) measured the size of the kidney by US in 10 cats and noted that the length of the kidney was 30.4–42.9 mm. An ultrasonographic study reported the mean renal length was 40.9±3.3 mm in 11 Sphynx (5 male and 6 female), 37.7±4.3 mm in 15 British Shorthair (8 male and 7 female) and 38.7±4.1 mm in 15 Ragdoll (5 male and 10 female) healthy adult cats (17). Tyson *et al.* (18) determined that the average actual renal kidney length in 12 cadaver cats, was 45 mm (SD ± 7) by vernier caliper measurements. It was observed that the renal length measurements taken by ultrasonography, regardless of the gender and location of the kidney, were longer than our measurements (3.63±0.58cm) taken by MRI or close to the lowest value of the given measurement range by US.

Park *et al.* (11) denoted that the renal length was 38.3±5.1 mm in the left kidney and 39.6±4.8 mm in the right kidney by US in 50 (23 females and 27 males) healthy adult Korean domestic short hair cats, weighing 2.1–5.5 kg. Darawiroj and Choisunirachon (12) determined that the average length of the left kidney was 35.2 ± 4.4 mm and the right kidneys were 35.4±4.6 mm by computer tomography in 27 (7 neutered and 9 intact females, and 6 neutered and 9 intact males) healthy domestic cats of different ages. According to the length of

the kidneys, our results obtained by MRI were shorter than the results obtained by Park *et al.* (11) by US. When we compared the results obtained by Darawiroj and Choisunirachon (12) by CT, the left kidney length was found to be the same as the mean value, but the right kidney length was found to be slightly longer (Table 1).

In this study, we used eight spayed out of ten females and four neutered out of ten male cats. We found that the location of the kidney (left vs. right) and the gender further affected the length of the kidney. Our study showed that the length of the kidney in males was longer than in females, but statistically not significant. Besides, male and female Persian cats have longer right kidneys than left ones. These results were statistically significant ($P < 0.05$) only in males and not in females (Table 2). It was also observed that neutering had no effect on the length of the kidney.

Park *et al.* (11) measured the width and depth of the kidneys in Korean domestic short hair cats by US. They found the renal widths were 26.5±3.4 mm and 26.6±3.3 mm in the left and right kidney in the dorsal plane, respectively. They also reported that the renal depth was 24.2±2.8 mm in the left kidney and 23.8±2.7 mm in the right kidney in the transverse plane. Darawiroj and Choisunirachon (12) measured that the average renal widths were 24.6 ± 2.8 mm, 24.5 ± 2.7 mm, and the renal depths were 21.9 ± 3.1 mm, 20.5 ± 2.3 mm in the left and right kidney by CT, respectively. The MRI data we obtained differed from previous studies' measurements (12) (Table 1). In this study, the widths as mentioned, the average cranial and caudal width of both kidneys, and the mid width were narrower than Park *et al.* (11). We observed the mid width of both kidneys was larger and the average width of both kidneys was narrower than the measurements obtained by Darawiroj and Choisunirachon (12). Furthermore, the mid width of the right kidney in female cats was significantly larger ($P < 0.05$) than the left kidney according to the MRI measurements (Table 2).

Reichle *et al.* (19) calculated renal volume, using the ellipsoid formula in five female healthy cats by ultrasonography, was 14800±2900 mm³. According to Tyson *et al.* (18), renal volume measured by US in 12 cadaver cats was 15280±6400 mm³. Tyson *et al.* (18) reported that the average actual kidney volume in cats was 18993±7682.5 mm³ using the Archimedes' technique. With the data collected from computer tomography images, they calculated the renal volume by using the ellipsoid formula and determined that

the renal volume was $15200 \pm 5700 \text{ mm}^3$ (18). In this study, the kidney volume measured by MRI in Persian cats was smaller than the data measured in previous studies (Table 1). The volume of the right kidney was significantly larger ($P < 0.01$) than the left kidney, depending on differences in measurements of the left and right kidney. Although it was not found to be statistically significant, the kidney volume of males was greater than that of females, in this study. This indicates that gender is an important factor for kidney size (Table 2).

Persian cats are popular around the world and are in the top five among the most numerous pedigree cat breeds (20). However, the certification system in Turkey has not been taken seriously compared to the US or UK. According to the Association of World Breeds, the only full member of the World Cat Federation, there are approximately 12 000 certified purebred cats in Turkey. Certified Persian cats account for about 35% of this. Furthermore, the number of registered Persian cats without a certificate is 5 times more than this. A disadvantage has been the scarcity of certified purebred Persian cats in this study. In addition, in this morphometric study, the preference for healthy Persian cats in a specific age range (young adult, 2-3 years old) made it difficult to find appropriate animals.

Limitations to this study were the relatively small number of cats used and the fact that they were not pedigree as registered by a Cat Breeders Association. The cats used in the study were deemed purebred Persian cats, based on their physical appearance and the physical appearance of their parents and grandparents as carried out by a veterinarian.

In conclusion, this is the first study on the kidney size of healthy Persian cats. In comparison to other previous studies performed with cats by US and CT, our MRI results were dissimilar. The differences in the size of the kidney may be due to several factors. For example, the number of samples, range of ages, body weight, reproductive status, and breed of cats as well as imaging methods play a role. Among imaging methods, MRI provides a more accurate image, especially, in soft tissue investigation. Wood and McCarthy (21) reported that perirenal adipose tissue and the kidney have similar echogenicity and thus emphasized that it may cause errors in the measurement of the kidney by US. It was considered that the reason for the difference between renal size measurements taken by ultrasonography and CT may be due to the thickening of the fat tissue

around the kidney in neutered cats and the echogenicity of this fat tissue, similar to the kidney. In cats, gonadal status (neutered or intact) had no statistically significant effect on kidney length (21) and width (22, 23). However, due to fat accumulation in their kidneys, neutered cats may have longer kidneys (23). No statistical significance was found in the study when comparing kidney measurements between neutered or intact animals.

This study may be important to describe normal morphometric data obtained by MRI on the renal size of healthy Persian cats. Additionally, this study provides MRI information of the cat kidney, which may be applicable in feline veterinary clinical practice.

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