Journal of Animal & Plant Sciences, 33(4): 2023, Page: 949-957
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2023.4.0688

CRANIOMETRIC COMPARISONS OF THE SKULL OF MALE AND FEMALE MALAKLI DOGS USING 3-DIMENSIONAL IMAGING: A COMPUTED TOMOGRAPHY (CT) STUDY

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ABSTRACT

The skull is an important anatomical structure to discern dog breeds and wolves from dogs. For this purpose, skull morphology and some morphometric measurements of Malakli dogs, a local breed in the Aksaray region, were examined. Thirty-one distances were measured, and the skulls, which were computerized tomography, were converted into three-dimensional (3D) images in fourteen skulls (7 male-7 and female) of adult dogs. Different morphological features and statistical findings that were not revealed by taking measurements from 30 distinct anatomical points of Aksaray Malakli dog skull bones were determined in accordance with the literature. It was determined that males were greatest than females in most of the osteometric measurements as well as in surface area and volume measurements. Through examination of the cranial morphometric characteristics and 3D images of Aksaray Malakli dogs, the results of this study demonstrated differences between the sexes. In addition to showing some similarities to the cranial structure of several carnivores, there are also some different anatomic characteristics.

Keywords: 3D modeling, Computed tomography, Craniometric, Malakli dog.

Published first online April 15, 2023 Published final August 04, 2023

INTRODUCTION

Aksaray Malaklı dogs are guard dogs bred in Aksaray in the Central Anatolia region. Aksaray Malaklı dogs show similarities to Kangal dogs but are differentiated from Sivas Kangal dogs by greater body weight and body dimensions and are evaluated as a different genotype. Although both dogs come from the same gene pool, with the owners taking body measurements into consideration, breeding and selection methods have resulted in some similarities in respect of morphological characteristics such as coat color and markings on the head and body (Alverez *et al.*, 2013;Aslım and Sinmez 2017).

Nevertheless, Aksaray Malakli dogs are generally associated with a greater body weight, a thickset body and head, drooping mouth, jowls, and eyelids, a strong muscular body, and high levels of aggression. As such, it has not been a genotype that has been monitored and protected for long in local packs. To determine various characteristics of Aksaray Malakli dogs and for this breed to be recognized as specific to Aksaray, there is a collaboration between the Aksaray Governorship, Aksaray City Council, some universities, and the Dog Breeding and Cynology Federation (Alverez *et al*., 2013; Aslım and Sinmez, 2017).

Anatomic studies play a very important role in the accumulation of biological knowledge of breeds, which can then be used in different ways in health and biological areas such as surgical applications and phylogenetic, taxonomic, and evolutionary studies (Brünner *et al*., 2002; Erdoğan *et al*., 2012; Atasoy *et al*., 2014; Brombini *et al*., 2018; Erolin, 2019). The skull is the main component of the skeleton that provides information about changes that show a taxonomic association and are the reason for selection in animals (Gündemir *et al*., 2020). Craniometry is the basis of clinical and surgical studies (Naaz and Pani 2012). Similarly, different foramens of the skull have clinical importance in regional anesthesia around the head (Ilgün and Özkan 2015).

The dimorphism of the skull and the pelvis has been emphasized by several authors. Krogman and Iscan stated that it was possible to determine sex and race, with the reliability of 95% and 92%, respectively, from the pelvis bone or skull in a collection of 750 human skeletons. The use of the skull and pelvis bones was also reported to provide 98% examination reliability. This shows the importance of these regions in sex determination (Karimi *et al*., 2011).

Various medical imaging modalities can be used to form three-dimensional (3D) anatomic models. Computed tomography (CT) and magnetic resonance imaging (MRI) are the most frequently used methods. Both CT and MRI scans are typically stored in DICOM (Digital Imaging and Communication) format, which is the international standard for communicating, storing, obtaining, writing, processing, and viewing medical imaging information. To transfer to a 3D modeling application, scans (including surface, photogrammetry, CT and MRI) are useful to both add color and to improve geometry (e.g., removing unnecessary data and artifacts and repairing missing elements and remodeling) (Khosravi *et al*., 2012). Anatomy is naturally a three-dimensional subject, and it is extremely important to learn the 3D associations of structures. Research has shown that 3D digital modeling is useful, especially for more complex anatomic structures, and could make a valuable contribution to current teaching methods in medicine and anatomy (Kirmizibayrak, 2004; Ograk *et al*., 2018). The aim of this study was to present differences according to breed using detailed analysis of the morphometric parameters on 3D images of the skull to determine the breed standard for the Aksaray Malakli dog. This will be of guidance for dog breeders, dog associations and specialist commissions, dog judges, and others working with dogs.

MATERIALS AND METHODS

The skulls of 14 (7 male-7 female) Aksaray Malakli dogs, aged 4–5 years old, regardless of the difference in weight, that had died of various reasons at the Veterinary Health and Practiced and Research Centre of Aksaray University Veterinary Faculty between 2015 and 2019, were used in this study. Each Malakli dog cranium was scanned with a 64-detector MDCT device (General Electric Revolution) at 80kv, 200 MA, 639 mGY, and 0.625 mm slice thickness. The Prokop (2003) 15 was taken as a reference in the scan dose and protocol. The CT scans were recorded in DICOM format. The segmentation technique in 3D Slicer (5.0.2) software was used on the CT images. In obtaining the morphometric data, first, the measurement points were determined. These measurement parameters were taken by von den Driesch (1976). 3D images of skull measurements are shown in Figures 1 and 2. In our article, Onar *et al*., 2001 used for Cranium index calculations.

Table 1. Studied cranial parameters (mm)

NO	ABBREVIATION	DEFINITION
1	TL	Total length
2	CBL	Condylobasal length
3	BL	Basal length
4	BCA	Basicranial axis
5	BFA	Basifacial axis
6	NL	Neurocranium length
7	UNL	Upper neurocranium length
8	VL	Viscerocranium length
9	FL	Facial length
10	MPL	Median palatal length
11	LHPP	Length of the horizontal part of the palatine
12	BDEAM	Breadth dorsal to the external auditory meatus
13	GBOC	Greatest breadth of the occipital condyles
14	GBBPP	Greatest breadth of the bases of the paraoccipital processes
15	HFM	Height of the foramen magnum
16	GNB	Greatest neurocranium of the breadth
17	ZB	Zygomatic breadth
18	LBS	Least breadth of skull = least breadth aboral of the supraorbital processes
19	FB	Frontal breadth
20	LBBO	Least breadth between the orbits
21	LPB	Least palatal breadth: measured behind the canines
22	GIHO	Greatest inner height of the orbit
23	HOT	Height of the occipital triangle
24	GBFM	Greatest breadth of the foramen magnum
25	GLN	Greatest length of the nasal
26	SL	Snout length
27	GDAB	Greatest diameter of the auditory bulla
28	GMB	Greatest mastoid breadth
29	SHSC	Skull height without sagittal crest
30	BACA	Breadth at canina alveoli
31	SH	Skull heigth

The definitions and abbreviations of the measured osteometric parameters are shown in Table 1. The next stage was to obtain and evaluate the osteometric parameters. A total of 30 osteometric measurements were taken from the cranium. After completion of the morphometric measurements, the cranium surface area and volume values were calculated.

The ethics of this study was carried out by AKSARAY UNIVERSITY ANIMAL EXPERIMENTS LOCAL ETHICS COMMITTEE, with the permission of the ethics committee numbered 2022/1.

The data obtained were analyzed statistically using SPSS 22.0 software. Results were stated as mean ± standard deviation (SD) values. The differences between males and females were examined with the Independent Samples t-test, and Pearson correlation analysis was applied to the measurements.

Table 2. Indices and formulas of the skulls

Index	Formules
Facial Index	Zygomatic breadth(ZB) x 100/Viscerocranium length (VL)
Cranial Index	Greatest neurocranium of the breadth (GNB) x 100/ Upper neurocranium length (UNL)
Skull Index	Zygomatic breadth (ZB) x 100/ Total length (TL)
Foramen magnum Index	Height of the for. magnum (HFM) x 100 / Greatest breadth of the for. magnum (GBFM).

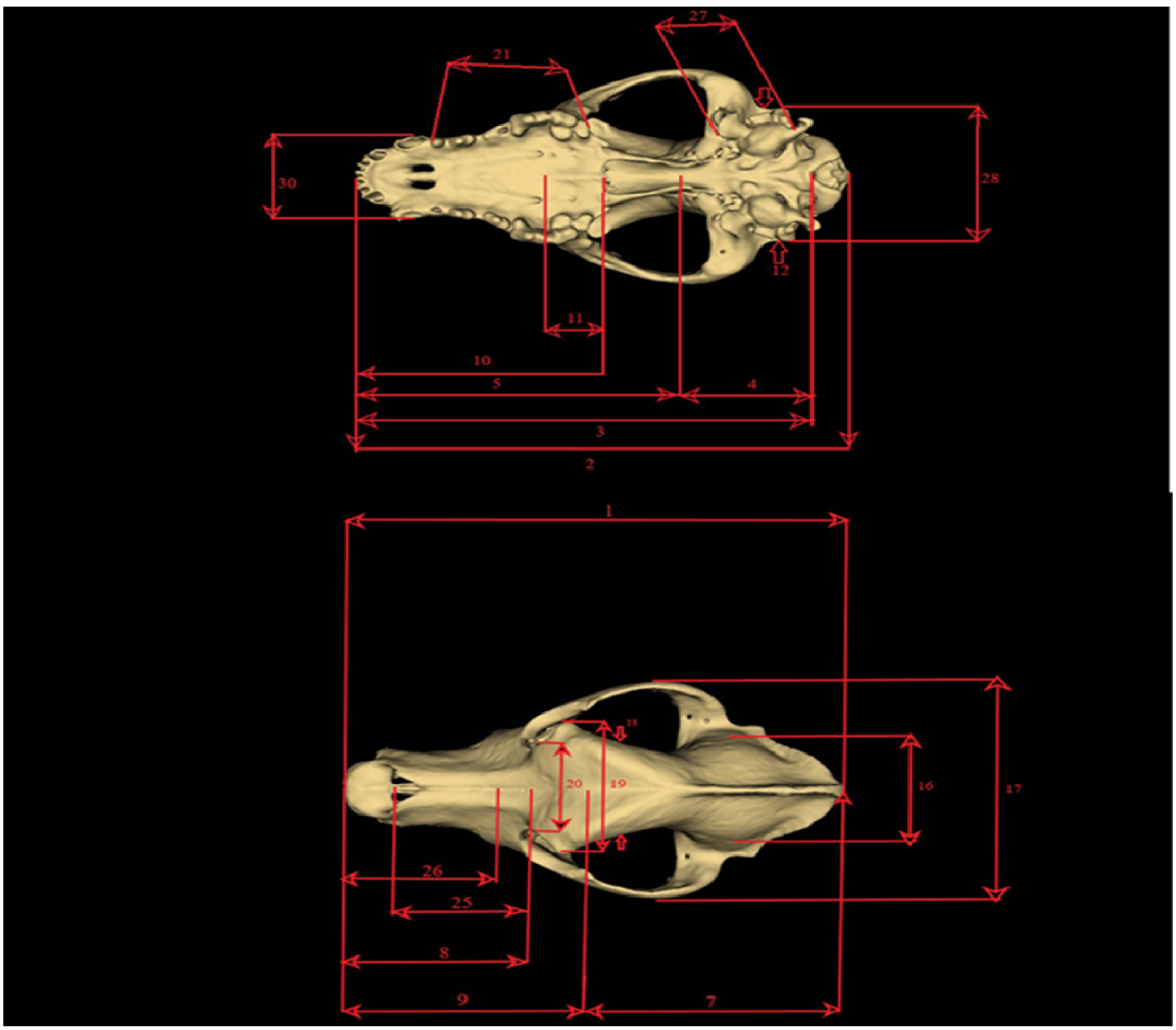

Figure. 1. Measurements of the skull of Aksaray Malakli dog (Dorsal and Ventral).

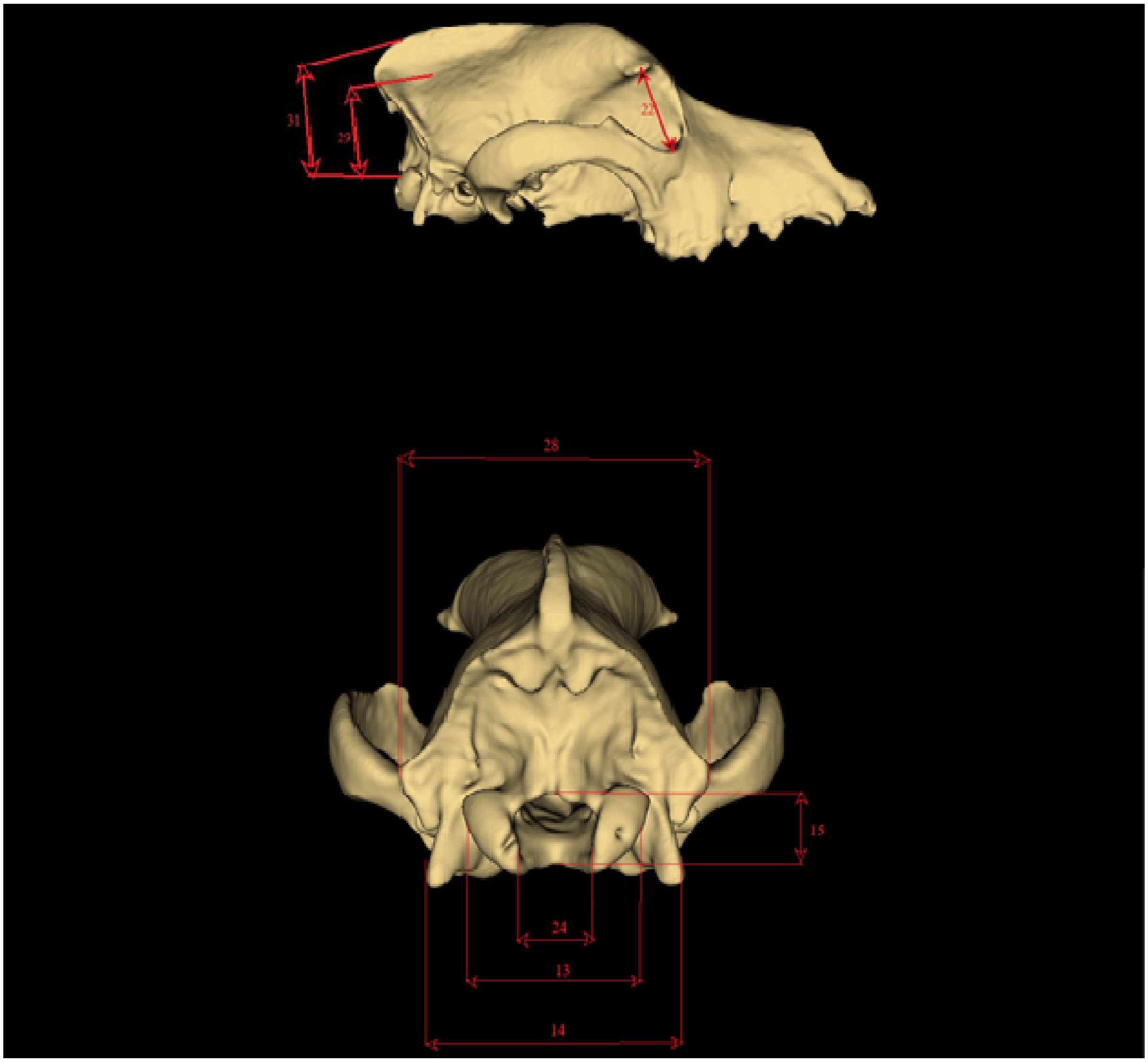

Figure. 2. Measurements of the skull of Aksaray Malakli dog(Lateral and Caudal).

RESULTS

A 3D model was created of each Aksaray Malakli dog, then measurements were taken on the model of the parameters defined in Table 3. Of these measurements, the highest value was total length (TL), which was determined to be statistically significantly greater in males at 277.11±8.49mm than in females at 264.14±1.75mm ($p<0.05$). The parameters SL was determined to be statistically significant ($p<0.01$). The data BL, LHPP, BDEAM, LPB, LBS, and HOT were determined to be statistically significant ($p<0.05$). The Male surface area and volume measurements of the Malakli dog were greater than that of the female dogs (Table 3).

The correlations between the measurement values are shown in Table 5. It was determined that there was a positive correlation between the TL measurement point and BL, BCA, BFA, UNL, FL, GLN, SL, MPL, LHPP, GDAB, GMB, BDEAM, GBOC, GBBPP, GBFM, HFM, GNB, ZB, LBS, FB, LBBO and LPB ($p<0.01$). No correlation was determined between the measurements of the BL parameters. Significant correlations were observed between the measurements of the other parameters ($p<0.01$, $p<0.05$).

Table 4 illustrates the craniofacial index measurement values obtained from the morphometric measurement value of the skull based on sex. Accordingly, it was determined that the facial index, skull index, cranial index, and foramen magnum index measurement values were statistically not significantly in the female Malaklı dogs compared to the male Malaklı dogs ($p>0.05$).

Table 3. Descriptive statistics of skull measurements of Aksaray Malaklı dog according to sex (Independent Samples t-test).

Cranium	*Gender*	*N*	*Mean*	*Sd*	*P*
TL	Male	7	277.11	8.49	0,012
	Female	7	264.14	1.75	
CBL	Male	7	245.17	2.21	0.406
	Female	7	244.01	1.53	
BL	Male	7	222.80	4.64	0,031
	Female	7	212.16	1.94	
BCA	Male	7	59.07	5.15	0,067
	Female	7	58.75	2.29	
BFA	Male	7	179.24	6.65	0,505
	Female	7	161.88	5.53	
UNL	Male	7	144.14	0.92	0,165
	Female	7	142.50	0.31	
VL	Male	7	114.18	1.24	0,358
	Female	7	112.70	0.57	
FL	Male	7	144.60	1.21	0,224
	Female	7	141.86	0.87	
GLN	Male	7	95.67	0.99	0,343
	Female	7	94.97	0.75	
SL	Male	7	103.55	1.40	0,006
	Female	7	96.66	0.49	
MPL	Male	7	126.49	3.44	0,057
	Female	7	116.42	0.68	
LHPP	Male	7	43.19	2.67	0,030
	Female	7	37.85	0.93	
GDAB	Male	7	41.75	0.83	0,178
	Female	7	41.14	0,28	
GMB	Male	7	91.50	0.89	0,380
	Female	7	76.25	0.65	
BDEAM	Male	7	90.57	1.46	0,011
	Female	7	82.51	0.46	
GBOC	Male	7	51.28	1.58	0,102
	Female	7	48.50	0.60	
GBBPP	Male	7	89.11	1.35	0,812
	Female	7	78.26	1.26	
GBFM	Male	7	18.71	0.61	0,712
	Female	7	17.69	0.53	
HFM	Male	7	19.18	0.67	0,934
	Female	7	17.69	0.94	
GNB	Male	7	58.15	1.15	0,107
	Female	7	55,04	0.40	
ZB	Male	7	141.12	2.65	0,189
	Female	7	135.07	1.80	
LBS	Male	7	54.53	0.97	0,04
	Female	7	53,61	0.26	
FB	Male	7	84.83	0.57	0,113
	Female	7	75,89	1.39	
LBBO	Male	7	59.32	0.28	0,285
	Female	7	58.20	0.24	
LPB	Male	7	37,80	1,98	0,022
	Female	7	35,86	0,25	
BACA	Male	7	46.12	1.25	0,285
	Female	7	45.57	0.54	

GIHO	Male	7	26.96	2.51	0,058
	Female	7	26.48	0.20	
SH	Male	7	55.48	1.19	0,902
	Female	7	54.42	1.13	
SHSC	Male	7	68.76	1.58	0,080
	Female	7	67.57	2.29	
HOT	Male	7	61.87	2.46	0,019
	Female	7	60.10	0.20	
Volume(cm^3)	Male	7	42.93	1.50	0,107
	Female	7	41.43	0.83	
Area(cm^2)	Male	7	451.01	19.36	0,046
	Female	7	428.11	9.12	

Tablo 4. Cranial and facial indices in Aksaray Makalı dog skull.

INDEX	Gender	N	Mean	SD	P
Facial Index	Male	7	123.61	3.12	0.767
	Female	7	118.26	3.07	
Skull Index	Male	7	50.94	1.04	0.082
	Female	7	51.13	0.48	
Cranial Index	Male	7	40.33	0.88	0.121
	Female	7	38.56	0.57	
Foramen Magnum Index	Male	7	102.57	2.81	0.728
	Female	7	100.32	2.82	

DISCUSSION

There is a need for systematic research to be conducted to obtain correct breed information and facilitate the establishment of an official breed standard, which could be useful for Aksaray Malakli dog breeders. The definition of a breed by the Dog Breed and Cynology Federation has been of great importance in protecting the local Turkish mastiff population (Uresovic *et al*., 2021).

Craniometric measurements are used to define breeds and to determine variations within breeds (Yalçın and Kaya, 2009; Karimi *et al*., 2011; Saber and Gummow, 2015). In the literature, the condylobasal length of the grey wolf has been reported as 215.76±12.22 mm (Khosravi *et al*., 2012), and the basal length measurement as 206.79±11.13 mm. According to the evaluations in this study, the condylobasal length and basal length of the Aksaray Malakli dog are longer than those of the wolf (Khosravi *et al*., 2012).

Ilgun and Özkan, (2015) reported the GIHO length to be 31.06±1.15mm and GBFM length to be 20.09±2.05 mm in Kangal dogs. The current study results showed that both GIHO length and GBFM length in male and female Aksaray Malakli dogs were shorter than those of Kangal dogs.In the study of Kaloyianni, (2002), the highest total length measurement point was reported as 180 mm in border terrier dogs, 195 mm in boxer dogs, 256.5 mm in Doberman dogs, 202 mm in dogo argentine dogs, and 243.5 mm in wolves. In our study, it was observed that the total length of the Malaklı dog was greater than the specified breeds. Christiansen, (2007) reported skull length in lions as 268.97 +12.2mm in females and 317.67+19.0mm in males, 259.47+13.9mm in females, and 291.97+21.4mm in males tigers. In our study, it was observed that the skull length of the Malak dog was shorter than that of the lion and male tiger and larger than the female tiger..

Onar *et al*., (2002) found the skull length as 193.90mm in a 120-day-old dog and measured the cheek width as 95.40mm in their study on German shepherd dogs. In our study with the Malaklı dog, it was determined that both measurement points in females and males were more significant than in the 120-day-old dog.In a study of Aksaray Malakli dogs by Urošević *et al*. (2021), the total length was reported to be 20.64 ± 1.68 cm in males and 16.75± 0.86 cm in females. Atasoy *et al*., (2014) reported the head length of Aksaray Malaklı dogs to be 30.92±0.24 cm in females and 32.98±0.18 cm in males, and face length to be 11.80±0.15 cm in females and 12.55±0.09 in males. In the current study, the measurements for females and males were calculated as 26.41 ± 1,75 cm and 27.71 ± 8,49 cm, respectively, for total length and 14.18 ± 087 cm and 14.46 ± 1.21 cm for face length. According to the study of Urošević *et al*., (2021) it was seen that the total length of the Aksaray malaklı dog we used in our study was more significant and smaller than the material used in the study of Atasoy *et al.,* (2014) Face length was determined to be higher in the material in our research.

The cranium measurements obtained in the current study were observed to be generally higher than the values obtained from studies of Kangal (Onar *et al*.,

Table 5. Correlation values of different skill measurements in the Alsaray Malalkli dog (Geen <0.01, White P<0.05, Red P>0.05)

	TL	CBL	BL	BCA	BFA	UNL	VL	FL	GLN	SL	MPL	LHPP	GDAB	GMB	BDEAM	BGOC	GBBPP	GBFM	HFM	GNB	ZB	LBS	FB	LBBO	LPB	BACA	GİHO	SH	SHSC	HOT
TL	1																													
CBL	,780(**)	1																												
BL	,804(**)	,885(**)	1																											
BCA	-0,337	0,009	-0,071	1																										
BFA	,824(**)	,939(**)	,860(**)	-0,125	1																									
UNL	,909(**)	,773(**)	,693(**)	-0,436	,783(**)	1																								
VL	0,388	,585(*)	0,453	0,195	,613(*)	0,379	1																							
FL	,719(**)	,834(**)	,762(**)	-0,122	,814(**)	,662(**)	0,361	1																						
GLN	,611(*)	0,423	0,42	0,037	0,492	0,465	0,278	,634(*)	1																					
SL	,755(**)	,953(**)	,844(**)	-0,078	,947(**)	,773(**)	,567(*)	,811(**)	0,487	1																				
MPL	,879(**)	,932(**)	,932(**)	-0,168	,902(**)	,843(**)	0,41	,799(**)	0,457	,916(**)	1																			
LHPP	,850(**)	,861(**)	,910(**)	-0,268	,888(**)	,799(**)	0,361	,757(**)	0,359	,849(**)	,951(**)	1																		
GDAB	0,11	0,429	0,294	0,477	0,402	0,063	,789(**)	0,309	0,294	0,38	0,157	0,045	1																	
GMB	,745(**)	,980(**)	,838(**)	-0,068	,925(**)	,787(**)	,608(*)	,838(**)	0,421	,968(**)	,912(**)	,821(**)	0,435	1																
BDEAM	,845(**)	,971(**)	,878(**)	-0,096	,966(**)	,826(**)	,613(*)	,830(**)	0,525	,979(**)	,950(**)	,887(**)	0,377	,970(**)	1															
BGOC	,872(**)	,824(**)	,870(**)	-0,214	,854(**)	,789(**)	0,346	,725(**)	0,469	,842(**)	,936(**)	,969(**)	0,007	,779(**)	,882(**)	1														
GBBPP	,793(**)	,959(**)	,892(**)	-0,058	,931(**)	,783(**)	,671(**)	,803(**)	0,48	,946(**)	,913(**)	,818(**)	0,516	,971(**)	,966(**)	,778(**)	1													
GBFM	,754(**)	,689(**)	,789(**)	-0,356	,733(**)	,748(**)	0,23	,693(**)	0,399	,730(**)	,851(**)	,812(**)	-0,039	,726(**)	,756(**)	,764(**)	,751(**)	1												
HFM	,653(*)	,663(**)	,822(**)	-0,272	,663(**)	,621(*)	0,341	,653(*)	0,322	,662(**)	,787(**)	,729(**)	0,161	,702(**)	,695(**)	,643(*)	,775(**)	,925(**)	1											
GNB	,650(*)	,840(**)	,665(**)	0,042	,843(**)	,650(*)	,861(**)	,647(*)	0,441	,844(**)	,717(**)	,600(*)	,678(**)	,878(**)	,872(**)	,586(*)	,908(**)	,542(*)	,570(*)	1										
ZB	,876(**)	,836(**)	,784(**)	-0,207	,855(**)	,826(**)	0,4	,819(**)	,665(**)	,891(**)	,881(**)	,854(**)	0,154	,825(**)	,909(**)	,919(**)	,809(**)	,690(**)	,549(*)	,679(**)	1									
LBS	0,355	0,511	0,324	0,239	,562(*)	0,36	,866(**)	0,346	0,473	0,528	0,319	0,181	,862(**)	,555(*)	,547(*)	0,178	,635(*)	0,193	0,273	,841(**)	0,341	1								
FB	,771(**)	,978(**)	,827(**)	-0,058	,953(**)	,789(**)	,646(*)	,764(**)	0,36	,953(**)	,910(**)	,857(**)	0,4	,970(**)	,972(**)	,824(**)	,941(**)	,669(**)	,615(*)	,878(**)	,824(**)	,548(*)	1							
LBBO	,670(**)	,913(**)	,761(**)	0,017	,871(**)	,676(**)	,736(**)	,787(**)	0,344	,856(**)	,776(**)	,771(**)	,541(*)	,896(**)	,885(**)	,732(**)	,868(**)	0,493	0,503	,836(**)	,771(**)	,551(*)	,913(**)	1						
LPB	,754(**)	,754(**)	,624(*)	-0,087	,773(**)	,652(*)	,715(**)	,780(**)	,611(*)	,728(**)	,680(**)	,613(*)	0,497	,767(**)	,809(**)	,643(*)	,785(**)	0,518	0,501	,855(**)	,774(**)	,636(*)	,765(**)	,820(**)	1					
BACA	0,524	0,348	,545(*)	0,072	0,318	0,263	0,218	0,404	0,258	0,181	0,43	0,401	0,138	0,271	0,327	0,379	0,379	0,482	,565(*)	0,283	0,269	0,095	0,269	0,292	0,497	1				
GİHO	0,443	0,256	0,495	0,175	0,244	0,114	0,047	0,347	0,27	0,086	0,362	0,416	-0,018	0,12	0,226	0,428	0,206	0,313	0,356	0,057	0,257	-0,127	0,169	0,221	0,341	,888(**)	1			
SH	0,419	0,503	0,353	-0,008	0,481	0,4	0,089	,757(**)	0,447	0,376	0,404	0,389	0,185	0,475	0,422	0,303	0,4	0,366	0,292	0,287	0,39	0,179	0,424	0,474	0,475	0,349	0,338	1		
SHSC	0,39	0,306	0,421	-0,003	0,186	0,264	0,258	0,219	0,078	0,204	0,45	0,371	-0,06	0,298	0,33	0,396	0,35	0,444	,542(*)	0,316	0,242	0,021	0,299	0,24	0,41	,671(**)	,565(*)	-0,041	1	
HOT	,785(**)	,555(*)	,635(*)	-0,046	,569(*)	0,519	0,253	,672(**)	,604(*)	0,439	,630(*)	,610(*)	0,105	0,471	,579(*)	,650(*)	0,527	,540(*)	0,489	0,428	,637(*)	0,185	0,497	0,496	,734(**)	,838(**)	,830(**)	,560(*)	,536(*)	1

2001; Erdoğan *et al*., 2012), Akbaş (Tepeli and Çetin, 2003; Erdoğan *et al*., 2012), and Kars dog breeds (Kırmızıbayrak, 2004). As the neurocranium length was longer than the viscerocranium length in the Malakli dogs, this shows that the head is longer than the face.

The majority of craniometric measurement values in both humans and animals are generally higher in males than females (Rooppakhun *et al*., 2010; Pitakarnnop *et al*., 2017; Gündemir *et al*., 2020). In a study of Van cats, it was reported that of 37 measurement parameters obtained with volumetric measurement values together with the cranium surface area, 28 were higher in male cats than in female cats, consistent with other data in the literature (Yılmaz and Demircioğlu, 2021). The current study results indicated that the cranium was larger in males than in females.

In their study, Saber *et al*. (2016) grouped the Australian domestic cats as flat-head and round-head skulls based on their head types and calculated the cranial, skull, and facial indices from the craniometric measurements and determined that these measurement values were 56.0± 4.0, 71.1 ± 4.4, 298.1 ± 34.0 in flat-head skull cats and 66.6 ± 4.9, 71.3 ± 2.4, 279.8 ± 31.9 in round-head skull cats, respectively. The cranial, skull and facial indexes of the Malakli skull in our study were also lower than the flat-head type skulls.

In another study conducted by Saber and Gummow, (2015) on cats, they found these values as 121.24 ± 18.29, 80.79 ± 6.08, and 121.67 ± 19.51, respectively. In Malaklı dogs, mean values were calculated as 40.33 ± 0.88 in males, 38.56 ± 0.57 in females for the cranial index, 50.94 ± 1.04 in males, 51.13 ± 0.48 in females for the skull index, 123.61± 3.12 in males, 118.26 ± 3.07 in female for the facial index.

It has been reported that the cranium or cranial morphometric measurements have been used for sex assignment in most mammal species (Travaini *et al*., 2020). However, in a study of 38 dried domestic cat skulls by Pitakarnnop *et al*., (2017) to determine sexual dimorphism, no significant difference was determined in the measured cranial parameters between males and females. It was seen that 30 measurement parameters taken from Malaklı dogs were not statistically significant in the distinction between male and female.

Saber and Gummow, (2015) reported that there was a significant correlation between facial length and skull length in dogs ($P<0.05$). In our study, it was seen that there was no correlation between facial length and skull length ($P>0.05$).

Conclusions: In conclusion, through examination of the cranial morphometric characteristics and 3D images of Aksaray Malakli dogs, the results of this study demonstrated differences between the sexes. In addition to showing some similarities to the cranial structure of several carnivores, there are also some different anatomic characteristics.

This study could be used in the taxonomic determination of carnivore species and in different disciplines such as anatomy, morphology, and osteoarchaeology, thereby contributing to further studies of Aksaray Malakli dogs. In addition to the morphometric measurements of Aksaray Malakli dogs, through the examination for the first time of 3D imaging and comparisons of male and female measurements, this study can be considered to contribute to the establishment of an important data bank for breed definition.

Conflict of Interest: The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

Data availability atatement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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