

Macroanatomical and morphometric study on the skull bones of Aksaray Malakli dogs

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Background: 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.

Materials and methods: Thirty-two distances were measured and seven ratios calculated in nine skulls of adult dogs. In our study, different morphological features and statistical findings that were not revealed by taking measurements from 32 distinct anatomical points of Aksaray Malakli dog skull bones were determined in accordance with the literature.

Results: Processus zygomaticus was found to be long and pointed in the Aksaray Malakli dogs. The results of morphometric analysis were as follows: facial index value 107.68 ± 4.98 , nasal index value 19.61 ± 3.25 , cranial index value 56.17 ± 2.52 , basal index value 30.57 ± 1.30 , skull index 54.68 ± 3.01 , palatal index I value 56.76 ± 1.89 and palatal index II value 59.83 ± 2.23 .

Conclusions: It can be concluded from the present investigation that the neurocranium length, facial index, cranial index, basal index, skull index, and palatal index values were statistically different from other dog breeds. (Folia Morphol 2022; 81, 1: 157–163)

Key words: neuroanatomy, macroanatomy, morphometric, cranial index

INTRODUCTION

Aksaray Malakli dogs are large guarding dogs and their name comes from the Aksaray region in Turkey where they come from. According to the findings in the genetic studies on dog breeds, it is reported that mastiff-type dogs may be a different breed due to their genetic similarity to Akbaş, Kars and Kangal shepherd dogs [2–4]. Aksaray Malakli dog has a grey-coloured, large body and drooping lips. The paws are bigger and thicker than the Kangal dog, which breeders mostly compare. However, it is reported that Aksaray Malakli dog is not preferred in

herd management, because it is not resistant to cold climate and because of the saggy nature of its lips; it drains the mouth, salivates while drinking water and it is tired quickly after guarding the herd [2, 3, 5, 18, 26, 27]. The skull is an important anatomical structure to discern dog breeds [1, 9, 11, 12, 28], Kangal and Malakli dogs [10, 18, 21], Tarsus Çatalburun dog [17], German wolfhound [19, 20], and grey wolf [14]. It has been found that there are many studies on skull morphology and morphometry in lynx [7], red fox [22], vulpes [25] and golden jackal [15]. In our study, the measurements taken from 32 anatomical points of

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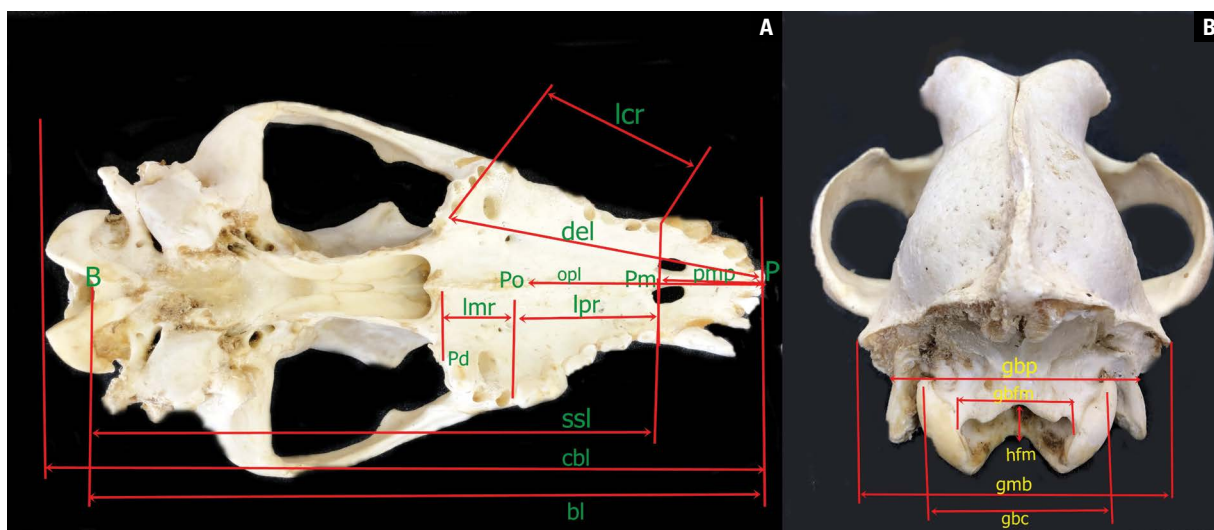


Figure 1. Measurements of the skull of Aksaray Malakli dog; **A.** Ventral view; **B.** Caudal view; Akmlk — Aksaray Malakli dog; pl — profile length; cbl — condylobasal length; bl — basal length; ssl — short skull length; pmp — premolare-prosthion; nl — neurocranium length; vl — viscerocranium length; mfl — median frontal length; unl — upper neurocranium length; fcl — facial length; ais — akrokranium-infraorbitale of one side; gll — greatest length of the lacrimal; gln — greatest length of the nasals; sfl — short lateral facial length; fabo — from the aboral border of one occipital condyle to the infraorbitale of the same side; del — dental length; opl — oral palatal length; llp — lateral length of the premaxilla; lcr — length of the cheektooth row (measured along the alveoli); lmr — length of the molar row (measured along the alveoli on the buccal side); lpr — length of the premolar row (measured along the alveoli on the buccal side); giho — greatest inner height of the orbit; gmb — greatest mastoid breadth; gbc — greatest breadth of the occipital condyles; gbp — greatest breadth at the bases of the paraoccipital processes; gbfm — greatest breadth of the foramen magnum; hfm — height of the foramen magnum; gncb — greatest neurocranium breadth; lbbo — least breadth between the orbits; gbaop — greatest breadth across the premaxillae; infl — distance between two infraorbitals; grpb — greatest palatal breadth.

Aksaray Malakli dog skull bones were compared with other dog breeds by making statistical calculations in line with the literature information. The results of the examination were compared with other carnivores. Significant differences were detected.

The aim of this study was to assess Aksaray Malakli dog skulls morphometrically in detail. By doing so, we hope to contribute to the international morphology database on dog breeds.

MATERIALS AND METHODS

Sample collection and processing

The skulls of 9 Aksaray Malakli dogs, aged 4–5 years old, regardless of the difference in weight and gender, that had died of various reasons at the Veterinary Health and Practice and Research Centre of Aksaray University Veterinary Faculty between 2015 and 2019, were used in this study.

Skulls were harvested and cleaned according to a standard protocol [13, 24]. In short, this protocol consisted of boiling the skinned skull in 5–10% NaHCO₃ for 1 day, cleaning from soft tissue manually thereafter, then immersing in a 10% hydrogen peroxide solution for 2–3 days. Skulls were prepared for measurements after maceration [24].

Morphometry

In the literature, there are reports on skull measurements. Simoens et al. [23] (Peking dog), Onar [19] (German wolf dog), Onar et al. [21] (Kangal dog) reported measurement locations and methods applied. Of the 44 measurement points reported in the literature [19, 20, 23], 32 measurement points that are prominent in the Aksaray Malakli dog were selected. Thirty-two measurements were made with a digital calliper (A Brand, 200 mL, Germany). Seven index ratios were calculated. The calculation methods used in the Kangal dog morphometry study [21] were applied. One measurement was taken from each skull (Figs. 1, 2). In the measurements, the average of both sides of the skull was taken. Images were taken with a camera (Canon CE500). The nomenclature used in this study is according to Nomina Anatomica Veterinaria [16].

Statistical analysis

Statistical significance of skull measurements was evaluated. Correlation test was used to determine whether there is a relationship between the variables and if so, in which direction and to what extent. The mean, standard deviation and correlation values of

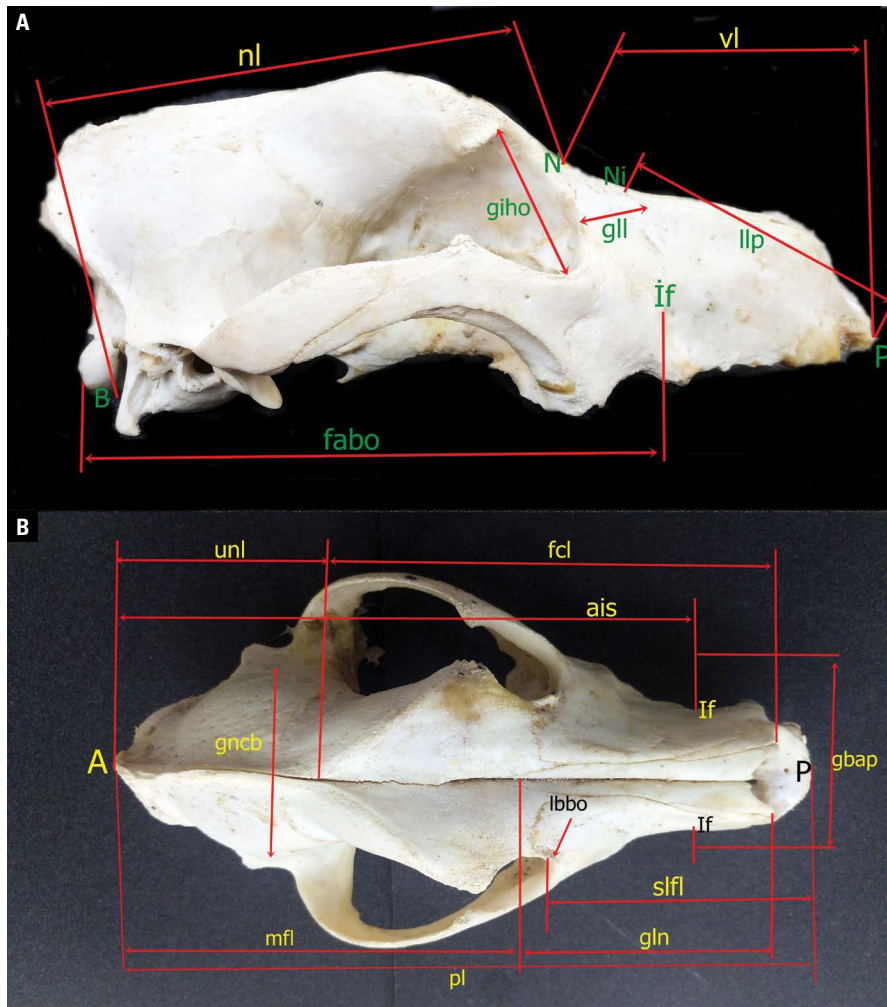


Figure 2. Measurements of the skull of Aksaray Malakli dog; **A.** Lateral view; **B.** Dorsal view; abbreviations — see Figure 1.

all measurements obtained were determined in the SPSS (18.0) version programme [6].

RESULTS

According to the macroanatomical findings in the Aksaray Malakli dog skull, the os frontale and os parietale were prominent. The os temporale was located laterally on the skull bone. The foramen was prominent towards the infraorbital cranial. Tuber faciale was not prominent. Processus zygomaticus of Aksaray Malakli dog was found to be tall and sharp. It was determined that the foramen magnum of os occipitale was surrounded by oval condyli occipitales, and the processi jugulares were curved ventrally. A thick arcus zygomaticus was prominent on the sides of the cranial bones (Figs. 1, 2). The relevant mean and standard deviation values of the craniofacial indices of the Aksaray Malakli dog's skull are shown

in Table 1. The calculated cranial indices in Aksaray Malakli dogs were as follows: facial index 107.68 ± 4.98 , nasal index 19.61 ± 3.25 , cranial index 56.17 ± 2.52 , basal index 30.57 ± 1.30 , skull index 54.68 ± 3.01 , palatal index I 56.76 ± 1.89 , and palatal index II 59.83 ± 2.23 . Average and standard deviation values of the Aksaray Malakli dog's skull morphometric parameters are shown in Table 2.

Condylbasal length of Aksaray Malakli dog was 227.03 ± 12.63 mm, basal length 214.80 ± 10.93 , neurocranium length 139.43 ± 3.37 mm, upper neurocranium length 67.66 ± 13.54 mm, facial length 154.76 ± 18.48 mm, height of the foramen magnum 20.09 ± 2.05 . The greatest inner height of the orbit was measured as 37.16 ± 1.60 mm (Table 1).

According to the correlation analysis of the Aksaray Malakli dog skull measurements, profile length (pl) and condylbasal length (cbl), short skull length

Table 1. Craniofacial indices of Aksaray Malakli dog skulls (Akmlk) (n = 9)

Akmlk	Facial index	Nasal index	Cranial index	Basal index	Skull index	Palatal index I	Palatal index II
Mean ± SD	107.68 ± 4.98	19.61 ± 3.25	56.17 ± 2.52	30.57 ± 1.30	54.68 ± 3.01	56.76 ± 1.89	59.83 ± 2.23

Facial index — maximum zygomatic width × 100/viscerocranial length; Nasal index — greatest breadth across the nasals × 100/greatest length of the nasals; Cranial index — maximum width of the neurocranium × 100/cranial length; Basal index — maximum width of neurocranium × 100/basal length; Skull index — maximum zygomatic width × 100/skull length; Palatal index I — greatest breadth of the palate × 100/median palatal length; Palatal index II — greatest breadth of the palate × 100/palatal length; SD — standard deviation

Table 2. Mean values of 32 morphometric parameters in Aksaray Malakli dog skulls (n = 9)

Parameters	Mean ± SD
pl	245.78 ± 15.35
cbl	227.03 ± 12.63
bl	214.80 ± 10.93
ssl	143.95 ± 22.38
pmp	69.17 ± 14.18
nl	139.43 ± 3.37
vl	114.39 ± 3.93
mfl	135.06 ± 12.55
unl	67.66 ± 13.54
fcl	154.76 ± 18.48
ais	177.65 ± 8.34
gll	40.95 ± 3.79
gln	85.74 ± 5.49
sfl	115.67 ± 4.68
fabo	158.95 ± 7.29
del	117.00 ± 5.97
lcr	77.51 ± 3.73
lmr	48.47 ± 5.19
lpr	36.02 ± 3.09
gih	37.16 ± 1.60
gmb	83.58 ± 3.68
gbc	46.57 ± 3.79
gbp	64.27 ± 3.90
gbfm	19.88 ± 2.20
hfm	20.09 ± 2.05
gncb	58.36 ± 3.77
lbbo	58.10 ± 4.54
gbap	45.57 ± 5.20
infl	51.74 ± 4.27
grpb	79.78 ± 4.69
llp	69.66 ± 8.44
opl	110.73 ± 12.55

SD — standard deviation; rest abbreviations — see Figure 1

(ssl), facial length (fcl), from the aboral border of one occipital condyle to the infraorbitale of the same side (fabo), basal length (bl), ssl, fcl, length between cbl

and bl, upper neurocranium length (unl) and fabo, bl to fabo, premolare–prosthion (pmp) length and oral palatal length (opl), there was a very strong positive correlation between fcl length and fabo length, neurocranium length (nl) and length of the molar row (lmr), and the greatest breadth across the premaxillae (gbap) and the distance between two infraorbitals (infl). On the other hand, it was found that there is a strong negative correlation between ssl length and pmp length (Table 3).

DISCUSSION

Atalar et al. [1] reported that the dorsal part of the neurocranium, which forms the skull, consists of frontal and parietal bones in wolves and foxes, and the lateral part of the temporal bone. Similar findings were detected in the Aksaray Malakli dog.

Karan et al. [11, 12] reported that foramen infraorbitale was shaped narrow and oval in dogs, and tuber faciale was absent. Similar to the literature [11, 12], there was no tuber faciale in our study, but the foramen infraorbital was in a deep pit.

In the study, the facial index of the Aksaray Malakli dog was found to be 107.68 ± 4.98. The facial index was reviewed in literature reviews in collie [8, 21] and Russian wolfhound dogs [8, 21] at 81, in German shepherd [8, 21], beagle [8, 21] and setter [8, 21] dogs at 111, and in Boston terrier [8, 21] and Pekingese dogs [8, 21] at 215. The facial index of Aksaray Malakli dog according to index values that of collie [8, 21], Russian wolfhound [8, 21], German shepherd [8, 21], beagle [8, 21] and setter [8, 21], and lower than that of Boston terrier [8, 21] and Pekingese [8, 21] dogs.

In our study, the cranial index value of Aksaray Malakli dog was 56.17 ± 2.52. It was reported at 48 in Collie and Russian wolfhound, 57 in German shepherd, beagle and setter dogs, and 81 in Boston terrier and Pekingese dogs [8, 21]. It was calculated as 73.24 in German wolfhound [20] and 71.28 in golden jackal [15]. Cranial index value of Aksaray Malakli dog was higher than that of collie [8, 21] and Russian wolfhound [8, 21] dogs, German wolfhound [19], golden jackal [15], German shepherd [8, 21], and

Table 3. Correlation values of different skull measurements in the Aksaray Malakli dog (n = 9)

pl	cbl	0.948***	bl	ssl	0.852*	mfl	unl	0.840*	fcl	ais	0.890**
	bl	0.956***		vl	0.779*		fcl	0.916**		fabo	0.970***
	ssl	0.962***		mfl	0.814*		ais	0.972***		del	0.765*
	pmp	-0.784*		unl	0.914**		fabo	0.853*		opl	-0.784*
	mfl	0.927**		fcl	0.949**		opl	-0.874**		giho	0.904**
	unl	0.919**		ais	0.822*		giho	0.788*		gmb	0.904**
	fcl	0.994***		gln	-0.779*		gmb	0.763*		gbc	0.891**
	ais	0.907**		fabo	0.949***	ais	fabo	0.850*		gbfm	0.793*
	gln	-0.786*		del	0.904**		opl	-0.817*		gbap	0.787*
	fabo	0.972***		giho	0.943**		giho	0.771*		infl	0.889**
	del	0.777*		gmb	0.955**		gmb	0.770*	gbfm	hfm	0.872**
	opl	-0.795*		gbc	0.931**	gln	fabo	-0.794*		gncb	0.829*
	giho	0.888**		gbp	0.899**		gncb	-0.849*		infl	0.757*
	gmb	0.901**		gbfm	0.789*		gbap	-0.822*	del	lcr	0.901**
	gbc	0.872*		gbap	0.796*	sfl	lcr	0.755*		lpr	0.822*
	gbfm	0.790*		infl	0.873**		lpr	0.797*		giho	0.853*
	gbap	0.779*	pmp	nl	0.834*		grpb	0.901***		gmb	0.856*
	infl	0.863*		mfl	-0.782*	fabo	del	0.810*		gbc	0.782*
cbl	bl	0.980***		Fcl	-0.771*		giho	0.853*		gbp	0.848*
	ssl	0.850*		opl	0.963***		gmb	0.846*		gbap	0.773*
	vl	0.838*		Llp	0.926**		gbc	0.897**		infl	0.791*
	mfl	0.822*		lmr	0.912**		gbp	0.763*	nl	opl	0.784*
	unl	0.966***		hfm	-0.824*		gbap	0.840*		llp	0.862*
	fcl	0.955**	ssl	pmp	-0.920**		infl	0.886**		lmr	0.982***
	ais	0.836*		mfl	0.912**	lpr	giho	0.759*	vl	unl	0.763*
	fabo	0.966***		unl	0.858*		gbc	0.797*		fcl	0.802*
	del	0.905**		Fcl	0.955**		lbbo	0.767*		lcr	0.840*
	lcr	0.823*		ais	0.882**		gbap	0.847*		lpr	0.887**
	lpr	0.819*		gln	-0.802*		infl	0.891**		giho	0.879**
	giho	0.945**		fabo	0.939**		grpb	0.759*		gmb	0.841*
	gmb	0.915**		opl	-0.905**	giho	gmb	0.947***		gbc	0.812*
	gbc	0.925**		lmr	-0.755*		gbc	0.910**		infl	0.886**
	gbp	0.837*		gmb	0.781*		gbp	0.859*	llp	lmr	0.935**
	gbap	0.816*		gbc	0.771*		infl	0.814*	hmf	gncb	0.843*
	infl	0.898**		hfm	0.762*	gmb	gbc	0.889**	gncb	gbap	0.756*
lcr	lpr	0.937**		gbap	0.779*		gbp	0.866*	lbbo	gbap	0.862*
	giho	0.797*		infl	0.827*		gbfm	0.869*	gbap	infl	0.953***
	infl	0.773*	opl	Llp	0.898**		gbap	0.762*			
	grpb	0.760*		lmr	0.877**		infl	0.877**			

Abbreviations — see Figure 1; *p < 0.05, **p < 0.01, ***p < 0.001

beagle [8, 21]. It was observed to be lower than setter [8, 21], Boston terrier [8, 21] and Pekingese [8, 21] dogs.

Khosravi et al. [14] reported basal index value in grey wolf was 60.56 ± 3.99 and cranial index value

was 60.66 ± 2.94 , whereas Onar et al. [22] evaluated basal index value in red foxes as 37.75 and 35.34, and cranial index value as 62.37 and 57.92. It was observed in our Aksaray Malakli dog that the basal index value

was 30.57 ± 1.30 and the cranial index value was 56.17 ± 2.52 — lower than grey wolf [14] and red fox [22].

Onar et al. [21] reported the skull index value as 64.00 in husky du labrador dog, 63.00 in pointer dog, 60.17 in St. Bernard dog, and Khosravi et al. [2012] as 53.13 ± 3.35 in grey wolf. In another study, it was reported that in red foxes [22] it was calculated as 52.52 and 52.53. The skull index value of Aksaray Malakli dog was found to be 54.68 ± 3.01 — higher than that of grey wolf [14] and red fox [22] while it was lower than husky du labrador dog, pointer dog and St. Bernard dog [21].

Onar et al. [22] evaluated the palatal index I value as 56.52 and 54.11, and the palatal index II value as 57.95 and 55.10 in their study in red foxes. The palatal index I value of Aksaray Malakli dog was 56.76 ± 1.89 , and the palatal index II value was 59.83 ± 2.23 — higher than red foxes.

In the literature studies, condylobasal length measurement was reported as 215.76 ± 12.22 in grey wolf [14], basal length measurement was 206.79 ± 11.13 mm, and in this study, condylobasal length of Aksaray Malakli dog was 227.03 ± 12.63 mm and basal length value was 214.80 ± 10 . According to these evaluations, the condylobasal length and basal length of Aksaray Malakli dog was longer than that of grey wolf [14].

In the study, the length of neurocranium in Aksaray Malakli dog was determined as 139.43 ± 3.37 mm. This measurement value was reported to be 74.21 ± 8.91 in grey wolf [14]. According to the measurement values, it was determined that the length of neurocranium of Aksaray Malakli dog was longer than that of grey wolf [14].

In the skulls of the Aksaray Malakli dog examined, the upper neurocranium length was 67.66 ± 13.54 mm. In the literature studies, upper neurocranium length measurement was reported to be 58.56 ± 5.99 mm in grey wolf [14]. Our investigation material revealed that Aksaray Malakli dog's upper neurocranium length is longer than grey wolf [14].

İlgün and Özkan [10] reported greatest inner height of the orbit as 31.06 ± 1.15 mm in Kangal dog. In our research material of Aksaray Malakli dog, this height was measured as 37.16 ± 1.60 mm. According to the measurement values, the greatest inner height of the orbit of the Aksaray Malakli dog was longer than the Kangal dog [10].

In our study, the height of the foramen magnum of Aksaray Malakli dog was measured as 20.09 ± 2.05 mm. In the study of İlgün and Özkan [10] on Kangal dog, the height of the foramen magnum is reported as 24.86 ± 0.59 mm. The height of the foramen magnum of Aksaray Malakli dog was found to be shorter than the Kangal dog.

CONCLUSIONS

According to the results of the study, it is thought that the skull measurements and index calculations of Aksaray Malakli dog will contribute to the creation of a databank in racial discrimination. It is also thought to provide resources for specialists working in different disciplines such as anatomy, morphology, osteo-archeology and can be used in determining the taxonomic classification of carnivorous species. However, it was concluded that more sample studies are needed to obtain more absolute data on the relationships between statistical parameters.

Conflict of interest: None declared

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