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Computed tomographic analysis of the cranial cavity and neurocranium in the German shepherd dog (Alsatian) puppies

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ABSTRACT

Fourteen male German shepherds (Alsatian) of 100 and 120 days of age were used in the study. The puppies were divided into two groups of equal numbers. While seven the 100-day-old puppies formed the first group, the second group consisted of the remaining seven puppies with an age of 120 days. Each head was examined in three series of cross-sections: sagittal, horizontal and transversal. The thickness and intervals of scanography were determined to be 5 mm; thus, the process of scanning was repeated for every other section of 5 mm. Maximum cross-sectional images of the cranial cavity were used in making craniometric measurements. A comparison of the measurements of the maximum width and height of neurocranium, the maximum zygomatic width and maximum height of cranial cavity revealed that there existed a statistically significant difference between the two groups (P<0.01). The difference of Length-length-1 and Length-length-2 indices of the neurocranium was even greater (P<0.001). As the age of the puppies increased, another significant difference was observed in the Length-width-2 index (P<0.01). The rise in the Length-width-2 index, which is in proportion with age, and the fall in the Length-length-1 and Length-length-2 indices of the neurocranium, which is out of proportion with age, demonstrated that the skulls of the puppies grew to form a long, narrow shape. The authors consider that the data obtained in this study may be of some use in the comparison of brain morphometry to the parameters of cranial cavity, and in the evaluation of cerebral atrophy and like conditions in German shepherds as a dolichocephalic breed.

Key words: morphometry, cranial cavity, computed tomography, puppies, German shepherd dog

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Introduction

The shape of the skull in dogs shows considerable breed and individual variation in form and size (SISSON, 1975). The shape of the skull is the most important criterion in determining the standard breeds of dog (ONAR, 1999; JOUVE et al., 2001). This explains the reason for the direct osteometric (KREMENAK and DEGNAN, 1969; ONAR, 1999; ONAR et al., 2001) and radiographic examinations carried out in various studies that attempted to determine sexual dimorphism and canine skull forms (KRSTIC et al., 1999; REGEDON et al., 1991c; 1993).

Computerised tomography (CT) enables high-resolution images to be obtained in all cross-sections of the head, thereby assisting researchers in attaining new findings on the head, which would certainly not be easy through the classical methods of examination. The use of this new technique has made it possible for researchers to measure more accurately the surface and volume of dogs by examining each cross-section of a certain thickness separately, and has thus made an immense contribution to the evaluation of dog breeds with different skull types (ROBINA et al., 1991; REGEDON et al., 1991a; 1991b; 1992).

The same technique has been conducive to brain anatomy studies in dogs (FIKE et al., 1981; KAUFMAN et al., 1981). Furthermore, Japanese wolf skulls have been surveyed in detail by this means (ENDO et al., 1997).

This study was carried out on German shepherd puppies of 100 and 120 days old, and CT was employed in measuring the cranial cavity and neurocranium. For this reason, the study is aimed at contributing to the appraisal of German shepherds with the help of the morphometric data obtained by CT analysis.

Materials and methods

Fourteen male German shepherds (Alsatian) of 100 and 120 days of age have been used in the study. The first group consisted of seven puppies with an age of 100 days. The remaining seven puppies, which were 120 days old, were included in the second group. CT (General Electric CT Sytec 3000P) sections of the heads were obtained under general anaesthesia by sodium thiopental (20 mg/kg, i.v.) 15 min after tranquillisation with

Combelen (0.05 mg/kg i.m.). Three series of cross-sections were determined for each head: sagittal, horizontal and transversal. The thickness and intervals of the scanography was 5 mm. Cross-sections for a whole head were thereby obtained (REGEDON et al., 1991a; ROBINA et al., 1991). Radiological procedures were standard (120 kV, 100 mA, 4.5 sec).

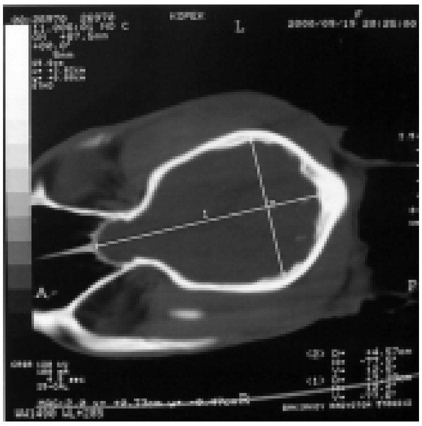

Fig.1. Computerised tomography of German shepherd puppy head. Measurements of the cranial cavity.
1. Maximum length of the cranial cavity,
2. Maximum width of the cranial cavity.

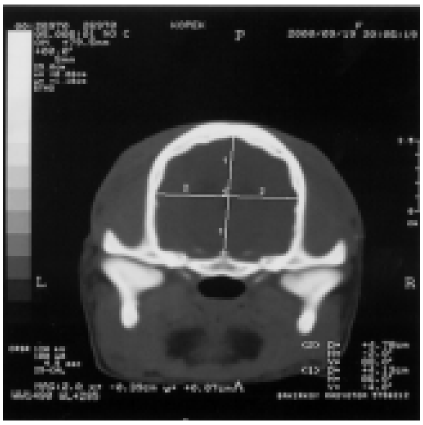

Fig. 2. Computerised tomography of German shepherd puppy head. Measurements of the cranial cavity continued.
1. Maximum height of cranial cavity,
2. Maximum width of the cranial cavity.

In making craniometric measurements, maximum cross-sectional images of the cranial cavity, acquired from the sagittal, horizontal and transversal images, were utilised. Shown below are craniometric measurement points (ENDO et al., 1997; ONAR, 1999; ONAR et al., 2001): 1. Maximum width of the cranial cavity: point of measurement to be level with euryon points (Figs. 1, 2); 2. Maximum width of neurocranium: euryon-euryon (Figs. 3, 4); 3. Maximum height of cranial cavity: distance between skull base and the highest inner point of braincase (Fig. 2); 4.

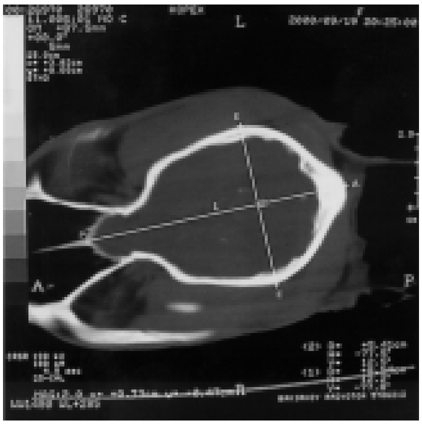

Fig. 3. Computerised tomography of German shepherd puppy head. Measurements of the neurocranium.
1. Maximum length of neurocranium
2. Maximum width of neurocranium.

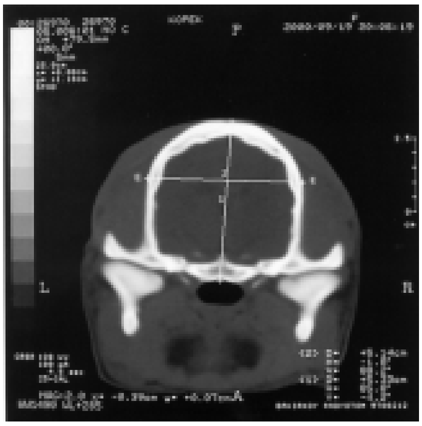

Fig. 4. Computerised tomography of German shepherd puppy head. Measurements of the neurocranium continued.
1. Maximum height of neurocranium
2. Maximum width of neurocranium.

Maximum height of neurocranium: distance between skull base and the highest point of external sagittal crest (Fig. 4); 5. Maximum length of the cranial cavity: distance between the base of tentorial process and ethmoidal fossa (Fig. 1); 6. Maximum length of neurocranium: distance from akrokranion to the join of cribriform plate and perpendicular plate of ethmoid bone (Fig. 3); 7. Maximum zygomatic width: zygion-zygion (Fig. 5); 8. Skull length: akrokranion-prosthion (Fig. 6).

Craniometric measurements were used in calculating eight different indices: 1. Neurocranial index: maximum width of neurocranium x 100 / maximum length of neurocranium; 2. Cranial cavity index: maximum width of cranial cavity x 100 / maximum length of cranial cavity; 3. Cranial index: maximum width of neurocranium x 100 / skull length; 4. Length-length-1 index: maximum length of cranial cavity / maximum length of neurocranium; 5. Length-length-2 index: maximum length of cranial cavity / skull length; 6. Length-length-3 index: maximum length of neurocra-

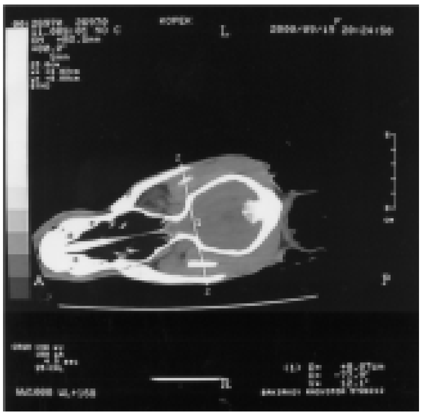

Fig. 5. Computerised tomography of German shepherd puppy head. Skull measurements. 1. Maximum zygomatic width.

Fig. 6. Computerised tomography of German shepherd puppy head. Skull measurements continued. 1. Skull length.

nium / skull length; 7. Length-width-1 index: maximum length of cranial cavity / maximum width of cranial cavity; 8. Length-width-2 index: maximum length of neurocranium / maximum width of neurocranium.

Following this procedure, the mean and standard deviation (sd) of craniometric measurements and indices for both groups were calculated. T-test was applied in order that the significance of the differences found between the mean values of the groups could be determined (EVRÝM and GÜNEȚ, 1998).

Results

This study owes much to the scanographical maximum images of the skulls, from which the craniometric measurements were taken. Table 1 presents mean and sd of these measurements.

All the aforesaid craniometric measurements were observed to increase with age. However, the increment had a statistical significance in only four of the measurements (Table 1): the maximum width and height of neurocranium, and maximum zygomatic width and maximum height of cranial cavity (P<0.01).

Table 1. Measurements of the cranial cavity and neurocranium (cm) of German shepherd puppies

Measurements		100 days old		120 days old		
	n	Mean	sd	Mean	sd	t
Maximum width of the cranial cavity	7	4.71	0.064	5.23	0.035	1.284 NS
Maximum width of the neurocranium	7	5.28	0.111	5.86	0.067	4.384**
Maximum height of the cranial cavity	7	4.13	0.032	4.52	0.035	4.299**
Maximum height of the neurocranium	7	5.32	0.024	6.29	0.042	3.433**
Maximum length of the cranial cavity	7	7.41	0.013	8.17	0.045	1.711 NS
Maximum length of the neurocranium	7	8.54	0.015	10.31	0.043	1.605 NS
Skull length	7	16.55	0.249	19.39	0.179	1.536 NS
Maximum zygomatic width	7	7.98	0.084	9.54	0.068	4.334**

** P<0.01, NS Not significant

Eight different indices were calculated with the help of craniometric measurements, the mean and sd of which are shown in Table 2.

Neurocranial, Length-length-1 and Length-length-2 were the indices in which a decrease out of proportion to age was found. The difference of these indices between the two groups was high and had a statistical

Table 2. Craniometric indices of German shepherd puppies

		100 days old		120 days old		
	n	Mean	sd	Mean	sd	t
Cranial cavity index	5	63.63	0.832	64.01	0.367	0.189 NS
Neurocranial index	5	61.79	1.358	56.79	0.803	5.141***
Cranial index	5	31.89	0.448	30.38	0.461	0.000 NS
Length-length-1 index	5	0.87	0.001	0.79	0.002	7.568***
Length-length-2 index	5	0.45	0.007	0.42	0.005	9.712***
Length-length-3 index	5	0.52	0.008	0.53	0.005	0.004 NS
Length-width-1 index	5	1.57	0.021	1.56	0.009	0.191 NS
Length-width-2 index	5	1.62	0.036	1.76	0.025	4.078 **

*** P<0.001, ** P<0.01, NS Not significant significance of P<0.001. On the other hand, the rise in the Length-length-2 index was in proportion to age (P<0.01). It was discovered that the differences that occurred with age between the other measurements and indices were not of any statistical significance.

In none of the scanographies of the animals examined were the bony structures improper, nor were any pathologies detected.

Discussion

German shepherd dogs have been reported to possess a dolichocephalic head, a classification that is based on craniometric measurements and indices (BREHM et al., 1985; ONAR, 1999). A morphometric study on the dolichocephalic development of German shepherd puppies were performed, osteometric measurements, which may help promote the definition of German shepherd breed, were taken, and the variations of these values were determined in puppies of this breed up to the age of 105 days (ONAR, 1999).

In this study, high resolution images of 100 and 120-day-old puppies were obtained through CT. This was followed by a close examination of the variations of craniometric measurements, which were taken on the images. In this way the craniometric variables occurring with age were attained. This naturally allows a comparison to be made in further studies between the data obtained by this means and those obtained through the direct osteometric method.

The study revealed that a statistically significant difference of P<0.01 existed between the values of the two groups mentioned, as follows: maximum width and height of neurocranium and maximum zygomatic width and maximum height of cranial cavity. The difference of Neurocranial, Length-length-1 and Length-length-2 indices in both the groups was even greater (P<0.001). A further clear correlation was observed to develop with age between the Length-width-2 index of one group and the other (P<0.01). The fall of the neurocranial, Length-length-1 and Length-length-2 indices in contrast to the rise in the Length-width-2 index indicated that a skull long and narrow in shape emerged. The greater increase in the length of neurocranium and skull accounted for the decrease in the above-mentioned indices. It was thus concluded that the development of the skull was in accordance with that of the dolichocephalic type.

It has been reported that sex could be determined with an accuracy of 99.99% by examining the cranial volume obtained from CT images (ROBINA et al., 1991; REGEDON et al., 1991a; 1991b). As the results found in this study pertain to cranial cavity and neurocranium, the authors consider that these might also be of some use in the determination of sex of male German shepherd dogs, by examining the cranial cavity.

In the detection of cerebral atrophy, the volumes of cranial cavity and brain have been compared and a relation of 87.7% has been discovered to exist between the former and the latter two volumes (REIFINGER, 1997). It has also been reported that there is a correlation between skull shape and nasal cancer risk (REIF et al., 1998), and that the dolichocephalic breed has a greater risk of developing this disease than the others (HAYES et al., 1982). Nevertheless, the question of whether cerebral atrophy, cerebral neoplasm, etc. seen in the cranial cavity, are related to the shape of this cavity, neurocranium or skull, has so far not been dealt with.

The statistical data acquired in this study allow the authors to state that the maximum length of neurocranium increases more than its width as the puppies grew. However, compared to the neurocranium, the values of cranial cavity were observed to change to a lesser degree. The facts mentioned below are considered to account for this result:

Neurocranial structures such as external sagittal crest became noticeable with age;

Skulls took a narrow-long shape;

Thickness of neurocranium increased.

The authors are of the opinion that it is important to be well informed about the changes that occur with age in the measurements of neurocranium and cranial cavity if a reliable correlation study between volume and cranium is to be achieved.

The authors further believe that the morphometric analysis of the brain and its comparison to the cranial cavity parameters will not only facilitate the detection of pathologies such as cerebral atrophy, but will also make it possible for future researchers to better understand and inspect the cranial cavity in German shepherd dogs as a dolichocephalic breed.

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SAŽETAK

Istraživanje je provedeno na četrnaest mužjaka njemačkog ovčara u dobi 100 i 120 dana. Štenad je bila podijeljena u dvije jednake skupine. Prva skupina obuhvaćala je sedam štenadi u dobi 100, a druga u dobi 120 dana. Glava svakog šteneta bila je analizirana trima tomografskim presjecima: sagitalnim, horizontalnim i transverzalnim. Tomografska pretraga provedena je u razmacima od 5 mm uz ponovljeno skeniranje. Maksimalne dužine lubanjske šupljine bile su korištene pri kraniometrijskim mjerenjima. Usporedbom najvećih vrijednosti dobivenih mjerenjem širine i visine lubanjske šupljine ustanovljeno je da postoji statistički značajna razlika između skupina ($P<0,01$). Razlike pokazatelja dužine-dužine-1 i dužine-dužine-2 neurokranija bila je čak veća ($P<0,001$). Povećanjem dobi štenadi ustanovljena je značajna razlika u pokazatelju dužina-širina-2 ($P<0,01$). Povećanje indeksa dužina-širina-2 koji je razmjeran dobi i smanjenje pokazatelja dužina-dužina-1 te dužina-dužina-2 neurokranija, koji nije razmjeran dobi, pokazalo je da su lubanje postajale sve duže i duže. Autori smatraju da opisani rezultati mogu biti od značenja u usporedbi morfometrije mozga u odnosu na parametre šupljine te u vrednovanju cerebralne atrofije i sličnih pojava u njemačkih ovčara kao dolihocefalne pasmine.

Ključne riječi: morfometrija, lubanjska šupljina, kompjuterizirana tomografija, štenad, njemački ovčar

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