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Topographic and Clinical New Approaches and Correlations of Extremities in Dogs*

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Abstract: Various traumatic lesions are encountered in the extremities of dogs. For surgeons, familiarity with relevant surface landmarks is a prerequisite for the successful selection of incision sites in choosing the most suitable location for access to organs and vessels. This study aimed to reveal in detail the topographic and clinical anatomy of the extremities in dogs. In this study, the extremities of dogs were approached topographically, the layers were photographed and the anatomical structures seen in the region were named. In addition, selection sites for clinical approaches were determined and correlations of the sites with each other were examined using palpable bone points. In conclusion, this study conducted in dogs not only contributed to adding colourful and fresh operation photographs to the literature but also revealed new and simple techniques for some of the anaesthesia applied to the nerve space. Additionally, osteometric analyses using a different technique revealed a positive correlation between regions. It has been concluded that some measurements between externally palpable points on a live dog can be used to calculate other lengths.
Keywords: Clinical anatomy, dog, extremity, morphometric analysis, topographic anatomy.

Köpeklerde Ekstremitelerin Topografik ve Klinik Yeni Yaklaşımları ve Korelasyonları

Öz: Köpeklerin ekstremitelerinde çeşitli travmatik lezyonlar görülmektedir. Cerrahlar için, organlara ve damarlara erişim için en uygun lokasyonu seçerken, ilgili yüzey işaretlerine aşinalık, kesi yerlerinin başarılı bir şekilde seçilmesi için ön koşuldur. Bu çalışma, köpeklerde ekstremitelerin topografik ve klinik anatomisini ayrıntılı olarak ortaya koymayı amaçlamıştır. Bu çalışmada, köpeklerin ekstremitelerine topografik olarak yaklaşılmış, katmanlar fotoğraflanmış ve bölgede görülen anatomik yapılar isimlendirilmiştir. Ayrıca, klinik yaklaşımlar için seçim bölgeleri belirlenmiş ve bölgelerin birbirleriyle korelasyonları, elle muayene edilebilen kemik noktaları kullanılarak incelenmiştir. Sonuç olarak, köpeklerde yapılan bu çalışma, literatüre renkli ve taze operasyon fotoğrafları eklenmesine katkıda bulunmakla kalmamış, aynı zamanda sinir boşluğuna uygulanan bazı anesteziler için yeni ve basit teknikler ortaya koymuştur. Ayrıca, farklı bir teknik kullanılarak yapılan osteometrik analizler, bölgeler arasında pozitif bir korelasyon olduğunu ortaya koymuştur. Canlı bir köpekte dışarıdan elle muayene edilebilen noktalar arasındaki bazı ölçümlerin, diğer uzunlukları hesaplamak için kullanılabileceği sonucuna varılmıştır.
Anahtar kelimeler: Ekstremite, klinik anatomi, köpek, morfometrik analiz, topografik anatomi.

Introduction

It is a basic clinical skill to be able to detect structures under the skin by referring to the characteristics of bone prominences, which are the most palpable structures (Standring, 2012). Since the surgical approach preferred in surgical interventions on bones or joints must preserve both anatomical and functional integrity, it is important to have information about the course of large vessels and nerves in the region (Dyce et al., 2010). For surgeons, familiarity with relevant surface landmarks is a prerequisite for the successful selection of incision sites in choosing the most appropriate location for access to organs and vessels (Standring, 2012).

Various traumatic lesions are encountered in the extremities of dogs. The most common of these lesions are fracture cases (Süer and Sağlam, 2006). The skeletal system is seen as a place where most of the parameters such as shape, height, length and size are easily accessible. As a result, bones are one of the body structures used for the characterization of different animal species, including humans (Salami et al., 2011). Osteometric analyses of long bones are widely used to determine changes in the size and morphology of dogs (Alpak et al., 2004).

This study aimed to detail the topographic and clinical anatomy of the extremities in dogs, in particular the anesthesia landmarks for some nerve extensions and the correlation between bone lengths using palpable bone landmarks.

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Materials and Methods

Animals

This study was conducted with 10 dog cadavers who died at Erciyes University Veterinary Faculty Animal Hospital. There was no discrimination based on gender, race or age for the cadavers used. These cadavers were used in accordance with the ph. 2 of article 8/k, of the Erciyes University Animal Experiments Local Ethics Committee Directive.

Photography and Image Editing

SAMSUNG NX300 digital camera was used to photograph the findings. The photography process was done by photographing topographical layers from the surface to the deep. Portable Photoshop CS2 V.9.0.2 was used to name the anatomical structures.

Measurements and Statistical Analyses

The distances between palpable bone landmarks of the fore- and hind limbs were measured between each other on cadavers. These measurements were made with a digital caliper with 0-100 mm sensitivity. The conformity of the data to a normal distribution was assessed using the Shapiro-Wilk test and histogram plots. Spearman's Rho correlation coefficient was used to evaluate the statistical significance of relationships between continuous numerical variables. All analyses were conducted using R Studio (Version 2021.09.1 Build 372 – ©2009–2021 RStudio, PBC). A significance level of $P<0.05$ was considered statistically significant. The distances between the points were named with letters. These measurements were shown on the skeleton and schematized (Table 1).

The use of anatomical terms in the text is based on Nomina Anatomica Veterinaria. (N.A.V., 2012)

Results

For measurements, landmarks that were suitable for palpation on a living animal and that would not change depending on the animal's leg posture and flexion-extension angles of the joints were selected. Thus, the accuracy and standardization of the measurements were ensured.

The values of the measured landmarks are indicated in Table 2. According to the correlation analysis performed with the obtained values, significant correlations were found between many values (Table 3).

When Table 3 was examined, it was determined that the distance between the *trochanter major* and *tuber ischiadicum* (g) in the hind limb did not have a significant correlation with all other measurements ($P>0.05$). In all other measurements, it was determined that there was mostly a highly significant correlation ($P<0.01$) between the measurements of the same animal.

In this study, the selection sites for anesthesia of some of the extremity nerves in dogs that can be used practically in the clinic were examined and some methods were reported for the first time.

Table 1. Lettering and schematic representation of measurements.

	Letter	Starting Point	End Point
Forelimb	**a**	Cartilage scapula	Acromion
	b	Tuber olecrani	Lateral border caput radii
	c	Lateral border caput radii	Proc. styloideus lateralis
	d	Tuber olecrani	Proc. styloideus lateralis
	e	Tuberculum majus	Epicondylus lateralis
Hindlimb	**f**	Trochanter major	Patella
	g	Trochanter major	Tuber ischiadicum
	h	Patella	Malleolus lateralis
	j	Tuberositas tibiae	Malleolus lateralis

Tablo 2. Measurements of palpable bony landmarks

MEASUREMENTS OF PALPABLE BONY LANDMARKS (cm)													
		Proximal point	Distal point	n1	n2	n3	n4	n5	n6	n7	n8	n9	n10
Forelimb	a	Cartilago scapula	Acromion	13	17	16	16	16	7.4	6.2	9	9	14
	b	Tuber olecrani	Lateral border caput radii	5	6	5	5	5.5	2.3	2	5	5	5.3
	c	Lateral border caput radii	Proc. styloideus lateralis	15	25	17	18	18.5	8.5	8.4	14	13.7	15
	d	Tuber olecrani	Proc. styloideus lateralis	17	27	21	21	22.5	10	9.7	16	16.2	16
	e	Tuberculum majus	Epicondylus lateralis	14.5	22	17	19	17.5	7	6.7	9	9.3	11
Hindlimb	f	Trochanter major	Patella	16.5	22	19	21	19.5	10.6	11	14	14	18
	g	Trochanter major	Tuber ischiadicum	4	6	4.5	4	4	2.5	2.3	4.5	4.5	5
	h	Patella	Malleolus lateralis	21	28	23	24	25	10.4	9.7	13.7	13.6	22
	j	Tuberositas tibiae	malleolus lateralis	18	24	19	20	20	7	6.7	10.5	10.6	19

Table 3. Correlation analysis between bony landmarks.

Landmarks	a	b	c	d	e	f	g	h
b	0.877** 0.002							
c	0.979** p<0.001	0.913** 0.001						
d	0.983** p<0.001	0.917** 0,001	0.979** p<0.001					
e	0.911** 0.001	0.803** 0.009	0.900** 0.001	0.895** 0.001				
f	0.966** p<0.001	0.843** 0.004	0.962** p<0.001	0.950** p<0.001	0.929** p<0.001			
g	0.617 0.077	0.718* 0.029	0.552 0.123	0.58 0.101	0.5 0.17	0.537 0.136		
h	0.962** p<0.001	0.840** 0.005	0.967** p<0.001	0.937** p<0.001	0.917** 0.001	0.996** p<0.001	0.535 0.138	
j	0.812** 0.008	0.761* 0.017	0.812** 0.008	0.819** 0.007	0.937** p<0.001	0.807** 0.009	0.416 0.266	0.795* 0.01

***A very high level of correlation was found (P<0.01).*
** A high level of correlation was found (P<0.05).*
r: Correlation percentage

Nerve Blocks of the Forelimb

1. *N. suprascapularis*: In the craniolateral approach to the region of *art. humeri*, the *n. suprascapularis* was seen just below the acromion after the tendon of the *m. infraspinatus* was cut and removed. Under this nerve, the joint capsule of the *art. humeri* was detected (Figure 1). *N. suprascapularis* block can be performed just distal to the acromion.

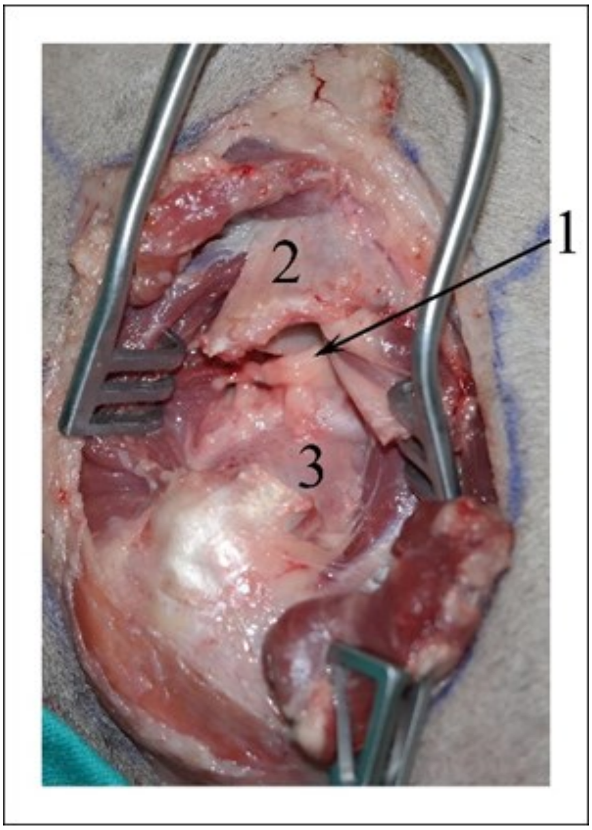

Figure 1. Appearance of the *n. suprascapularis* after the tendon of the *m. infraspinatus* is cut and removed (left front leg). 1. *N. suprascapularis*, 2. *Acromion*, 3. Joint capsule

2. *N. radialis:* *N. radialis*, passing from the medial to the lateral side of the leg, was exposed after the dissection of the cranial edge of the *m. triceps brachii caput laterale* in the lateral approach to the brachial region. It was determined that *n. radialis* was divided into branches at the lower ¼ of the distance between the *art. humeri* and the lateral edge of the *caput radii* (Figure 2). *N. radialis* block can be performed at the level of the lower 1/3 of the distance between the *tuberculum majus* of the humerus and the *epicondylus lateralis* of the humerus.

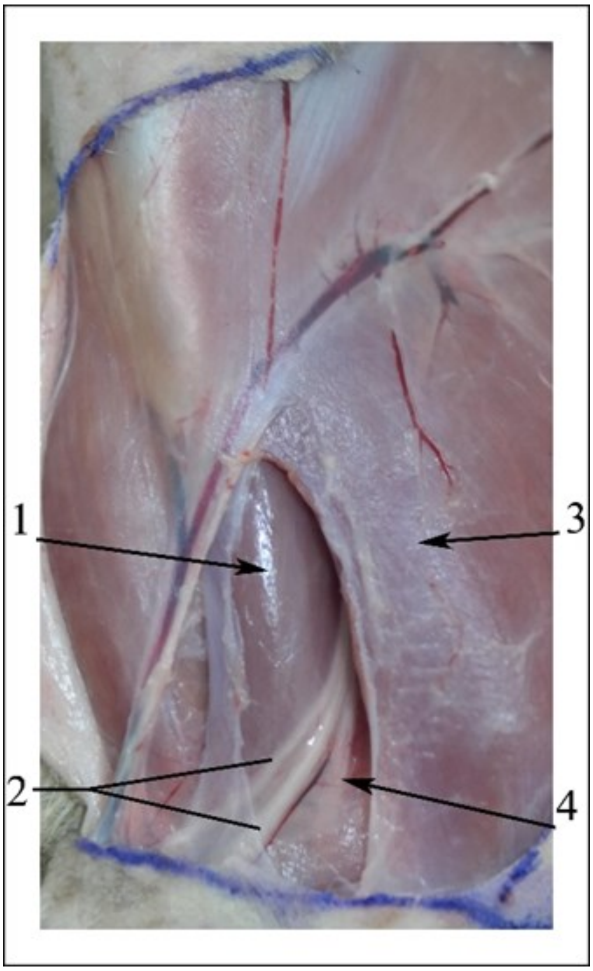

Figure 2. *N. radialis* (left front leg) after dissection of the lateral head of *m. triceps brachii*. 1. *M. brachialis*, 2. Superficial rami of *n. radialis*, 3. Lateral head of *m. triceps brachii*, 4. Profundus ramus of *n. radialis*.

3. *N. medianus*: In the region antebrachii mediale, it was observed that the *n. medianus*, passing under the muscles, descended distally from the groove between the radius and ulna together with the a. and *v. medianus*. *N. medianus* block can be performed by injection into the *sulcus radioulnaris*, which can be felt by palpation, at the level of the middle of the length of the radius (Figure 3).

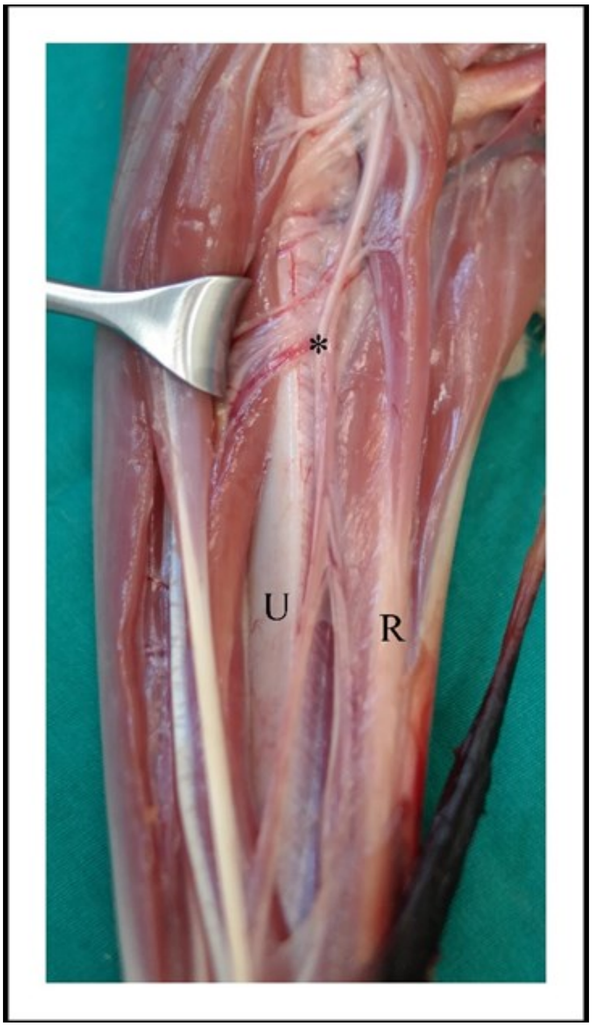

Figure 3. Regio antebrachii medialis (left front leg). U: Ulna, R: Radius, *: *a. mediana*, *n. medianus, v. mediana*

4. *N. ulnaris*: The block of the *n. ulnaris*, which passes close to the caudal border in the median cubital region, can be performed subcutaneously from the cranial 1/3 of the distance between the *epicondylus medialis* of the humerus and the *tuber olecrani* (Figure 4).

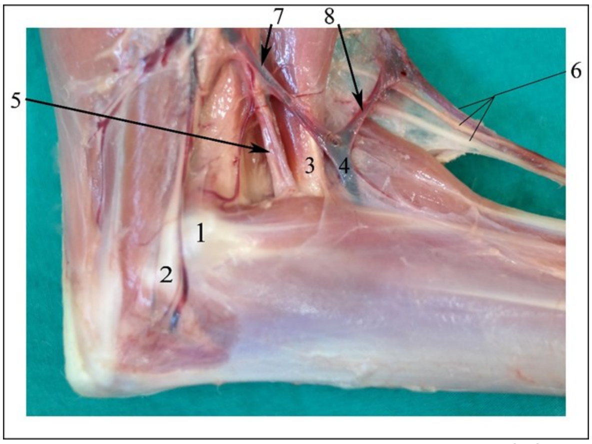

Fig. 4. Medial approach to the regio cubiti (left front leg). 1. *Epicondylus medialis*, 2. *N. ulnaris*, 3. Tendo of the *m. biceps brachii* , 4. *V. mediana*, 5. *A. mediana* and *n. medianus*, 6. Lateral–medialis ramus of the superficial ramus of the *v. cephalica-n. radialis* 7. *V. brachialis*, 8. *V. mediana cubiti*.

Nerve Blocks of the Hind Limb

1. ***N. ischiadicus*****:** In the coxal articular region, *n. ischiadicus* was identified descending distally in a curved manner just behind the *trochanter major*. *N. ischiadicus* block can be performed through the palpable fossa just caudomedial to the *trochanter major* (Figure 5).

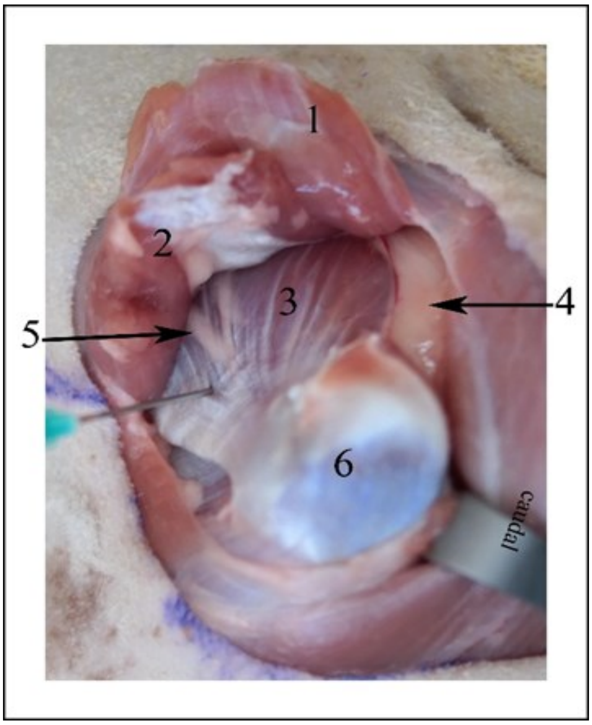

Figure 5. Regio *art. coxae*, lateral approach (left hindlimb). 1. *M. tensor fascia latae*, 2. *M. gluteus medius*, 3. *M. gluteus profundus*, 4. *N. ischiadicus*, 5. *N. gluteus cranialis*, 6. *Trochanter major*.

2. ***N. tibialis*****:** *N. tibialis* block located in the regio cruris can be performed from both lateral and medial approaches. *N. tibialis* can be felt with mediolateral palpation under the skin between the *tendo calcaneus communis* and the tendons just cranial to it. *N. tibialis* block can be performed here within the middle 1/3 of the length of the tibia (Figure 6).

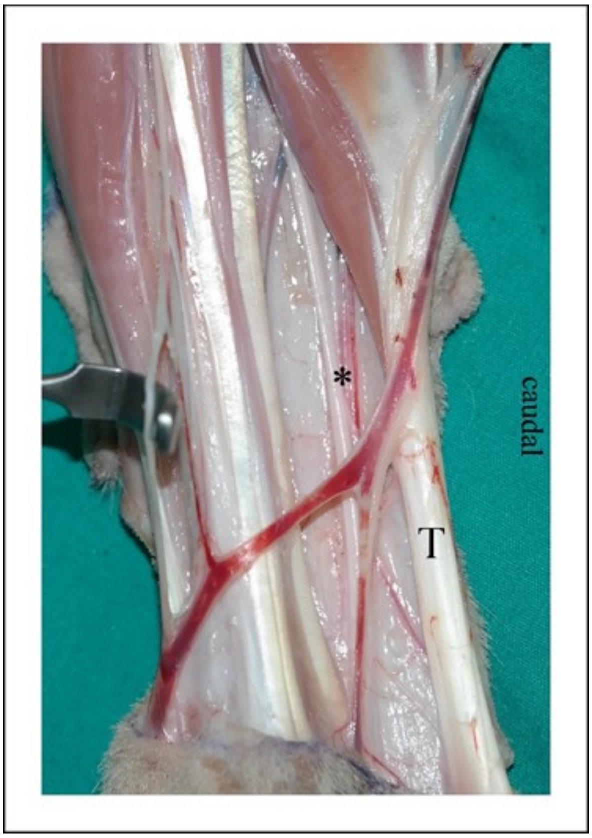

Figure 6. Lateral approach to the regio cruris (left hind leg). T: *Tendo calcaneus communis*, **: n. tibialis* and *v. saphena medialis*, Nerve held with retractor: *n. fibularis superficialis*.

Discussion and Conclusion

As a result of the literature review, techniques including the caput, corpus and distal ends of the bones, their diameters and the ratios of substantia compacta and substantia spongiosa were used in all osteometric studies performed on bones (Berteaux and Guintard, 1995; Onar and Kahvecioğlu, 1999; Steyn and İşcan, 1999; Alpak et al., 2004; Akman et al., 2006; Taşer et al., 2009; Salami et al., 2011; Pazvant and Kahvecioğlu, 2013; Onar et al., 2015; Pazvant et al., 2015). In our study, since the extremities were approached topographically, it was not possible to reach all the measurable structures of the bones. In addition, following the main concept of the study, it was deemed appropriate to approach the bones from a topographic perspective. For this purpose, measurements were made using externally palpable bone points on regions of the extremities. This method is thought to be more practical as it can also be performed on live animals. While taking the measurements, measurements were made only at the points specified in Table 1 to ensure that the extension or flexion of the joints did not affect the measurements taken. Such a measurement technique was not found in the literature searches. The fact that these measurements can be performed on live animals distinguishes our study from other morphometric studies.

In the sources reporting that the course of the *n. suprascapularis* in the scapular region passes distally to the acromion and heads upwards, the block of this nerve is not described (Çalışlar et al., 1998; Dursun, 2008; Tobias and Johnston, 2012). In this study, it was determined that the course of the nerve was the same as in the literature. In order to complete the deficiency in the literature, it was determined that the distal part of the acromion was suitable for the block of this nerve.

In the literature, there is no mention of *n. ulnaris* block located in the median cubital region (Dursun, 2008; Done et al., 2009; Evans and Lahunta, 2010). As a contribution to literature, we determined that *n. ulnaris* block can be performed at the cranial 1/3 of the distance between the *epicondylus medialis* of the humerus and the *tuber olecrani*.

In the literature, it was reported that point for *n. medianus* block is slightly behind the medial aspect of the *art. cubiti* and it can be done by taking the pulse from the *a. mediana* for nerve block (Çalışlar et al., 1998; Dursun, 2008; König and Liebich, 2014). In our study, it was determined that *n. medianus* block can also be performed from the radioulnar groove in the medial antebrachial region, which is not stated in the literature.

Dursun (2008) reported the point for *n. ulnaris* block as the middle of the ulnar groove between *m. extensor carpi ulnaris* and *m. flexor carpi ulnaris*. Contrary to literature information, it is thought that it would be more appropriate to perform *n. ulnaris* block in the upper 1/3 of the length of the ulna rather than in the middle of the ulnar groove. The reason for this is that the ulnar groove, which can be palpated more clearly in the upper 1/3, decreases in depth as it descends distally.

In an ultrasound-assisted study conducted on dogs regarding the block of the *n. ischiadicus* passing through the coxal articular region, Campoy et al. (2010) detected the nerve passing through the region with the help of a probe placed between the *tuber ischiadicum* and trochanter major and then blocked the nerve by entering it from the caudal part of the leg in the direction of the *m. semimembranosus* with a needle. Mahler and Adogwa (2008), in a study conducted on dogs, blocked the *n. ischiadicus* by entering the needle from the middle of a line drawn between the *spina iliaca d*orsalis and the *tuber ischiadicum*; a line parallel to the median line dorsal to this line; and a perpendicular connecting these two lines, with one corner being the *tuber ischiadicum*. Different from the literature, a third and very simple method was found in our study. The palpable depression caudomedial to the trochanter major was determined as the blockage point of the *n. ischiadicus*.

According to Dursun (2008), the *n. tibialis* passing through the regio cruris anesthesia can be performed from here located in the groove between the *tendo calcaneus c*ommunis and *m. flexor hallucis longus*. In our study, *n. tibialis* can be anaesthetized by palpating it under the skin, both laterally and medially, within the middle 1/3 of the length of the tibia, between the *tendo calcaneus communis* and the tendons in front of it. This method is considered to be both clearer in terms of description and easier to apply in dogs.

Alpak et al. (2004) determined that there was a correlation between the long bones and the cranium in their morphometric study between some measurements of the cranium and long bones in dogs. However, they did not evaluate the correlation between long bones. In our study, correlations between bones were calculated based on palpable bone points and significant positive correlations were found.

This study, which found that the distance between reference points that can be easily measured by palpation in a living animal has significant positive correlations that can be used clinically in many ways, is thought to offer a more practical method compared to other studies in the literature.

In conclusion, this study performed on the extremities of dogs has not only contributed to the addition of colorful and fresh operation photographs to the literature but also revealed new and simple techniques for some of the anesthesia applied to the nerves. In addition, it is thought that the osteometric analyses and measurement techniques used can be easily applied to live animals and will form the basis for new studies in this field. It has been concluded that some measurements between externally palpable points on a live dog can be used to calculate other lengths.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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