J. Vet. Sci. (2009), **10**(1), 77−80
DOI: 10.4142/jvs.2009.10.1.77

JOURNAL OF
Veterinary Science

Ultrasonographic examination of the carpal canal in dogs

Erkut Turan[1,*], Yelda Ozsunar[2], Ismail Gokce Yildirim[1]

[1]Departments of Anatomy, Faculty of Veterinary Medicine, and [2]Departments of Radiology, Faculty of Medicine, University of Adnan Menderes, PK: 17, 09016, Isikli-Aydin, Turkey

The aim of this study was to determine the course of the median nerve and its adjacent structures in the carpal canals of 8 healthy dogs by using high-frequency transducers. Before performing ultrasonography, the transverse and posteroanterior diameters as well as the perimeter of the carpus were measured at just proximal to the side of the carpal pad. The anatomical structures were then determined at two levels of the carpal canal, which were named the proximal and distal levels, on the transverse sonograms. The cross-sectional areas, perimeters and the transverse and posteroanterior diameters of the median nerve were measured at these levels. Although all the measurements were larger at the proximal level, significant differences between the proximal and distal levels were determined for the cross-sectional area, the perimeter and the transverse diameter of the median nerve. On the transverse sonogram, the deep digital flexor tendon was seen in almost the center of the carpal canal like a comma shape and also it had a small concavity on the caudal side. The superficial digital flexor tendon was seen as an ovoid shape on the transverse sonograms and it was located nearly at the posterior side of the carpal canal. Both tendons were seen as intermediate-grade echogenic structures. The median artery was located inside of the concavity of the deep digital flexor tendon. Also, the median nerve was seen at the posteromedial side of the median artery. As a result of this study, the cross-sectional areas of the median nerve ranged between 1.01-2.68 mm^2 at the proximal level and between 0.93-1.91 mm^2 at the distal level.

Keywords: carpal canal, dog, median nerve, ultrasonography

Introduction

The carpal canal is a passage in the carpus through which the median nerve and the tendons of the flexor muscles travel to the paw. This canal is formed superficially by the superficial part of the flexor retinaculum (the transverse carpal ligament) and deeply by the palmar part of the joint capsule [7]. Median nerve compression beneath the flexor retinaculum of the carpus is the most common entrapment neuropathy, and this is known as carpal tunnel syndrome (CTS) in human medicine [16,17]. This syndrome has been reported only in horses in the veterinary field [14,19]. CTS has been described experimentally, and prolongation of the sensory nerve action potential of the median nerve was determined at the hyperflexion position of the carpal joint in dogs [20]. The computed tomographic morphometry of the canal has also been well documented in this species [21]. The later studies showed that there were great similarities of the carpal region between human and dog for both the anatomic and electrophysiological aspects [20,21]. Therefore, these studies speculated that CTS can be diagnosed in dogs if veterinarians are aware of its possibility and they test for it.

The diagnostic evaluation of peripheral nerve diseases is based on clinical examination, electrophysiological tests and the imaging techniques such as magnetic resonance imaging, computed tomography and ultrasonography (US). In this circumstance, the diagnostic value of high-frequency US has increased for assessing the nerve status in human medicine [5,12,25,26]. In the veterinary field, the ultrasonographic appearance of the brachial plexus and the optic and sciatic nerves in dog and seven peripheral nerves in horse has been reported on [1,3,9,13,18]. However, the ultrasonographic appearance of the canine carpal canal and median nerve has not been investigated. This investigation may supply useful data for diagnosing median nerve diseases and for conducting experimental studies on peripheral nerves for which dog are used as an animal model [24]. We also think that the increase in basic knowledge about the normal ultrasonographic appearance of the canine carpal canal, the median nerve and its adjacent structures will encourage veterinary surgeons to use this technique as a diagnostic tool for peripheral nerve diseases.

The present study is aimed to record the ultrasonographic

*Corresponding author
Tel: +90-256-247-07-00; Fax: +90-256-247-07-20
E-mail: terkut@yahoo.com, eturan@adu.edu.tr

appearance of the median nerve and its adjacent structures in the carpal canal of healthy dog by using high-frequency transducers.

Materials and Methods

Eight healthy dogs (4 German shepherds, 2 Setters, 1 Alaskan malamute, 1 Labrador retriever) weighing an average of 27.25 ± 4.65 kg (range: 21-35 kg) were used in this study. The age of the 5 male dogs and the 3 female dogs ranged between 18 to 48 months with a mean age of 33 ± 15.71 months. This study was approved by the Animal Ethics Committee of the University of Adnan Menderes (Turkey).

Each dog was placed in right lateral recumbency, and then the transverse (TDC) and posterioanterior (PADC) diameters of the carpus were measured with micrometric callipers. The perimeter (PC) of the carpus was also measured with using a measuring tape. All these measurements were taken from just proximal to the side of the carpal pad.

The hair of the posterior side of the left carpus was clipped and the transverse ultrasonographic scans were obtained following neutral positioning of the left carpal joint. During this process, one dog was sedated with 1.1 mg/kg xylazine (Rompun; Bayer, Germany) intramuscularly because of the dog's bad temper. Ultrasonographic examination was performed with a 7.5-12 MHz linear array transducer (Toshiba Aplio, Japan) at two levels as the proximal and distal carpal canal levels. The probe was placed just proximal and medial to the carpal pad for the proximal (PCCL) and distal (DCCL) carpal canal levels, respectively (Fig. 1). The cross-sectional area (NA), the perimeter (NP), the transverse diameter (NTD) and the posteroanterior diameters (NPAD) of the median nerve were measured from the two levels by tracing with electronic callipers the margin of the nerve at the time of US. Measurements of all the variables were made only one time.

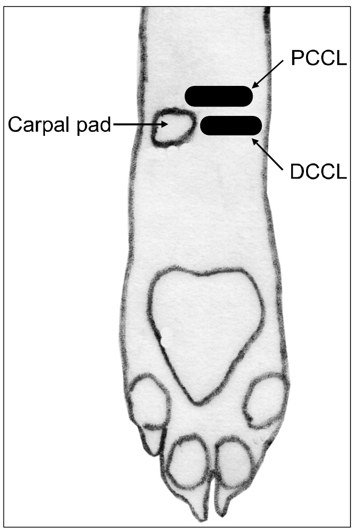

Fig. 1. Schematic presentation of the probe placement for the proximal (PCCL) and distal (DCCL) carpal canal levels in the left forelimb.

Statistical analysis was performed by using the SPSS statistical package (version 10.0; SPSS, USA). First, a Shapiro-Wilk one sample test was performed in order to test the dog's weight and age for a normal distribution. The mean values and standard errors were calculated as descriptive statistics. The Wilcoxon test was also used to determine the differences in the values between the proximal and distal levels. The level of significance was set at p values < 0.05 for all analyses.

Results

The dogs constituted a homogeneous group according to their weights, ages and measurements of the carpal region, except the TDC, which were confirmed by the results of the Shapiro-Wilk test. The TDC and PADC were 40.02 ± 1.92 and 33.29 ± 1.92 mm, respectively. The PC was 14.13 ± 0.40 mm.

The ultrasonographic examination was performed without sedation in all the dogs, except one male German shepherd dog, and the carpal canal was easily monitored at the two levels of scanning. On the sonogram, the deep and superficial digital flexor tendons had a surrounding hypoechoic rim and these tendons were seen as intermediate-grade echogenic structures. The inner parts of the deep and superficial digital flexor tendons contained inhomogeneous areas. The deep digital flexor tendon was seen like a comma shape in almost the center of the canal, while the superficial digital tendon was ovoid shape at the posterior side of the canal. The median artery was located at the posterior side of the deep digital flexor tendon. The median nerve was seen on the posteromedial side of the median artery and it was clearly distinguished by color Doppler imaging. The ultraonographic appearance of the median nerve was an ovoid shape with bright punctuate echoes distributed throughout a hypoechoic background (Fig. 2).

The NA, NP, NTD and NPAD had greater values at the proximal level than at the distal level. The greatest difference was recorded in the NA as a ratio of 18.8%, while the NPAD had the smallest difference as 8.9%. The significant differences between the two levels were determined statistically for the NA, NP and NTD (Table 1).

Discussion

For dogs, there are great variations of the size between breeds and between the individuals within the same breed. Therefore, a homogeneous group is one of the prerequisite conditions for acquiring basic knowledge and making

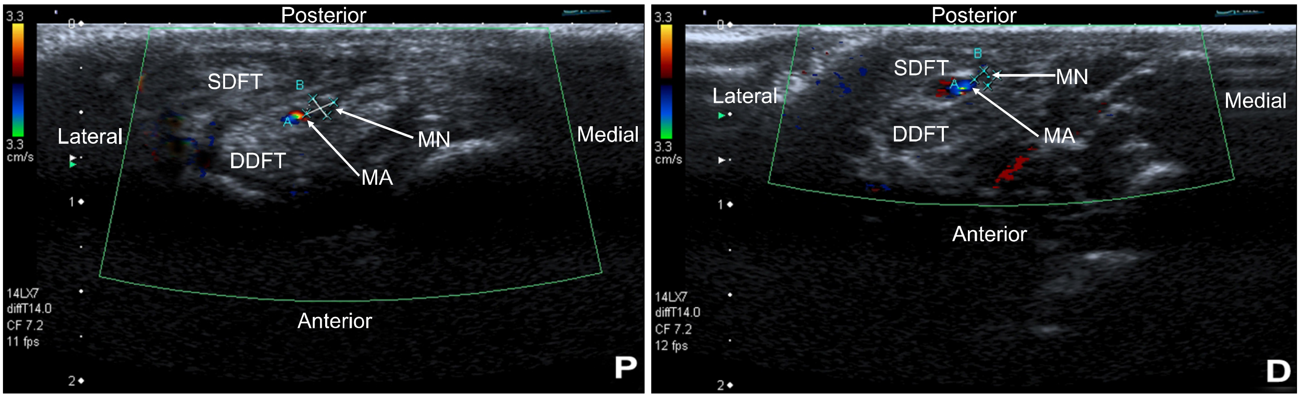

Fig. 2. Transverse ultrasonographic scans of the carpal canal at the proximal (P) and the distal (D) levels of the carpal canal. Color Doppler imaging is helpful to easily localize the median nerve. Note that the size of the median nerve is larger at the proximal part of the carpal canal as compared to the distal part. The transverse diameter (A) and the posteroanterior diameter (B) of the median nerve, the median nerve (MN), the median artery (MA), the deep digital flexor (DDFT) tendons and the superficial digital flexor tendons (SDFT).

Table 1. The comparison of the measurements at the proximal (PCCL) and distal (DCCL) carpal canal levels in dogs

	No.	PCCL	DCCL	Percentage of PCCL/DCCL	
		MV ± SEM	MV ± SEM		
NA (mm^2)	8	1.54 ± 0.19	1.25 ± 0.13	18.8 %	0.012*
NP (mm)	8	4.49 ± 0.25	4.02 ± 0.21	10.5 %	0.012*
NTD (mm)	8	1.69 ± 0.09	1.49 ± 0.07	11.8 %	0.025*
NPAD (mm)	8	1.24 ± 0.08	1.13 ± 0.05	8.9 %	0.128

The cross-sectional area (NA), perimeter (NP), transverse diameter (NTD), posteroanterior diameter (NPAD) of the median nerve. *$p < 0.05$.

accurate measurements. The dogs of this study constituted a homogeneous group according to their body weights and ages, as well as the measurements of the carpal region, except the TDC.

Different diagnostic techniques can supply useful information for diagnosing both unilateral and generalized neuropathies in human medicine [6,12,26]. Ultrasonography is one of these techniques, and US does not require general anaesthesia, it is rapid and non-invasive and it offers real time monitoring. The examination of soft-tissue structures is also possible [22]. These aforementioned advantages were confirmed by our findings and sedation was required for only one dog in this study. For these reasons, US is gradually being introduced to examine dogs [3,9]. However, familiarity with the ultrasonographic appearance of anatomical structures is important for reliably interpreting the US images. In the transverse plane, the normal tendons in dogs have medium echogenity with hyperechoic pinpoints that represent the collagen fibers within the tendon [10,11]. Our findings were in line with the preceding reports for the flexor tendons within the carpal canal. Ultrasonographic identification of the nerves in both the sagital and transverse planes requires detailed anatomical knowledge of the imaged area [9]. In the transverse plane, a nerve can be identified by rotating the probe 90° after finding the nerve in the sagittal plane [8,9] or by using some anatomic landmark such as vessels and tendons [2,9,22].

In this study, identifying the median nerve was easily done with color-flow Doppler by using the median artery as an anatomic landmark. Also, the superficial course of the median nerve was very helpful to identify it.

The peripheral nerves in healthy dogs are hyperechoic structures that contain internal punctuate echoes in the transverse plane [1,3,9]. The median nerve in the carpal canal had a minor difference of its echogenity as compared to the other peripheral nerves, and this is similar in humans [2,22]. This echogenitic difference of the peripheral nerves may be related to two reasons: the neighbouring tendons and the extra accumulations of connective tissue [22].

The quantity of a nerve may be a diagnostic criterion for some peripheral nerve diseases. A correlative cadaver study showed that US is a very precise method to assess the diameter, perimeter and area of a nerve [1,3]. Good correlation has been observed between the nerve measurements and carpal tunnel syndrome in humans [4,15,23]. A median nerve cross-section area greater than 0.09 cm^2 at the level of the proximal tunnel is reported to be best diagnostic criterion of carpal tunnel syndrome in humans [15]. In this circumstance, the measurement points should be standard and easily replicated; however, many studies do not report on the measurements points in detail [2]. In this study, the measurements were performed from the inner border of the perineural echogenic rim surrounding the median nerve to both proximal and distal level of the carpal canal. The values obtained from the distal level had a smaller range, compared to the values obtained from the proximal level. For example; the range of the median nerve area was 0.98 at the distal level to 1.67 at the proximal level. This smaller range reflects that the size of the median nerve is more stable at the distal level and it may be more suitable to define the reference values of the median nerve at this level of the carpus. All measurements were larger at the proximal level than at the distal level of the carpal canal and significant differences were calculated for the cross-sectional nerve area, the nerve perimeter and the transverse nerve diameter between the proximal and distal transverse scans.

In conclusion, our results showed that US of the carpus was an easily applicable technique and the median nerve could be assessed quantitatively in dogs. This technique has several advantages to be a routine diagnostic tool for assessing peripheral nerve disease. However, more descriptive studies on different nerves in both healty and sick animals are required and the reference values for the various breeds and ages of dogs are also needed.

References

1. **Alexander K, Dobson H.** Ultrasonography of peripheral nerves in the normal adult horse. Vet Radiol Ultrasound 2003, **44**, 456-464.
2. **Beekman R, Visser LH.** High-resolution sonography of the peripheral nervous system - a review of the literature. Eur J Neurol 2004, **11**, 305-314.
3. **Benigni L, Corr SA, Lamb CR.** Ultrasonographic assessment of the canine sciatic nerve. Vet Radiol Ultrasound 2007, **48**, 428-433.
4. **Bleecker ML, Bolhman M, Moreland R, Tipton A.** Carpal tunnel syndrome: role of carpal canal size. Neurology 1985, **35**, 1599-1604.
5. **Buchberger W, Schon G, Strasser K, Jungwirth W.** High-resolution ultrasonography of the carpal tunnel. J Ultrasound Med 1991, **10**, 531-537
6. **El Miedany YM, Aty SA, Ashour S.** Ultrasonography versus nerve conduction study in patients with carpal tunnel syndrome: substantive or complementary tests? Rheumatology 2004, **43**, 887-895.
7. **Evans HE, Christensen GC.** Miller's Anatomy of the Dog. p. 248, Saunders, Philadelphia, 1979.
8. **Hudson JA, Steiss JE, Braund KG, Toivio-Kinnucan M.** Ultrasonography of peripheral nerves during wallerian degeneration and regeneration following transection. Vet Radiol Ultrasound 1996, **37**, 302-312.
9. **Hudson JA, Finn-Bodner ST, Steiss JE.** Neurosonography. Vet Clin North Am Small Anim Pract 1998, **28**, 943-972.
10. **Kramer M, Gerwing M, Hach V, Schimke E.** Sonography of the musculoskeletal system in dogs and cats. Vet Radiol Ultrasound 1997, **38**, 139-149.
11. **Lamb CR, Wong K.** Ultrasonographic anatomy of the canine elbow. Vet Radiol Ultrasound 2005, **46**, 319-325.
12. **Lee CH, Kim TK, Yoon ES, Dhong ES.** Correlation of high-resolution ultrasonographic findings with the clinical symptoms and electrodiagnostic data in carpal tunnel syndrome. Ann Plast Surg 2005, **54**, 20-23.
13. **Lee HC, Choi HJ, Choi MC, Yoon JH.** Ultrasonographic measurement of optic nerve sheath diameter in normal dogs. J Vet Sci 2003, **4**, 265-268.
14. **Mackay-Smith MP, Cushing LS, Leslie JA.** "Carpal canal" syndrome in horses. J Am Vet Med Assoc 1972, **160**, 993-997.
15. **Martinoli C, Bianchi S, Gandolfo N, Valle M, Simonetti S, Derchi LE.** US of nerve entrapments in osteofibrous tunnels of the upper and lower limbs. Radiographics 2000, **20**, S199-213.
16. **Mazurek MT, Shin AY.** Upper extremity peripheral nerve anatomy: current concepts and applications. Clin Orthop Relat Res 2001, **383**, 7-20.
17. **Preston DC.** Distal median neuropathies. Neurol Clin 1999, **17**, 407-424.
18. **Rose S, Long C, Knipe M, Hornof B.** Ultrasonographic evaluation of brachial plexus tumors in five dogs. Vet Radiol Ultrasound 2005, **46**, 514-517.
19. **Squire KR, Adams SB, Widmer WR, Coatney RW, Habig C.** Arthroscopic removal of a palmar radial osteochondroma causing carpal canal syndrome in a horse. J Am Vet Med Assoc 1992, **201**, 1216-1218.
20. **Turan E, Bolukbasi O.** Evaluation of possible carpal tunnel syndrome in dogs. Vet Rec 2004, **155**, 122-124.
21. **Turan E, Erden H.** Computed tomography and morphometry of the carpal canal in the dog. Ann Anat 2003, **185**, 173-178
22. **Walker FO, Cartwright MS, Wiesler ER, Caress J.** Ultrasound of nerve and muscle. Clin Neurophysiol 2004, **115**, 495-507.
23. **Winn FJ Jr, Habes DJ.** Carpal tunnel area as a risk factor for carpal tunnel syndrome. Muscle Nerve 1990, **13**, 254-258.
24. **Yamanaka K.** An experimental study on compression neuropathy-the effect of neurolysis on the blood-nerve barrier. Nippon Seikeigeka Gakkai Zasshi 1992, **66**, 714-727.
25. **Yesildag A, Kutluhan S, Sengul N, Koyuncuoglu HR, Oyar O, Guler K, Gulsoy UK.** The role of ultrasonographic measurements of the median nerve in the diagnosis of carpal tunnel syndrome. Clin Radiol 2004, **59**, 910-915.
26. **Ziswiler HR, Reichenbach S, Vögelin E, Bachmann LM, Villiger PM, Jüni P.** Diagnostic value of sonography in patients with suspected carpal tunnel syndrome: a prospective study. Arthritis Rheum 2005, **52**, 304-311.