Ultrasonography study of tendons and ligaments of metacarpal region in the camel (*Camelus dromedarius*)

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Abstract

Twelve left camel forelimbs were collected, and ultrasonography was performed at five different levels around the metacarpal region. Limbs were then cut in the transverse plane at levels corresponding to the ultrasound images. Transverse and sagittal plane images were taken at each of the five levels, keeping all ultrasound imaging factors constant. Echogenicity, diameter, width and cross sectional area of the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT) and suspensory ligament (SL) were evaluated. Characteristics of echogenicity and different tendon and ligament sizes were measured and discussed.

Introduction

Camelids share some orthopedic conditions such as traumatic injuries, flexural contracture, tendon rupture and tendinitis with cattle and horses (Singh and Gahlot, 1997; Masoudifard, 2008). As in equine (Avella *et al.,* 2009) and bovinepractice (Kofler, 2009; Johann and Hannes, 1995), ultrasonography can help diagnose these problems in the camel *(Camelus dromedarius*), despite differences in etiology, animal temperament and body size (Masoudifard, 2008).

Ultrasonography of the tendons and ligament in metacarpal region is one of the easiest methods to study the echogenicity, diameter, width and cross sectional area (CSA) of the SDFT, DDFT and SL in different breeds of horses (Cuesta *et al.*, 1995; Vosough *et al.*, 2007; Masoudifard, 2008) and cattle (Johann and Hannes, 1995; Kofler, 2009). To the knowledge of the authors, no study has yet reported the ultrasonographic anatomy of tendons and ligaments in the metacarpal region of one-humped camels, and therefore this study was designed to determine reference values for these structures. The incidence of musculoskeletal injuries in the camel has been reported to be about 16% of all disorders (Singh and Gahlot, 1997), of which some could be diagnosed ultrasonographically (Singh and Gahlot, 1997; Reef *et al.*, 1998). This study aims to provide reference values to aid diagnosis of musculoskeletal disorders of the one-humped camel.

Materials and Methods

Twelve left forelimbs of one-humped camels without any sign of lameness prior to slaughter were collected from a slaughter house. All forelimbs were prepared for ultrasound examination by shaving the hair and applying abundant ultrasound coupling gel. Ultrasonography was performed using a 3 - 12.5 MHz T-Shape linear transducer attached to a 730 Pro Voluson General Electric unit (GE Medical Systems Kretztechnik GmbH & Co OHG). The metacarpal region was divided into five levels, labeled A, B. C, D and E. Level A was 3 cm below the carpal joint; level B was where the SDFT sheaths the DDFT, 6 cm below level A; level C was where the DDFT became elongated, 6 cm below level B; level D was at the bifurcation of the SDFT and DDFT and level E was at the bifurcation of the SL, 6 cm below level D. Transverse and sagittal views were taken at all five levels, keeping the same ultasonographic settings.

Image capture was designed so that the lateral side of the limb was on the left side of the transverse image and the proximal part of the limb was on the left side of the sagittal image. All ultrasound images were recorded onto DVD for further investigation and the best images were saved in the memory of the unit. The CSA, width and thickness of the SDFT, DDFT and SL were measured on selected images by using Scion image software. In order to increase the precision, sonograms were magnified and all CSA measurements were performed twice. If differences were greater than 10%, measurements were taken again. The mean values and standard deviations were analyzed using Microsoft Office Excel 2007 (Microsoft Corporation).

Results

Transverse images

At level A, the SDFT was oval and its echogenicity was less than in the DDFT in all cases. Although SDFT echogenicity was less than in the SL in two cases, in the other 10 cases it was equal to that in the SL. In cross section, the DDFT was circular and the SL was comma-shaped with an echogenic strip on its dorsal side (Figure 1). At level B, the CSA of the SDFT was larger and the lateral border was sharper than its medial border. The oval DDFT was surrounded by the SDFT like a crescent and was of equal or greater echogenicity compared to the SDFT. The SL was comma-shaped and its echogenicity was greater toward the distal end (Figure 2).

At level C, the SDFT gradually became wider as it approached its bifurcation and was less echogenic than the DDFT. The SL showed no change from level B (Figure 3). At level D, both the SDFT and DDFT were bifurcated. There was an anechoic circular structure between the branches of the SDFT that was considered to be a blood vessel. The SDFT was less echogenic than the DDFT. The SL maintained its oval cross section (Figure 4). At level E, the SL was also bifurcated. The SDFT was hypoechogenic and the DDFT was oval (Figure 5).

Sagittal images

At level A, the parallel fibers of the SDFT and DDFT were isoechoic and in close contact, and their interception was distinct. The SL was characterized by a sharp border (Figure 6). At level B, the SDFT, DDFT and SL had the same characteristics as in level A. Although the SDFT and DDFT were slightly thicker at this level, the SL was thinner. At level C, the thickness of the SDFT and the DDFT was less than at level B, while the SL was thicker than at level B, but not as thick as at level A. At level D, there was a slight decrease in SL diameter. At level E, the echogenicity of the DDFT and the diameter of the SL were larger, and the attachment of SL to the proximal sesamoid bones was well-defined. The thickness of the SDFT was less than 3.61 mm at any level, and the thickness of the DDFT was less than 9.51 mm in level E and less than 5.56 mm at any other level. The maximum thickness of the SL was 13.65 mm, at level A (Table 1). The greatest width of the SDFT was 23.11 mm at level C. The highest width of the DDFT was 18.08 mm at level E. The maximum width of the SL was 35.88 mm at level D (Table 2).

The maximum CSA of the SDFT was 63.13 mm^2 at level B. The greatest CSA of the DDFT was 69.27 mm^2 at level C. The maximum CSA of the SL was 103.44 mm^2 at level E (Table 3).

Discussion

Since no reports are available on the ultrasonographic structure of camel tendons and ligaments in the metacarpal region, the current study

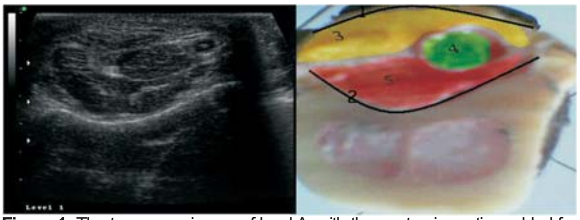

Figure 1: The transverse image of level A, with the anatomic section added for illustration. 1: skin surface, 2: metacarpal bone surface, 3: SDFT, 4: DDFT, 5: SL.

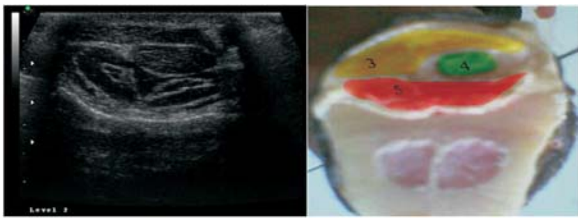

Figure 2: The transverse image at level B, with the anatomic section added for illustration. 3: SDFT, 4: DDFT, 5: SL.

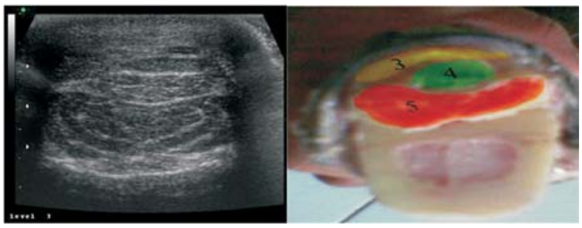

Figure 3: The transverse image at level C, with the anatomic section added for illustration. 3: SDFT, 4: DDFT, 5: SL.

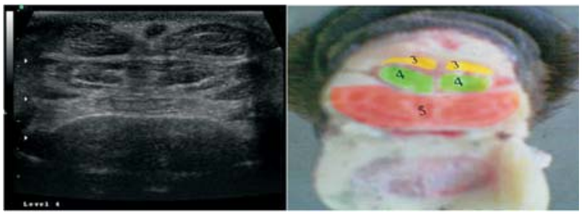

Figure 4: The transverse image at level D, with the anatomic section added for illustration. 3: SDFT, 4: DDFT, 5: SL.

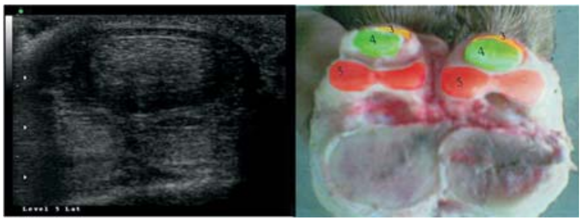

Figure 5: The transverse image at level E, with anatomic section added for illustration. 1: skin surface, 2: metacarpal bone surface, 3: SDFT, 4: DDFT, 5: SL.

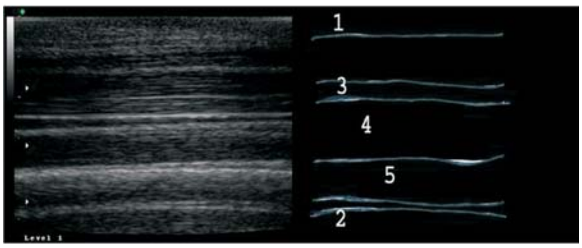

Figure 6: Sagittal image at level A, with anatomic section added for illustration. 1: skin surface, 2: metacarpal bone surface, 3: SDFT, 4: DDFT, 5:SL.

Table 1: Dorso-palmar diameter of tendons and ligaments (mean ± standard deviation).

Measurement	Structure	Level A	Level B	Level C	Level D (M.)	Level D (L.)	Level E (M.)		Level E (L)	
Thickness (mm)	SDFT	2.64± 0.11	3.61± 0.11	2.61± 0.09	1.85± 0.06	1.67± 0.05	1.61± 0.07		1.59± 0.06	
	DDFT	5.46± 0.13	5.56± 0.22	4.73± 0.32	4.95± 0.29	4.62± 0.47	9.28± 0.31		9.51± 0.52	
							L	M	L	M
	SL	13.65± 0.47	9.30± 0.27	12.22± 0.54	12.26±0.55		9.19±0.51	9.14±0.56	9.09±0.39	9.28±0.34

Table 2: Latero-medial width of tendons and ligaments (mean ± standard deviation).

Measurement	Structure	Level A	Level B	Level C	Level D (M.)	Level D (L.)	Level E (M.)		Level E (L.)	
Width (mm)	SDFT	8.08± 0.36	19.23±1.04	23.11± 1.24	8.93± 0.43	8.53±0.35	15.11± 0.95		15.65± 0.84	
	DDFT	12.25± 0.46	12.38±0.29	17.99± 0.42	11.52± 0.30	11.92±0.81	18.06± 0.63		18.10± 0.63	
							L	M	L	M
	SL	26.01± 0.58	27.10±0.89	33.73± 0.37	35.88±1.30		9.75±0.23	10.57±0.59	9.96±0.56	10.90±0.50

Table 3: CSA of tendons and ligaments (mean ± standard deviation).

Measurement	Structure	Level A	Level B	Level C	Level D (M.)	Level D (L.)	Level E (M.)		Level E (L.)	
CSA (mm^2)	SDFT	15.94±0.39	63.16±1.16	54.90±2.39	25.70±0.43	25.11±0.31	36.72±0.55		35.12±1.23	
	DDFT	56.52±1.41	54.08±1.36	69.27±1.52	50.10±0.91	47.73±1.60	137.74±1.43		138.97±1.60	
							L	M	L	M
	SL	215.01±0.71	211.86±1.11	287.84±1.50	382.66±3.71		103.21±1.31	105.14±2.24	102.14±3.97	98.9±3.02

was carried out to provide these values. Ultrasonography is a noninvasive, cost-effective, accessible modality that can provide useful information for evaluation of musculoskeletal disorders (Reef *et al.*, 1998; Vosough *et al.*, 2007). Ultrasonographic findings can be compared to histopathology and gross anatomical appearance to characterize the tissue in the area of injury (Reef *et al.*, 1998). This procedure is widely undertaken in horses (Cuesta *et al.*, 1995; Reef *et al.*, 1998; Masoudifard, 2008), miniature horses (Vosough *et al.*, 2007) cattle (Kofler, 2009) and camels (Kassab, 2008). As the weight-bearing status of the animal affects tendon contraction and could influence tendon CSA (Avella *et al.,* 2009; Masoudifard, 2008), this study was conducted on cadaveric rather than live specimens. The difference between ultrasonographic measurements and gross anatomical size is considered not to be significant in horses (Cuesta *et al.*, 1995). However, some authors mentioned a difference of up to 4.5% between these measurement techniques (Singh and Gahlot, 1997), possibly due to shrinkage of structures in formalin, or the absence of blood-filled vessels in cadaveric specimens (Reef *et al.*, 1998). Therefore, our study measured fresh cadaveric specimens. Knowledge of the normal ultrasound characteristics and dimensions of the commonly-injured tendons and ligaments in the camel is important for diagnosis of injury. Transverse CSA of the SDFT was minimum in level A (15.94 mm^2), so it is likely that most injuries will occur at this level. The lowest measured CSA for DDFT was 50.1 mm^2 at level B. Minimum CSA of the SL was 211.86 mm^2, also measured at level B. Each structure was roughly cylindrical longitudinally, which is consistent with findings in the horse despite differences in body size (Avella *et al.,* 2009; Gillis *et al.*, 1995; Reef *et al.*, 1998).

In all levels the most echogenic structure was the DDFT. The SL was relatively hypoechogenic with some echogenic linear areas inside it. At all levels, the SDFT was less echogenic than the DDFT. The ultrasonographic appearance, echogenicity and echotexture of structures in the metacarpal region of the camel are similar to previous studies in the horse (Avella *et al.,* 2009; Reef *et al.*, 1998; Masoudifard, 2008), miniature horse (Vosough *et al.*, 2007) and cattle (Kofler, 2009).

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