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RESEARCH ARTICLE

Arthrography and Arthrosonography of the Friesian cattle (*Bos taurus*) carpus

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Abstract

The radiographic, computed tomographic and ultrasonographic of the carpal region of twelve clinically normal Friesian cattle (*Bos taurus*) was determined. Radiographic examination was performed in dorsopalmar, lateromedial projections. The carpus was ultrasonographically investigated with the help of an 8-MHz linear transducer. Bone windows CT were performed. The bony structures and articulations of the carpal joint were outlined. The extensor tendons were easily identified at the dorsal aspect of the carpus. The flexor tendons were observed at the palmar aspect. Other soft structures examined include the lateral collateral ligament and the medial collateral ligament. The lumina of carpal tendon sheaths and the boundaries of the carpal joint pouches could not be defined. The objective of this study was to define the normal ultrasonographic appearance of the structures of the carpal region in healthy Friesian cattle as well as to state the normal radiography and CT of the same region in order to establish clinically relevant reference data.

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INTRODUCTION

The carpal joint is a complex synovial joint. It consists of the antebrachio-carpal joint, the intercarpal joint and the carpometacarpal joint (Getty, 1975). The joint is enclosed within a common joint capsule surrounded by various tendons and ligaments.

Loss of production in beef and dairy cattle is very often caused by lameness (Weisbrode, 1982). Lameness in cattle is as a sequence of diseases of joints and ligaments (47%), tendons (21%), muscles (9%), bones (7%), nerves (7%) and other tissues including skin (10%) (Baggott and Russell, 1981). Most bovine carpal disorders are secondary to other orthopaedic or systemic diseases, leading to prolonged pressure on the dorsal aspect of the carpus when the cattle are standing, or tertiary due to haematogenous infection of the carpal joints or tendon sheaths (Dirksen, 1994; Munroe & Cauvin, 1994; Geishauser, 1996; Kofler, 1997; Weaver, 1997).

Radiography remains the cornerstone of diagnostic imaging technique for the evaluation of the musculoskeletal disorders. After localization of lameness by means of physical examination, survey radiographs can quickly and accurately provide morphologic characterization of bone and soft tissue abnormalities which concurrently lead to formation of a definitive or differential diagnosis. It can also delineate the nature and extent of involvement and define the extent of the lesion (Vallance et al.; 2012). Radiography is effective for the evaluation of bony structures, but the fact that a three-dimensional structure is projected onto a two-dimensional plate leads to the major disadvantage of a superimposition of bony structures and lack of differentiation of soft tissues (Kraft and

Gavin 2001; Latorre et al., 2006; Park et al., 1987). However, clinical examination and radiography don't allow a definitive diagnosis to be reached or accurate identification of the soft tissue structures involved (Kofler, 2000).

Ultrasonography has been established as a useful diagnostic tool for imaging soft tissue changes in human, equine and bovine musculoskeletal disorders (Genovese *et al.*, 1986; Dik, 1990; Meier *et al.*, 1993; Tnibar *et al.*, 1993; Chhem *et al.*, 1994; Munroe & Cauvin, 1994; Craychee, 1995; Mettenleiter, 1995; Kofler, 1996ab, 1997). The normal ultrasonographic appearance of the anatomical structures of the carpal region in healthy cattle had been reported by (Kofler, 2000) as well as in camel (kassab, 2008).

CT has become a well-established diagnostic imaging modality for the evaluation of musculoskeletal disorders (Vallance et al.; 2012). CT of the carpus had been studied in horse (Kaser et al.; 1994). To our knowledge, until now a reference for the normal CT anatomy of the Friesian cattle carpus has not been reported. Therefore, the objective of this study was to depict the radiographic and ultrasonographic appearance as well as a detailed CT reference of the bony and soft tissue structures of the Friesian cattle carpus to develop an optimal technique for examination of these structures to serve as a reference for evaluation of carpal pathology.

MATERIALS AND METHODS

The forelimbs of twelve Friesian cows of various ages and sexes and their weight ranged between 450 and 550 kg were used for the present study. All animals were clinically sound and the carpal joints were normal, based on the animal's history and physical examination.

The carpal joints of ten Friesian cows were radiographed in two projections, dorsopalmar and lateromedial views using a digital X-ray machine (Philips Digital X-ray Unit; Philips GmbH, Hamburg, Germany). The cattle were restrained in a crush and examined in a standing position. In some animals light sedation with xylazine (0.034 mg/kg bodyweight, intramuscular) was required to limit their movement. The left and right carpal and distal antebrachial regions of these 10 cattle were examined ultrasonographically. The hair over the carpal region was shaved, the skin was cleaned and coupling of gel applied. Ultrasonographic examination of the carpal joint was performed using a Toshiba equipped with an 8 MHz transducer.

The carpus was ultrasonographically investigated in four planes (dorsal, medial, lateral and palmar) in both transverse and longitudinal views beginning with the proximal and moving towards the distal region. The position, echogenicity and degree of demarcation of the tendons and ligaments and the joint pouches were determined. The lateral collateral ligament of the carpal joints was visualized on the lateral aspect of the limb; carpal flexor tendons from the palmar aspect of the limb; carpal extensor tendons from the dorsal aspect; and the medial collateral ligament of the carpal joints from the medial side

The carpal and distal antebrachial regions of 4 cadaver limbs from two slaughtered, adult Friesian cows showing no superficial evidence of disease were used for CT. The limbs of the slaughtered cows were disarticulated at the shoulder to maintain the soft tissue tautness of carpal structures. CT examination of the carpal joint was performed within 4 hours after cattle were slaughtered. The limbs underwent consecutive CT scan in helical fashion in a proximal to distal direction, with slice thickening of 1 mm, using TOSHIBA 600 HQ (third generation equip TCT). CT scan was carried out at Ahmed Farid radiology Center-Benha.

RESULTS

Radiographic Examination: The bony structure of the carpal region of Friesian cattle consisted of the distal extremity of the radius, carpal bones (radial, intermediate, ulnar, accessory, fourth and fused second and third carpal bones) and the proximal extremity of the fused third and fourth metatarsal bones (Fig. 1A&B).

The computed tomography (CT): By use of the computed tomography bone window settings, all bone structures including radial, intermediate, ulnar, accessory, fourth and fused second and third carpal bones and the proximal extremity of the metacarpus were seen on the transverse CT images (Fig. 1C&D). The carpal bones had smooth

outline and homogenous contours. The inter-carpal transverse bone relations could be evaluated throughout the CT images. An important finding of this study was that the entire images had excellent delineation between the cortex and medulla of the bones.

Ultrasonography: The longitudinal ultrasonographic scanning of the common digital extensor tendon (CDET) and the extensor carpi radialis tendon (ECRT) was performed on the dorsolateral (CDET) and dorsomedial (ECRT) aspects of the carpal joint. Both tendons appeared as parallel linear hyperechoic structure. ECRT size was larger than CDET (Fig.2A). The transverse image of the common digital extensor tendon (CDET) and the extensor carpi radialis tendon (ECRT) appear ultrasonographically as an elliptical to oval echogenic in shape structure and ECRT had a large size than CDET (Fig. 2B.).

The ultrasonographic examination of the carpal joints revealed that the synovial fluid appeared as a small anechoic area surrounded by hyperechoic capsule (Fig. 3).

The ultrasonographic examination of the bone surfaces of the radius, ulna, the carpal and metacarpal bones were imaged as smooth linear hyperechoic contours showing acoustic shadowing distally.

The joint spaces of the dorsal aspect of the carpus appeared as clearly defined interruption of the bone surface (Fig.3). The joint spaces could be imaged simultaneously during examination of the CDET and ECRT. The boundaries of the joint pouches of radiocarpal, intercarpal and carpometacarpal joints could be identified. However at the level of the joint space, the dorsal pouches were appeared as small, triangular anechoic area.

The medial collateral ligament was depicted as a large, highly echogenic band in the transverse and longitudinal imaging planes (Fig.4A). The lateral collateral ligament appeared as a small, irregular shape echogenic band located caudomedial to lateral digital extensor tendon (Fig.4B).

The ultrasonographic examination of the carpus region proximal to the level first row from the palmo-medial aspect screening the median artery and vein were characterized as tubular or band shaped anechoic structures, located side by side, closer to the accessory carpal bone and adjacent to the medial margin of the deep part of the superficial digital flexor tendon (Fig. 4C&D).

The superficial digital flexor tendon consists of a superficial part and deep parts running through the carpal canal. It appears oval with curved edges to its medial, lateral and palmar aspects, and is relatively flat dorsally where it contacts the deep digital flexor tendon. The deep digital flexor tendon is a rounded and more echogenic structure. It is always thicker laterally than medially (Fig. 4D).

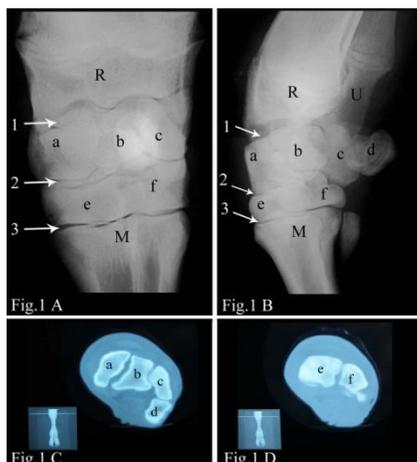


Fig. 1: Radiography ,(Dorsopalmer (A) and . Latero-medial (B) radiograph) and transverse CT images at the level indicated in the scout film (C&D) of the left Friesian cattle carpus . R, distal epiphysis of the radius U, distal epiphysis of the ulna; M, Metacarpal bone; a, Radial carpal bone; b, intermediate carpal bone; c, ulnar carpal bone; d, accessory carpal bone; e, fused second and third carpal bones; f, fourth carpal bone. 1, antebrachiocondylar joint, 2, intercarpal joint, 3, carpometacarpal joint.

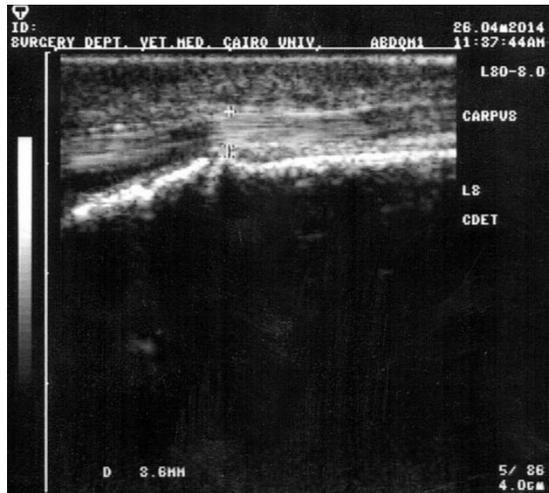


Fig. 2 A

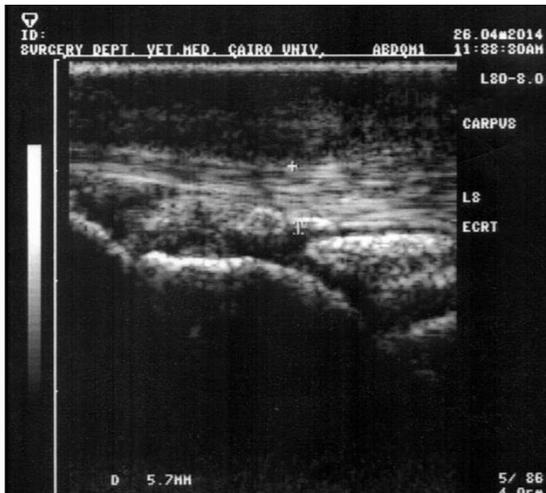


Fig. 2 B

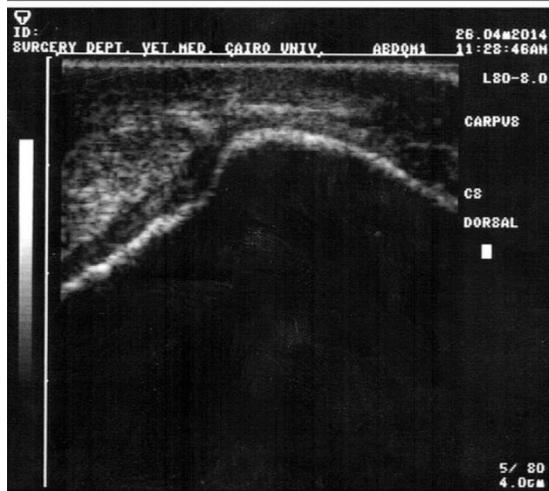


Fig. 2 C

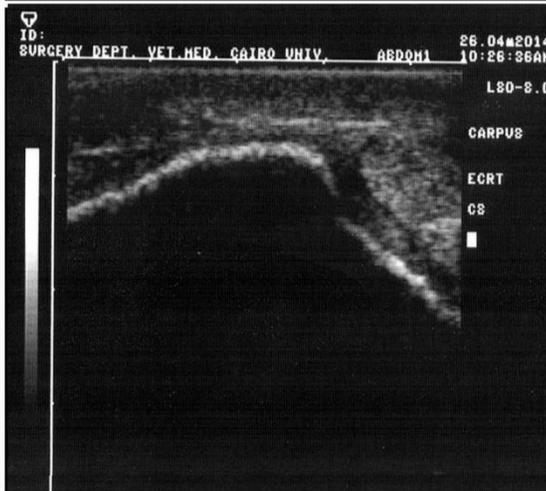


Fig. 2 D

Fig. 2: Longitudinal ultrasonogram of the Common digital extensor tendon CDET (A) and extensor carpi radialis tendon ECRT (B) and Transverse ultrasonogram of the Common digital extensor tendon CDET (C) and extensor carpi radialis tendon ECRT (D) .

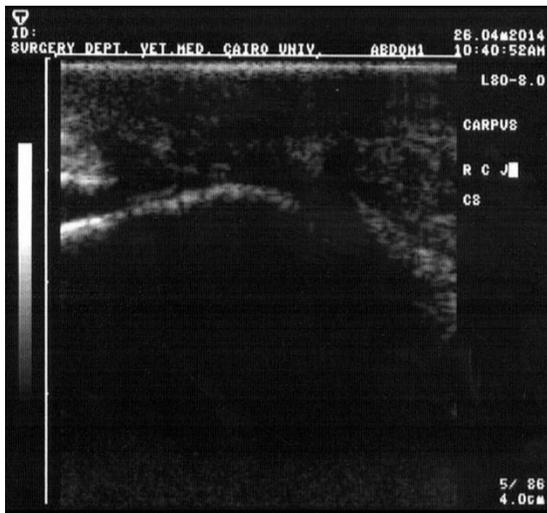


Fig. 3 A

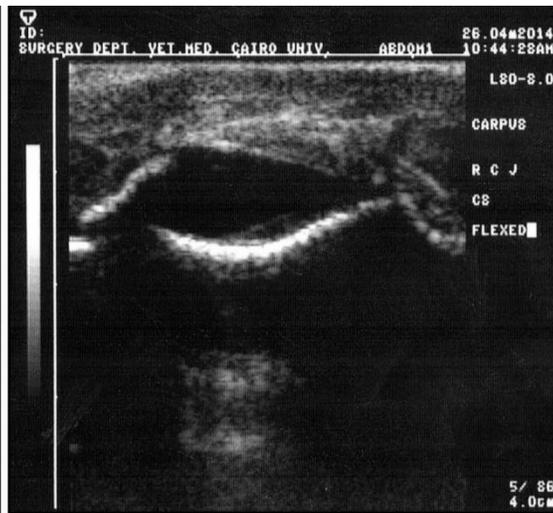


Fig. 3 B

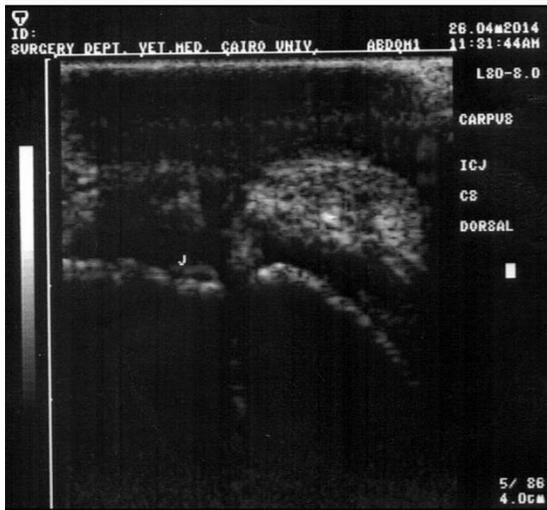


Fig. 3 C

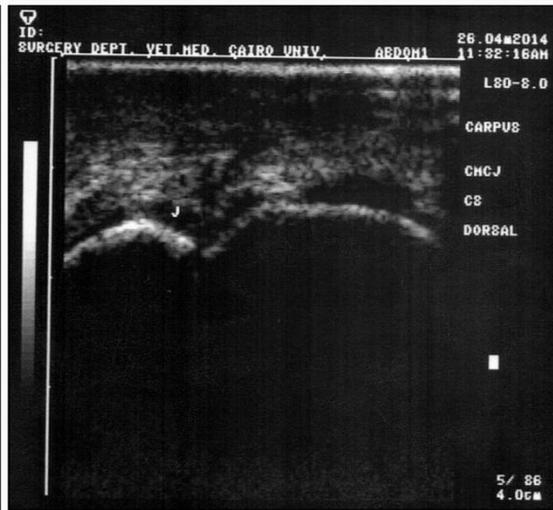


Fig. 3 D

Fig. 3: Transverse ultrasonogram of the carpal joint "radiocarpal joint RCJ nonflexed (A), flexed (B), intercarpal joint ICJ (C) and carpometacarpal joint (D)" .

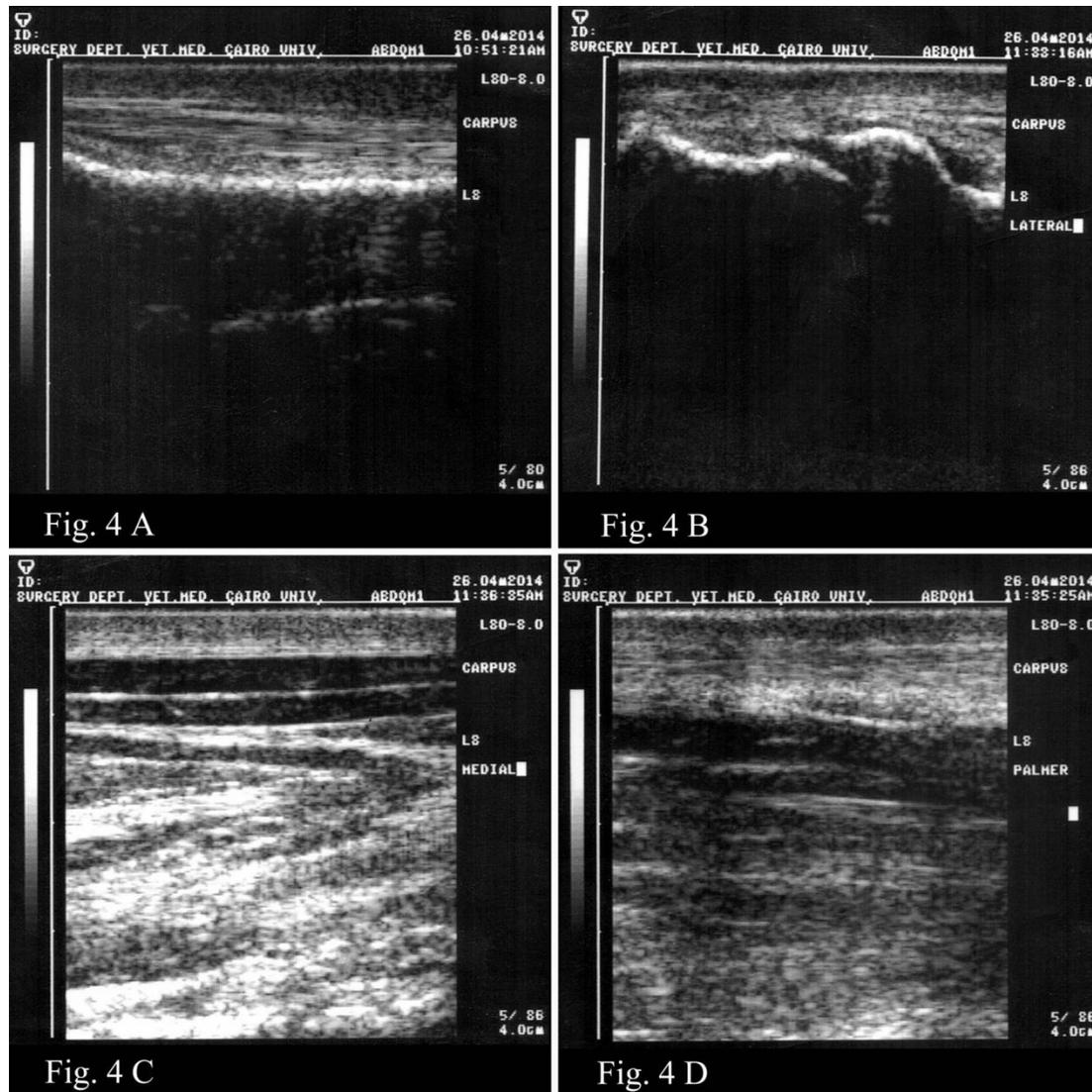


Fig. 4: Transverse ultrasonogram of the medial collateral ligament (A), lateral collateral ligament (B) and longitudinal ultrasonogram of the carpal canal, at the medial aspect (C) palmar aspect of the carpus region (D).

DISSCUSSION

The knowledge of normal structure of the carpal region of the cattle by means radiography, CT and ultrasonography is essential for examination of these compositions, for estimation of the healthy status of the carpal joint and aid to appraisal the diseased condition of the joint. The results of the present study provides the normal radiographic and ultrasonographic appearance as well as a detailed CT reference of the bony and soft tissue structures of the Friesian cattle carpus to develop an optimal technique for examination of these structures to serve as a reference for evaluation of carpal pathology. These results agree with Kofler, 2000; Kassab, 2008 ; Hagag, 2013).

Lameness in animals leads to loss of production in beef and dairy cattle (Dirksen, 1994; Munroe & Cauvin, 1994; Geishauser, 1996; Kofler, 1997; Weaver, 1997). The physical examination and radiography are currently the most common diagnostic techniques for evaluation of lameness. Radiography remains the foundation stone of diagnostic imaging technique for the evaluation of the musculoskeletal disorders, but the major disadvantage of a superimposition of bony structures and lack of differentiation of soft tissues (Kraft and Gavin, 2001; Latorre et al.,

2006; Park et al., 1987). CT has become a well-established diagnostic imaging modality for the evaluation of musculoskeletal disorders (Vallance et al., 2012). CT of the carpus had been studied in horse (Kaser et al., 1994). Until now a reference for the normal CT anatomy of the Friesian cattle carpus has not been reported.

The ultrasound has many advantages as it is non-invasive, non-irritating, fast, and relatively inexpensive and provides good visualization of the soft-tissue structures of the joint. Its major disadvantage is that the information acquired from the examination is highly operator-dependent and requires experience and a thorough knowledge of the joint constructive.

In the present study, an 8-MHZ transducer allowed better resolution of all examined anatomic structures, similar to those horses (Tnibar et al., 1993), sheep (Macrae and Scott, 1999) and camel (Kassab, 2008). The transverse images are most useful because some extensor tendons are side by side for much of their length and cannot readily be distinguished by longitudinal images.

Carpal tendons and ligaments in Friesian cattle have a homogenous echogenic texture; similar findings were reported in cattle (Flury, 1996; Kofler, 2000) and for tendons in horses (Tnibar et al., 1993; Mettenleiter, 1995). Most of the extensor and flexor tendons in the cattle are clear and can be easily imaged over the distal radius, the carpus and the proximal metacarpus. Easily identified structure landmarks provide useful aid for the examination of these tendons.

The superficial digital flexor tendon and deep digital flexor tendon have similar echogenicities, although the deep digital flexor tendon is sometimes more echogenic, which is in agreement with that observed in horses (Cuesta et al., 1995). The joint capsule and synovial fluid were not identified because of the lack of joint distention and very thin joint capsule in normal joints. These findings are in agreement with previous ultrasonographic studies of the joints of dogs (Reed et al., 1995), horses (Penninck et al., 1990) and cows (Kofler, 2000). On the other hand, joint troubles could be easily identified by ultrasonographic examination because the condition to be distinguished characterized by thick joint capsule and synovial accumulation.

Conclusion:

The objective of this study was to define the normal ultrasonographic appearance of the structures of the carpal region in healthy Friesian cattle as well as to state the normal radiography and CT of the same region in order to establish clinically relevant reference data for diagnosis and prognosis of carpal bone and soft-tissue injuries.

Contribution of each author

All authors are equally contributed

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