



Research Article

Ultrasonographic Anatomy of the Equine Carpal Region (*Equus caballus*)

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ABSTRACT

The present study was conducted to describe the normal sonographic anatomy of the carpal region in ten clinically healthy drought stallions. Longitudinal and transverse scans were taken on the different aspects of carpal region using 10 MHz linear probe. Five cadavers were subjected to a fine anatomical dissection, latex injection for joint capsule and cross anatomical sections were also done using bone saw at three levels (distal radius, middle carpal joint and proximal metacarpal). Extensor carpi radialis and common digital extensor tendons were observed at the distal radius, dorsal aspect of carpus and proximal metacarpus. Lateral collateral ligament, medial collateral ligament, superficial and deep digital flexor muscles and tendons were identified easily in both anatomical dissection and ultrasonographic examinations, while lateral digital extensor, extensor carpi obliquus tendon, dorsal and palmar intercarpal ligaments were seen during anatomical dissection but difficult to recognize by ultrasound. Anatomical and ultrasonographic investigations of the carpal region in drought horses provide reference for carpal evaluation and prognosis against different carpal affections.

Key words: Equine, Anatomy, Ultrasonography, Arthrology, Carpal Region

INTRODUCTION

The carpal region is a complex region with numerous anatomical structure included carpal bones, synovial structures, ligaments, tendons and muscles (Getty, 1975; Dyce *et al.*, 2010).

Carpal affections were commonly diagnosed in equine practice. Lameness associated with carpal disorders may arise from different pathological changes associated with tendinous, muscular, ligamentous and joint structures included within the carpal region (Magnusson and Ekman, 2001; Malone *et al.*, 2003; Vaughan *et al.*, 2014 and Whitcomb, 2014; Shields *et al.*, 2015; Jorgensen *et al.*, 2015).

Ultrasonography became an integral role in the routine examination of the carpal joints (Redding, 2001a,b and Whitcomb, 2008) in equine, (Macrae and Scott, 1999) in sheep, (Kofler, 2000) in cattle and (Kassab, 2008) in camel.

The aim of the study was to correlate between anatomical dissection and ultrasonographic examination of the carpal region of equine. This correlation facilitates the carpal assessment for beginners and practitioners.

MATERIALS AND METHODS

Anatomical study

The anatomical study was done at carpal region in five normal fore limbs isolated from shoulder joint. Three fresh specimens were finely dissected and the anatomical findings were recorded. Cross anatomical sections were applied in two fresh specimens at three levels by using bone saw. The proximal section was applied at the level of the distal extremity of radius, the second one was done at the level of the mid-carpal joint and the last one was done at the proximal extremity of metacarpus. These anatomical sections were compared with the corresponding ultrasonography.

Latex injection was applied in two fresh cadavers for determining the extension of joint capsules within the carpal region. The needle was inserted into the radio-carpal joint cavity in the dorsal aspect at the midway between the extensor carpi radialis tendon and the common digital extensor tendon. Gum milk latex colored blue with Rotring ink was injected in the radio-carpal joint. The mid-carpal joint cavity was injected with red gum milk latex. The obtained results were photographed using Nikon digital camera 12.1 mp, 0.7x.

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Ultrasonography study

Ultrasonographic study was applied on five clinically normal drought stallions of various ages (5-9 years old) and weight (300-450 kg). These stallions were admitted to Surgery, Anaesthesiology and Radiology Department, Faculty of Veterinary Medicine, Cairo University. The hair over the carpal region of both right and left forelimbs of the horses were clipped and shaved, and followed by an acoustic coupling gel was applied. Scanning was performed using 10 MHz linear probe (Toshiba just vision 200, Japan) with displayed depth 4-6 cm. Ultrasonographic scanning was done with the animal fully weight-bearing. Ultrasonographic examination of the carpal joint was performed in a systematic manner including dorsal, lateral, medial and palmar aspects of the joint (Whitcomb, 2014). All the structures were examined in both longitudinal and transverse scans.

RESULTS

The anatomical dissection and ultrasonographic examinations of the carpal region were done in a systematic manner. The carpal region was divided into dorsal, lateral, medial and palmar regions. The palmar region alienated into two regions proximal and distal to the accessory carpal bone.

The dorsal aspect of carpal region

The dorsum of the carpal region supported by the extensor retinaculum, which represented by a loose fibrous sheath covering the fibrous layer of the carpal joint capsule, it sheltered dorsolaterally allowing the passage of the ligaments of the extensors muscles and connected with the two collateral ligaments from every two sides (Fig. 1A).

The tendon of the extensor carpi radialis (ECR) was a broad large tendon, passed along the middle dorsal aspect of the carpal region to be inserted into the metacarpal tuberosity (Fig. 1, 2). ECR tendon appeared ultrasonographically as a homogenous echogenic structure with linear fiber pattern extends over the carpal joints in longitudinal scans (Fig. 2). It appeared as oval echogenic structure with thin anechoic fluid represent the tendon sheath in the transverse scans at distal radius and at the level of radio-carpal joint (Fig. 4E).

The common digital extensor (CDE) tendon was passed along the dorsolateral aspect of the carpal region (Fig. 1, 2). It appeared ultrasonographically as homogenous echogenic structure extended at dorsolateral aspect of the carpus (Fig. 1, 2). It appeared as flattened oval echogenic structure proximal to the distal radius (Fig. 4D). The tendon sheath appeared as thin anechoic fluid around the tendon (Fig. 1).

The joint capsule (JC) was fibrous layer covered the joint cavity, attached at the distal end of the radius, until reach to the proximal end of the metacarpus, more adherent to the carpal bones and the middle carpal ligament (Fig. 1). The synovial membrane formed three synovial sacs corresponding to each joint, the radio-carpal sac was the largest sac in its volume, followed by the middle carpal sac, which placed between the two rows of carpal bones, extended proximally and distally, this sac communicated with the carpo-metacarpal sac (Fig. 9A)

through the distal extension between the third and fourth carpal bone. The (JC) appeared ultrasonographically as hypo echoic joint capsule caudal to the echogenic fibers of the ECR with anechoic synovial fluid. The radio-carpal joint, middle carpal joint and carpo-metacarpal joints were been easily identified ultrasonography (Fig. 2).

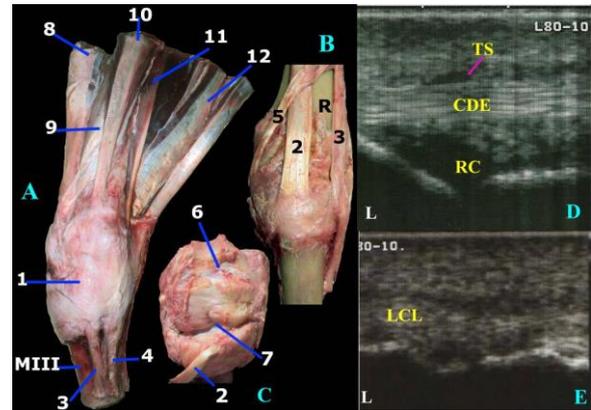


Fig. 1: A photograph showing the left carpal region of the horse. A- The anatomical dissection of the dorsolateral surface, B- The anatomical dissection of dorsal carpal region, C- Joint capsule, D- Longitudinal scan (LS) of the dorsolateral aspect of the carpus, E- Longitudinal scan of the lateral carpal region. 1- Extensor retinaculum, 2- Tendon of extensor carpi radialis, 3- Tendon of common digital extensor, 4- Tendon of lateral digital extensor, 5- Tendon of extensor carpi obliquus, 6- Radio-carpal joint capsule, 7- Middle carpal joint capsule, 8- Extensor carpi radialis M., 9- Extensor carpi obliquus M., 10- Common digital extensor M., 11- Lateral digital extensor M., 12- Ulnaris lateralis M. CDE- Common digital extensor, LCL- Lateral collateral ligament, RC- Radio-carpal joint, TS- Tendon sheath.

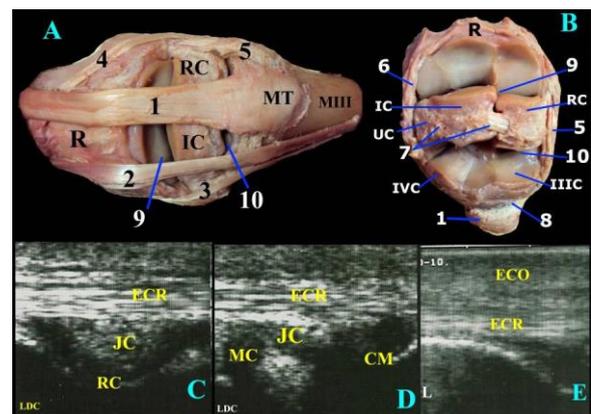


Fig. 2: A & B- photograph showing the anatomical dissection of dorsal region of the right carpal joint. C, D & E- Longitudinal scans of the dorsal aspect of the carpal region. 1- Extensor carpi radialis tendon, 2- Common digital extensor tendon, 3- Lateral digital extensor tendon, 4- Extensor carpi obliquus tendon, 5- Medial collateral tendon, 6- Lateral collateral ligament, 7- Dorsal intercarpal ligaments, 8- Dorsal carpo-metacarpal ligaments, 9- Radio-carpal joint cavity, 10- Middle carpal joint cavity. ECR- Extensor carpi radialis tendon, ECO- Extensor carpi obliquus tendon, JC- Joint capsule, RC- Radio-carpal joint, MC- Middle carpal joint, CM- carpo-metacarpal joint. R- Radius, RC- Radial carpal bone, IC- Intermediate carpal bone, UC- Ulnar carpal bone, IIC- Third carpal bone, IVC- Fourth carpal, MT- Metacarpal tuberosity, MIII- Third metacarpal bone.

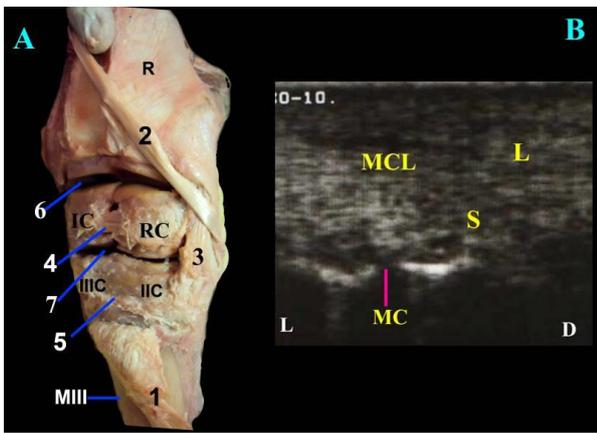


Fig. 3: A photograph showing the right carpal region. A- Medial view, B- Longitudinal scan of Medial carpal region. 1- Tendon of extensor carpi radialis, 2- Tendon of extensor carpi obliquus, 3- Medial collateral ligament, 4- Dorsal middle carpal ligament, 5- Dorsal carpometacarpal ligament, 6- Radiocarpal joint cavity, 7- Middle carpal joint cavity, MCL- Medial collateral ligament, MC- Middle carpal joint, S- Short fibers, L- Long fibers, RC- Radial carpal bone, IC- Intermediate carpal bone, IIC- Second carpal bone, IIC- Third carpal bone, MIII- Third metacarpal.

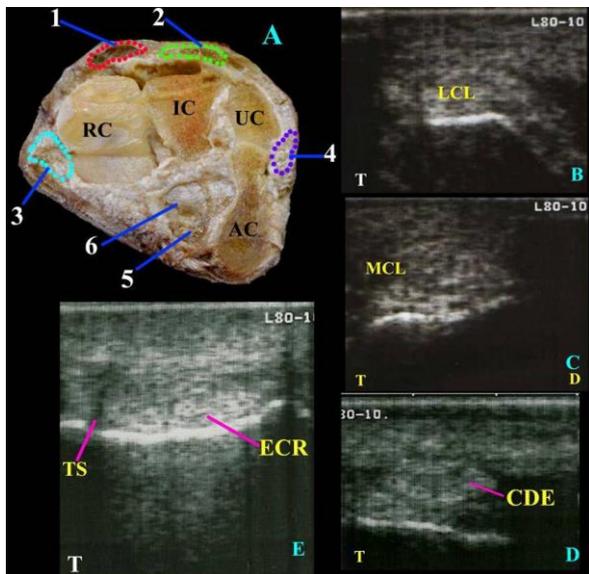


Fig. 4: A photograph showing structures within carpal region. A- Cross section at the proximal extremity of metacarpus, B- Transverse Scan (TS) of the lateral collateral ligament, C- TS of the medial collateral ligament, D- TS of common digital extensor tendon, E- TS of extensor carpi radialis tendon. 1- Tendon of extensor carpi radialis, 2- Tendon of common digital extensor, 3 - Medial collateral ligament, 4- Lateral collateral ligament, 5- Superficial digital flexor tendon, 6- Deep digital flexor tendon, LCL- Lateral collateral ligament, MCL- Medial collateral ligament, ECR- Extensor carpi radialis tendon, EDE- Common digital extensor tendon, TS- Tendon sheath, RC- Radial carpal bone, IC- Intermediate carpal bone, UC- Ulnar carpal bone, AC- Accessory carpal bone.

The dorsal intercarpal ligaments were horizontal short ligaments, distributed in between the carpal bones, all over the dorsal surface (Fig. 2/7). The carpometacarpal ligaments were two oblique ligaments, inserted between third carpal bone and third metacarpal one (Fig. 2/8). The dorsal intercarpal and carpometacarpal ligaments were difficult to be identified by ultrasonography.

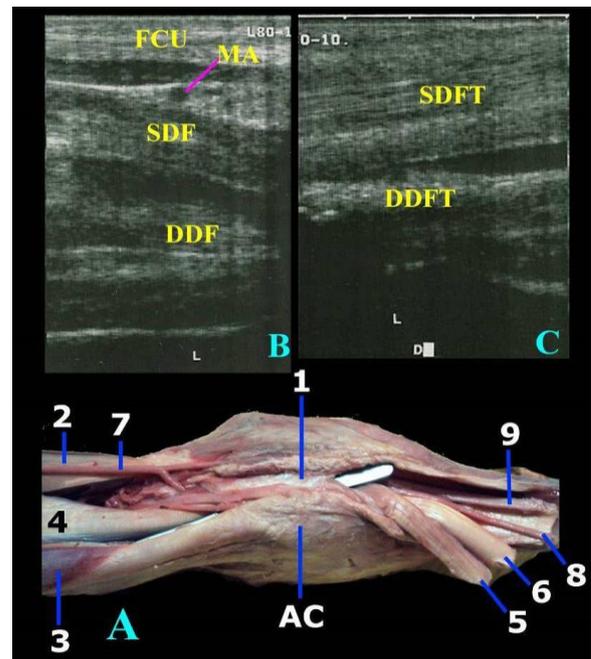


Fig. 5: A photograph showing the palmar surface of the carpal region in the horse. A- Carpal canal, B- Longitudinal scan proximal to accessory bone, C- Longitudinal scan distal to accessory carpal bone. 1- Flexor retinaculum, 2- Extensor carpi radialis M., 3-Flexor carpi ulnaris M., 4- Superficial digital flexor M., 5- Superficial digital flexor tendon., 6- Deep digital flexor tendon, 7- Median A., 8- Medial palmar A., 9- Medial palmar N., FCU- Flexor carpi ulnaris M., SDF- Superficial digital flexor M., DDF- Deep digital flexor M., SDFT- Superficial digital flexor tendon, DDFT- Deep digital flexor tendon.

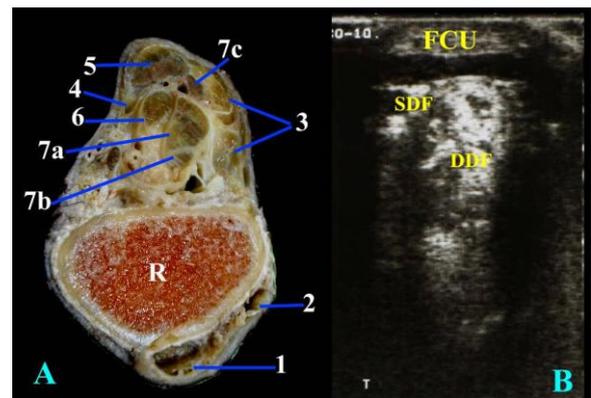


Fig. 6: A photograph showing the structures within the carpal region. A- Cross section at the level of the distal extremity of radius, B- Transverse scan proximal to accessory carpal bone. 1- Extensor carpi radialis M., 2- Common digital extensor M., 3- Ulnaris lateralis M., 4- Flexor carpi radialis M., 5-Flexor carpi ulnaris M., 6- Superficial digital flexor M., 7- Deep digital flexor M., 7a- Humeral head, 7b- Radial head., 7c- Ulnar head, MA- Median A., FCU- Flexor carpi ulnaris M., SDF- Superficial digital flexor M., DDF- Deep digital flexor M, R- Radius.

The lateral carpal region included mainly the lateral collateral ligament (LCL), that extended from the lateral styloid process proximally and inserted distally into to the ulnar, fourth carpal by deep fibers and to the third, fourth metacarpal bones by superficial fibers (Fig. 2B, 9B). LCL appeared ultrasonographically as a thin echogenic band in longitudinal scans (Fig. 1) and as a small flattened echogenic structure in the transverse scan (Fig. 4B).

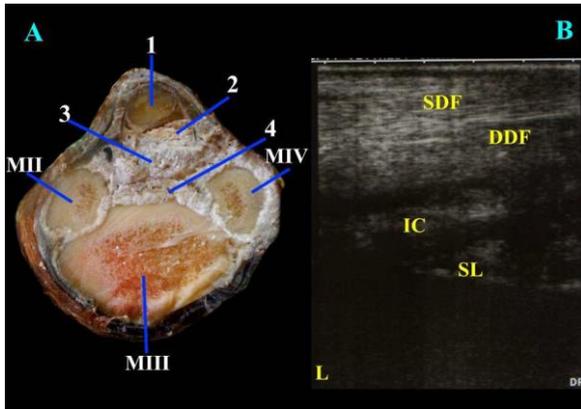


Fig. 7: A photograph showing the palmar surface of the carpal region distal to accessory bone in the horse. A- Cross section at the level of the proximal extremity of metacarpus, B- Longitudinal scan at the same level. 1- Superficial digital flexor tendon, 2- Deep digital flexor tendon, 3- Inferior check ligament, 4- Suspensory ligament, SDF- Superficial digital flexor tendon, DDF- Deep digital flexor tendon, IC- Inferior check ligament, SL- Suspensory ligament, MII- Second metacarpal, MIII- Third metacarpal, MIV- Fourth metacarpal bone.

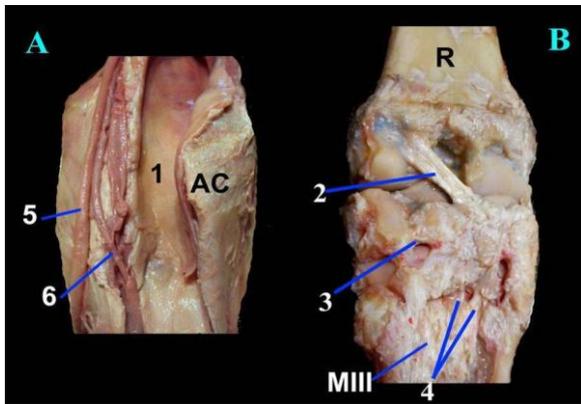


Fig. 8: A photograph showing the anatomical dissection of the palmar surface of the carpal joint in the horse. A- Common palmar ligament, B- Palmar carpal region after removal of the common palmar ligament. 1- Common palmar carpal ligament, 2- Radio-carpal ligament, 3- Palmar middle carpal ligament, 4- Palmar carpometacarpal ligament, 5- Medial palmar A., 6- Medial palmar N, R- Radius, AC- Accessory carpal bone, MIII- Third metacarpal bone.

The medial carpal region included the tendon of extensor carpi obliques (ECO) which passed diagonally through the medial extensor groove on the radius, until reached to the medial aspect of the carpal region (Fig. 1, 2, 3).

The medial collateral ligament (MCL) was seen as a thick strong fibrous ligament attached to the medial styloid process proximally and inserted by long fibers in the proximal extremity of the second and third metacarpal bones distally, and by short fibers to the radial carpal and second carpal bones (Fig. 2, 3). MCL appeared ultrasonographically as a thick echogenic band with more linear fiber pattern at its origin on the distal radius with irregular fiber pattern at its distal half, also the long and short fibers of the MCL were easily identified in the longitudinal scan (Fig. 3). It appeared as a flattened oval echogenic structure in the transverse scans (Fig. 4C).

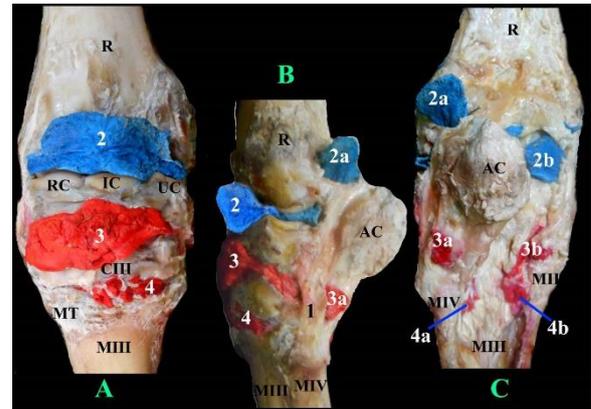


Fig. 9: A photograph showing the left joint capsule injected with colored latex. A- Dorsal view, B- Lateral view, C- Palmar view. 1- Lateral collateral ligament. 2- Radio-carpal sac, 2a- Lateral palmar sac of radio-carpal sac, 2b- medial palmar radio-carpal sac, 3- Middle carpal sac, 3a- Lateral palmar sac of middle carpal sac, 3b- Medial palmar sac of middle carpal sac, 4- Carpometacarpal sac, 4a- Lateral palmar extension of carpo-metacarpal sac, 4b- Medial palmar extension of carpo-metacarpal sac. R- Radius, RC- Radial carpal bone, IC- Intermediate carpal bone, UC- Ulnar carpal bone, AC- Accessory carpal bone, IIC- Third carpal bone, MT- Metacarpal tuberosity, MII- Second metacarpal, MIII- Third metacarpal, MIV- Fourth metacarpal bone.

The palmar carpal region

The structures were sited proximal to the accessory bone; the superficial digital flexor (SDF) muscle and the humeral, radial, ulnar heads of the deep digital flexor (DDF) muscle (Fig. 5A, 6A). Moreover, the palmar extensions of the radio-carpal joint capsule were the lateral and medial parts (Fig. 9C). The SDF muscle appeared ultrasonographically as a heterogeneous echogenic structure with mixed anechoic band and echogenic bands while, the DDF muscle appeared heterogeneous echogenic structure with its four heads (Fig. 5B).

The structures placed distal to the accessory bone; the lateral and medial extensions of both middle carpal and carpometacarpal joint sacs (Fig. 9C).

The carpal canal was surrounded dorsally by the common palmar ligament, laterally by accessory carpal bone and palmaromedially by flexor retinaculum. It enclosed the superficial, deep digital flexor tendons, medial palmar artery and nerve. The flexor retinaculum (Transverse palmar carpal ligament) was thick fibrous layer covering the palmaromedial surface of the joint leading to complete closure to the carpal canal (Fig. 5A). The common palmar carpal ligament was a thick broad fibrous layer of the joint capsule, it considered the dorsal boundary of the carpal canal and it was tightly attached to the carpal bones palmarly (Fig. 8A).

The radiocarpal ligament, palmar intercarpal ligaments were inserted between the palmar surfaces of the carpal bones (Fig. 8B). The palmar carpometacarpal ligament located between the palmar surface of the third carpal bone and proximal palmar aspect of the metacarpus (Fig. 8B).

The distal palmar structures at the level of carpometacarpal joint were the SDF and DDF tendons that appeared ultrasonographically as echogenic structures with homogeneous linear pattern within the carpal canal (Fig. 5C).

DISCUSSION

The carpal joint of horse was investigated from both anatomical and ultrasonographic aspects giving detailed findings of the different carpal structures. This study was a complementary study of previous studies conducted on the carpal joint. The correlation between the normal anatomical and ultrasonographic study supplied the practitioners with a complete basic data about the carpal region.

The normal anatomy of the carpal region, including superficial and deep digital flexor muscles, tendons of extensors muscles, medial and lateral collateral ligaments, dorsal and palmar intercarpal ligaments, dorsal and palmar carpometacarpal ligaments, also the joint capsule in horse was described by Getty (1975) and Dyce *et al.* (2010).

Ultrasonography was a safe, non-invasive and valuable diagnostic tool for examination of carpal region soft tissue structures. In the current study, a 10 MHz linear probe gave a better resolution for different anatomical structures same findings were recorded by Tnibar *et al.* (1993) in the horse, Kofler (2000) in cattle and Kassab (2008) in the camel.

ECR and CDE tendons appeared as homogenous echogenic bands owing to tendentious nature which in agreement with Tnibar *et al.* (1993) and Mettenleiter (1995). There was small anechoic fluid around these tendons represented the tendon sheath and these findings were in the same line with Reef (1998) and Whitcomb (2008) in the horse.

The extensor carpi obliquus tendon was difficult to be detected by ultrasonography similar observation was detected by Kassab (2008) in the camel.

The medial collateral ligament was larger than the lateral collateral one. An irregular fibers pattern was recorded at the distal half of this ligament, which may be due to the different orientation of fibers at their insertion to the bones of the carpus and metacarpus in the horse (Whitcomb, 2008).

The fleshy part of SDF and DDF proximal to the accessory carpal joint was appeared as heterogeneous echogenic structure with anechoic areas within these structures which could be attributed to the muscular content and this in the same line with Whitcomb (2014) in the horse. The SDF and DDF tendons distal to the accessory carpal bone were appeared as homogenous echogenic bands due to their tendentious content which agreed with Tnibar (1993) and Whitcomb (2008) in the horse.

Joint capsules represented by three sacs radio-carpal, middle carpal and carpo-metacarpal joints. The joint capsule was easily detected ultrasonographically caudal to the ECR which in agreement with Whitcomb (2008) and Whitcomb (2014) in horse and disagreed with findings recorded in cattle Kofler (2000). The joint capsule of the radio carpal below the ECR appeared hypo-echoic which may be attributed to the fat cushion which observed at the dorsal aspect of the joint such a statement observed by Whitcomb (2014) in the horse.

The radio-carpal sac was the largest sac in its size, followed by the middle carpal sac and these findings were correlated with the ultrasonographic findings seen in

longitudinal scans at the dorsal aspect of carpus. These findings were in the same line with König (2005) in the horse and Alsafy *et al.* (2015) in the donkey.

The correlation between anatomical dissection and ultrasonographic procedures facilitate studying and examination the different carpal structures. Moreover, the normal anatomical and ultrasonographic findings provide reference images for beginners and practitioners.

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