Topographic Description of Metacarpal Tendons and Ligaments of Anatoly Donkey by Ultrasonography and Introducing a New Ligament

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ABSTRACT

Introduction: Topographic anatomy of the tendons and ligaments in healthy cases provides a normal atlas to diagnose abnormalities. The aim of this study was to provide ultrasonography description of the palmar tendons and ligaments of the Anatoly donkey.

Methods: The metacarpal regions of 6 healthy Anatoly donkeys were prepared for ultrasonography and divided to 6 levels (1a, 1b, 2a, 2b, 3a, 3b), each 3 cm long apart. For better description, 2 left and right forelimbs were anatomically studied too.

Results: All the structures started to appear with an acceptable contrast and visibility at 1b level. Echogenicity of deep digital flexor tendons (DDFT) from 2b level was hyperechoic to isoechoic compared to superficial digital flexor tendons (SDFT) and suspensory ligament (SL) from this level observed the branching area was hyperechoic in comparison to DDFT and SDFT; however MSL and LSL were hypoechoic compared to SDFT and DDFT. Also the inferior check ligament (ICL) and new discovered ligament (second superior check ligament) had been detected in both anatomical and ultrasonographic studies. There were not any echogenicity differences between right and left forelimbs.

Conclusion: Previous investigations have proved that there is no difference between the echogenicity of each ligament and tendon at different levels in the left and right limbs which was confirmed in the current study as well. The findings of our study are also highly compatible with the previous findings in horses regarding echogenicity and shape of the palmar tendons and ligaments. Generally it is assumed that transverse images provide a better image of tendons and ligaments.

Key Words:

Ultrasonography, Palmar Tendon and ligament, Anatoly donkey, Second superior check ligament

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1. Introduction

Equidae family typically support a greater proportion of their body weight with their forelimbs during steady state locomotion [1,2]. Diagnostic 2- dimensional ultrasonography of horses' tendons and ligaments was first introduced as an appropriate method for the evaluation of the morphological changes in the above structures by Rantanen in 1982 [3]. In 1986, Genovese et al. described the morphological features of the tendons and ligaments of the Thoroughbred and Standardbred breeds' horses [4]. Ultrasound, which is commonly used to diagnose suspensory ligament injury, can be used in the field too [5].

Anatoly donkey is a member of the ungulates, but there are no published data describing the ultrasonography of its forelimbs. The purpose of this study was to examine the possibility of ultrasonographic description of their palmar tendons and ligaments and preparing its standard reference. Also, we tried to describe the anatomic topography of palmar tendons and ligaments in this region.

2. Materials and Methods

All procedures involving the experimental use of animals were approved by the Animal Ethics Committee, a branch of the Research Council of the Veterinary School in Shahid Bahonar University, Kerman, Iran, and administered by the National Animal Ethics Advisory Committee.

Six healthy 5-7 years old Anatoly donkey with no clinical sign in their limbs were selected. The animals were not related to each other. Ultrasonography examination on the metacarpal region of the right and left forelimbs was performed under general anesthesia, with IV injection of acepromazine maleate (Santa Cruz Biotechnology, USA) at a dosage of 0.03 mg/kg body weight and xylazine hydrochloride 2% (Alfasan, Woerden-Holland) at a dosage of 0.27 mg/kg body weight. The lateral and the medial parts of the metacarpal region from the upper part of the lateral splint to the ergot were shaved after applying a generous amount of foam to the skin. The area was cleaned using alcohol to remove any epidermal fat depositions. The shaved area was divided to 6 levels (1a, 1b, 2a, 2b, 3a, 3b), each 3 cm long apart. The ultrasonography of the right and the left metacarpal regions was performed using a Pie Medical 100 Falco vet and an 8 MHz linear transducer. The above area was ultrasonographically examined in both transverse and longitudinal appearances with the same power, depth, and focus of the machinery. The detection of tendons and ligaments structures was done in comparison with the images of the anatomy and diagnostic imaging reference books [6,7]. Then, 2 donkeys were euthanized and their right and left forelimbs were dissected. At first the skin and superficial fascia and then deep fascia was removed. The carpal canal was opened at the palmar surface by cutting the flexor retinaculum to detect the tendons and structures passing from it. Finally tendons and ligaments at the palmar surface of the metacarpus were dissected and named from antebrachium to fetlock joint separately. Findings in this part were used to interpret the ultrasonographic images.

3. Results

Anatomical descriptions

The suspensory ligament took the form of a uniform ligament which passed between the two splint bones. This ligament was divided into 2 diverging branches which were inserted on the proximal concave abaxial surfaces of sesamoid bones. Each branch was extended a band obliquely medial and laterally to join the common digital extensor tendon on the dorsal aspect of the first phalanx.

Superficial digital flexor muscle was formed a strong tendon at the level of the carpal joint, where it combined with a strong fibrous band, accessory ligament or superior check ligament which originated from the caudomedial surface of the radius and blended with superficial digital flexor tendon (SDFT). It passed distally through the carpal canal to the palmar aspect of the metacarpus. SDFT is laid mediopalmar to the deep flexor tendon in the carpal region (Figure 1).

A second accessory ligament with strong collagenous band originated from the deep fascia of the palmar region at the level of the proximal one fifth of the mediopalmar surface of the metacarpus and joined to the SDFT at this side. We named it second accessory ligament of superior check ligament. It was as thick as the superior check ligament. A common tendon with SDFT was then formed at the upper quarter of the metacarpus which passed to the digits (Figures 1 and 2).

The deep digital flexor tendon (DDFT) passed over the flexor aspect of the carpus, medial to the accessory carpal bone. Distal to the carpal joint, this tendon became roundish and was in close relation with the SDFT. In the upper quadrant of the metacarpus, an accessory ligament or inferior check ligament, which was a continuation of the deep palmar carpal ligament after the carpal joint connected to it (Figures 1 and 2).

In the distal quarter of the metacarpus, above the gliding surface of the sesamoid bones, the superficial tendon enclosed the deep tendon in a ring-like cuff. The 2 tendons were thus closely related as they continued over the palmar aspect of the fetlock.

Ultrasonographic description

Transverse images

In the transverse images of the palmar region, the closest structure to the transducer goes to the top of the image and the most distant one, which is the palmar surface of the metacarpal region goes to the lowest part of the image.

Level 1a (1-3 cm under the carpal joint)

In this area no proper image was recorded.

Level 1b (3-6 cm under the carpal joint)

No full image of any structure was recorded, but some parts of the following structures were seen on the screen; skin, subcutaneous tissues, deep digital flexor tendon (DDFT), and superficial digital flexor tendon (SDFT). SDFT had a crescent shape with its thickness in the medial part. It seemed that SDFT tends to the medial part in comparison to the DDFT and the longitudinal axis. The echogenicity of SDFT was a little less than DDFT at this level. DDFT had a complete circular shape at this level and the width and the thickness of the tendons were almost the same. In the palmar region, SDFT and in the dorsal area, soft tissue and vascular space were observed with a higher echogenicity than SDFT. The inferior check ligament (ICL) had a homogeneous echogenic appearance and was the next most echogenic structure after the DDFT. The echo pattern of the ICL was unchanged from that of the SDFT and DDFT. As mentioned in the result, we detected a new ligament in the proximal region of the metacarpus that was named second accessory ligament of SDFT. This ligament showed a homogeneous echogenic appearance. The echo pattern of the second superior check ligament was similar to that of SDFT and DDFT. It means that the echogenicity of this ligament was the same as ICL (Figure 3).

Level 2a (6-9 cm under the carpal joint)

The observed structures from the top of the image were skin and the subcutaneous tissues, DDFT, SDFT, vascular and soft tissue space, SL, and the surface of the third metacarpal bone. SDFT had a crescent shape and was more significant at this level. The thickness of the tendon has increased and the thick part of the crescent shape was located medial to DDFT and the longitudinal axis of the limb. The echogenicity of this tendon was somehow less than that of DDFT at this level. DDFT was egg-shaped at this level and its width seemed to be wider than its thickness. In the palmar part, SDFT and in the dorsal part, vascular and soft tissue spaces were identified. The echogenicity of DDFT was somehow higher than that of SDFT just as the previous levels. Although the presence of suspensory ligament is obvious, no complete and describable image was recorded.

Level 2b (9-12 cm under the carpal joint)

All the structures were observable at this level too. Right from the top, skin and the subcutaneous tissues, SDFT, DDFT, vascular and soft tissue space, SL, and the surface of the third metacarpal bone were identified. SDFT had a crescent shape to some extent, and seemed to be located mostly toward the dorsal part of DDFT and

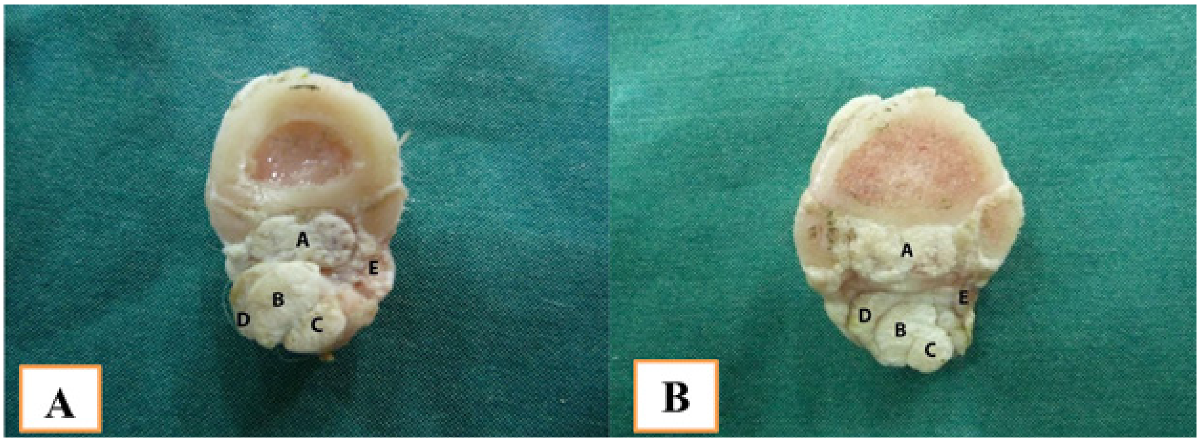

Figure 1. Cross sectional images from 2 different regions (A, B) of metacarpus. A: Suspensory ligament, B: DDFT, C: SDFT, D: Inferior check ligament, E: Second accessory ligament of SDFT.

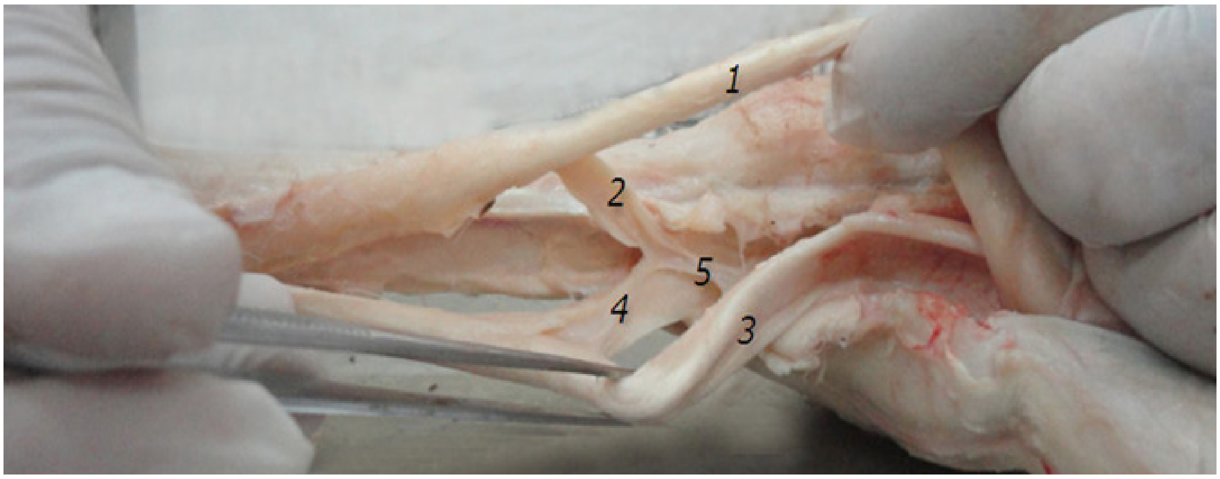

Figure 2. Ligaments that originate from deep fascia of palmar surface and join to superficial digital flexor tendon and deep digital flexor tendon in palmar view: 1) Superficial digital flexor tendon, 2) Second accessory ligament of superficial digital flexor tendon, 3) Deep digital flexor tendon, 4) Inferior check ligament, and 5) Deep fascia of palmar surface.

much less to the medial part. Echogenicity at this level was mostly isoechoic with DDFT. DDFT at this level apparently showed an increase in size with a circular and somehow isoechoic shape with SDFT. The space between DDFT and SL was reduced at this level. SL was more prominent at this level with a rectangular shape and its echogenicity was significantly higher than DDFT and SDFT, which seemed homogeny and steady as well. The echo of the third metacarpal bone appeared much more notable and hyperechoic (Figure 4).

Level 3a (12-15 cm under the carpal joint)

All the structures such as skin, subcutaneous tissues, DDFT, SDFT, vascular and soft tissue space, SL, and the surface of the metacarpal bone were fully observable at this level. SDFT appeared to be narrower, however its width showed no marked difference compared to its width at the previous level. It had a bracket shape with rather sharp edges. The echogenicity of this structure was less than DDFT. SL was observed clearly with limpid borders and a butterfly shape and a narrower width, which seemed to be close to the branching place of the ligaments. The

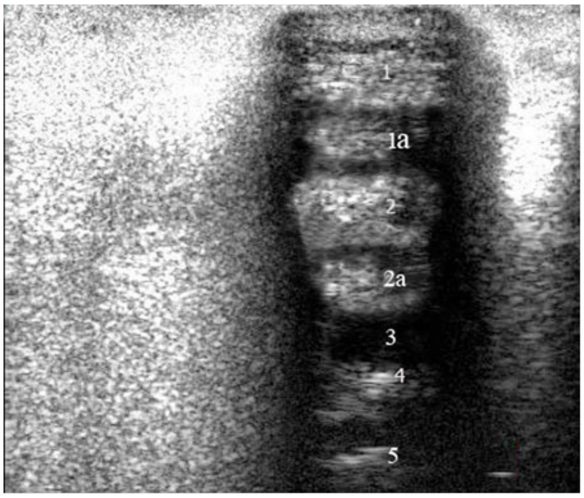

Figure 3. The observed structures from the top of the image were skin, subcutaneous tissues, SDFT (1), Second superior check ligament (1a), DDFT (2), ICL (2a), vascular and soft tissue space (3), SL (4), and the surface of the third metacarpal bone (5). Although the presence of suspensory ligament is obvious, no complete and describable image was recorded.

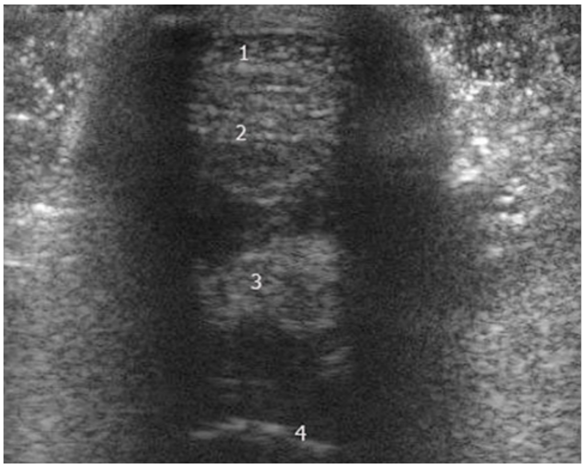

Figure 4. Right from the top, skin and the subcutaneous tissues, SDFT (1), DDFT (2), SL (3), and the surface of the third metacarpal bone (4) were identified. SDFT had a crescent shape to some extent and seemed to be located mostly towards the dorsal part of DDFT and much less to the medial part. Echogenicity at this level was mostly isoechoic with DDFT. SL (3) was more prominent at this level with a rectangular shape.

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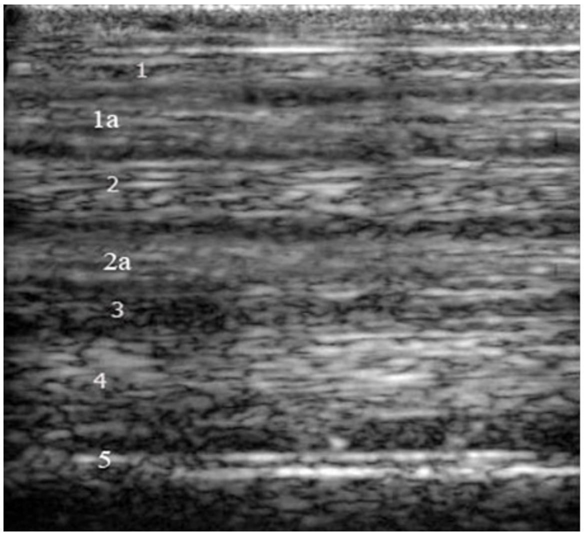

Figure 5. The longitudinal images at the level 1a: SDFT (1) and second superior check ligament (1a), DDFT (2) and ICL (2a) were close to each other in a way that the borders could not be recognized. Vascular and soft tissue space was hypoechoic with a lower echogenicity at the lower part which was completely identifiable (3). At this level, the suspensory ligament (4) was seen. The echo of the third metatarsal bone (5) was seen too.

echogenicity of this structure was a little higher than SDFT and DDFT.

Level 3b (15-18 cm under carpal joint)

This level was at the fetlock joint and the detectable structures were skin, subcutaneous tissues, DDFT, SDFT, dorsomedial and dorsolateral sesamoids, SL, and the echo of the third metacarpal bone. SDFT seemed narrower than previous level and had an increase in width in a way that extended to the sides of DDFT. Echogenicity was analogous to DDFT, which had an oval and elongated shape with an increase in width. On the sides and dorsal part of DDFT, 2 echogenic convex lines were identified which were due to the head of the dorsolateral and dorsomedial sesamoid bones causing the sound between the above structures. Also, dorsal to the DDFT, a rectangular and hyperechoic structure was recognized which was the palmar intersesamoid ligaments. On the lateral part of this ligament, a small echogenic area or line was observed that was related to the middle condyle of the third metacarpal. Other branches of SL were not observable at this level.

Longitudinal images

In these images, echogenic narrow and parallel lines are seen all over the longitudinal tendons and ligament structure which indicates the fibrous pattern of these structures. In the longitudinal images at level 1b, SDFT and second superior check ligament were so close to each other that sometimes the borders were not detectable. In these images, DDFT and ICL were also very close to each other (like previous ligaments). At these levels, vascular and soft tissue spaces were hypoechoic with a lower echogenicity and the SL border down the vascular and soft tissue space were fully observable. The surface of the third metacarpal bone was clearly detected as a hyperechoic line. In the longitudinal images and at the levels of 2a and 2b, DDFT and SDFT were close to each other in a way that the borders could not be recognized. Vascular and soft tissue space hypoechoic with a lower echogenicity at the lower part were completely identified. At this level, the suspensory ligament was interrupted at the branching place of the ligament. The rest of SL branches are not observable in the longitudinal view and in the middle of metacarpus. If the transducer is positioned longitudinally and leaned to the medial or lateral side of metacarpus, the branches of SL were observable which appeared echogenic and hemogenic. At the last level, the longitudinal view of SDFT and DDFT were seen and the metacarpal bone surface and the intercondylar process of the third metacarpal were observed as an echogenic line (Figure 5). All results were similar in right and left forelimbs.

4. Discussion

Diagnosis and treatment of lameness as one of the most important and common disorders in horses have always been requested from horse specialists. Before 1950s, the treatment of bones, joints, and tendon injuries was restricted to the use of blistering agents, heating the area, and taking some rest. However, the development of radiological techniques provided a prompt diagnosis of the bones and joints disorders. In this regard, the surgical procedures such as arthrotomy and arthroscopy as well as administration of the drugs such as nonsteroidal anti-inflammatory drugs and intra-articular steroids were useful and appropriate means in the treatment of the osseous and articular disorders.

Few investigations have been conducted on the tendons and ligaments of the horse limbs due to the difficulties in proper detection of tendon and ligament injuries. Then, the only diagnostic method was the veterinarians' skills in palpation of the structures. Although ultrasonography was primarily introduced as a means for diagnosis, it seemed to be efficient and helpful in evaluation, treatment, and follow up in the injured tendons and ligaments [8]. The safeness and practical nature of ultrasonography has made it a very reliable and valid way compared to other methods. Several studies have proved the correctness of the ultrasonographic inspections of the tendons and ligaments by comparing them with necropsy findings [9, 10]. In the present study, the echogenicity of DDFT at the 1b level was hyperechoic to isoechoic compared to SDFT and SL from the level observed the branching area was hyperechoic in compare with DDFT and SDFT. However, MSL and LSL were hypoechoic compared to SDFT and DDFT. Although the echogenicity of SL is anticipated to be lower due to the presence of muscular tissue, its increase may be a result of the tension induced by weight bearing pressure in a way that the collagen fibers are extended a little more which leads to increase in exposure of the sound waves resulting to an increase in echogenicity [11, 12].

The decrease observed in the echogenicity of MSL and LSL branches can be due to the oblique route of internal and external branches tending to the lateral part of the limb, which leads to a poor vertical exposure of the sound waves.

Investigations have proved that there is no difference between the echogenicity of each ligament and tendon at different levels in the left and right limbs which was confirmed in the current inspection as well [11, 13]. MacDiarmid (1995) believed that DDFT is more echogenic than SDFT [14]. Wood et al. (1993) concluded that SL is more echogenic than SDFT and DDFT in the transverse view and the brightness of DDFT and SDFT is equal in horses according to their observations over 1340 cases [11]. Genovese et al. (1986) announced that inferior check ligament had the highest echogenicity in the hindlimb structures and the echogenicity of DDFT and SDFT were almost similar. However, DDFT is somehow more echogenic [15]. Gillis et al. (1995) reported that the average echogenicity of SDFT is less than DDFT in horses in all metacarpal levels [13]. Sand (1998) believed in balance of the echogenicity of the DDFT and SDFT at 1b level; however, ICL was more hyperechoic than the above structures. They also reported that DDFT has a triangular shape at 1a level in transverse images and SL is more hyperechoic than DDFT and SDFT [16]. Cuesta et al. (1995) reported the sameness of DDFT and SDFT echogenicity; however, in some occasions DDFT showed a higher echogenicity than SDFT due to indefinite reasons [17].

The results of the current study on the Anatoly donkey were consistent with the previous investigations in horses on echogenicity and shape of the palmar tendons and ligaments. Generally, it is assumed that transverse images provide a better resolution of tendons and ligaments and any injury in any part of the above structures can be diagnosed easily; however, some probable injuries around the tendon may be left unseen in longitudinal images. No suitable images were provided in the present study in the upper part which can be due to the anatomical situation and shape of the area in a way that tendon structures are narrow and form a process on the limb with a cavity on the lateral side. Using a waterproof probe and performing the ultrasonography inside the water seems to be the solution, which can be studied in future investigations. All the structures started to appear with an acceptable contrast and visibility at 1b level.

In anatomy references, it has been mentioned that ICL is usually so narrow in the forelimbs that its ultrasonographic detection in both intact and injured conditions is difficult [18, 19]. It was similar to our findings in anatomy study. For a more precise study, comparing ICL with the structure in the opposite limb is suggested. Necropsy and looking closely at the structures as well as examination of their presence and size seem to be necessary for further investigations on Anatoly donkey. On the whole, the inspection of SL in the hindlimb is more difficult compared to the forelimbs because in the hindlimb the superficial tendons and SL are not as parallel and straight as they are in the forelimb. This condition leads to the forming of edge shadow artifacts of the upper structures on the SL. Besides, it seems that due to the irregular shape of the upper part of SL, a close comparison with the structure in the opposite limb is required to detect minor disorders [19].

According to our findings, suspensory ligament and its extensor branches in Anatoly donkey were similar to those of the horse. Inferior check ligament joins to the deep digital flexor tendon in the upper quadrant of the metacarpus while it is in the middle third of the metacarpus in the horse [18, 19]. Other properties of the deep digital flexor muscle and its tendon in the Anatoly donkey were similar to those in the horse [18, 19, 20].

Although properties of superficial digital flexor tendon in this study were similar to horse [18, 19], there is no report about the second accessory ligament of superficial digital flexor tendon. Apparently, this ligament has been developed in Anatoly donkey as a reinforcing ligament. It seems that, there is a specific morphological feature in Anatoly donkey that associates with running long distances and supporting more weight. On the other hand, this accessory ligament of the superficial digital flexor tendon, which is specifically found in this breed, can fix and support SDFT. The ICL is the third most frequently injured tendon or ligament structure in the forelimb. Desmitis of ICL is a common injury typically found in older horses or ponies. Enlargement of ICL will result in the reduction of the soft tissue gap between SL and ICL

[21]. It seems that because of the position of second superior check ligament, they are equally important.

Acknowledgments

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