



Some Morphological and Radiographical Studies on the Flexor Aspect Hind Foot in Buffalo

Safwat Ali

Department of Anatomy and Embryology, Faculty of Veterinary Medicine, Minia University, Egypt

ABSTRACT

Key words:

Ducks Buffalo,
Radiography,
Gross
Anatomy, CT
scan, Hind Foot

The general morphological features of the digital flexor tendons and the synovial sheaths associated with them were studied on thirteen hind feet of adult buffalo, after the injection of the sheath either by colored gum milk latex or by a radiopaque emulsion. Dissection has revealed that, the terminal tendons of both the superficial and deep digital flexor muscles enclosed in a complex common digital sheath. The more suitable sites for injection in the synovial sheaths of the flexor tendons were determined. Also this study extends to include the middle interosseous muscle and its connection with adjacent structures. Computed tomography scan were used to identify the bony and soft tissue structures of the metatarsus and digits. The obtained results were discussed with those recorded in other domestic animals.

Corresponding Author: Safwat Ali, asafawato@yahoo.com

1. INTRODUCTION

In old buffalos, whose milk has been dried, and that cannot be made to carry much flesh are much subjected to several complaint such palsy in which the hind foot are the parts which most frequently attached. The original evil said to be in foot, involving partial or total loss of motion of hind foot. The original evil said to be in foot, involving partial or total loss of motion of hind foot. Veterinary surgeons have lately adopted an admirable method of relieving the pain that the animals must otherwise endure from several disease of the foot. They cannot interfere without having full anatomical information on structures encountered in the foot of buffalo. (Kossaibati and Esslemont, 2000).

Exact knowledge of the topographical anatomy of the digital tendons and the synovial sheaths associated with them are of great importance, both to the surgeon and to the practitioner. However, the relevant publication has revealed that, the tendons and tendon sheaths of most domestic animals was described by various authors (Ereisha, 1982; Nielsin, 1968; Ottaway and Worden, 1940; Sisson and Grossmen, 1967; Seiferle et al., 1986), nothing cloud be traced on the corresponding

structure in the buffalo. The present work is therefore an attempt to give some information on the morphological features and topography of the flexors tendons and their sheaths and to define a suitable site for the injection of these synovial sheaths.

Moreover, the present work aimed to provide a guide for the anatomical structure and systemic evaluation of the hind foot of the buffalo by means of computed tomography (CT) scan which may be a useful noninvasive and offer several advantages over the conventional radiology.

2. MATERIALS AND METHODS

Work was done on fifteen freshly amputated hind feet of adult buffaloes five specimens were dissected to demonstrate the features of the various tendons that find its way into the plantar aspect of the digital region. The morphological features of the tendon sheaths were studied on the rest of the specimens.

Distension of the synovial sheathes of these specimens were carried out either by the injection of a radio-opaque barium sulphate suspension (2 specimens) or by the injection of colored gum

milk latex (3 specimens). Three more specimens were injected with barium sulphate suspension in saphenous artery to estimate the arterial blood supply.

For CT scan, two specimens were used. The limbs were underwent consecutive CT scan using CT scanner [TOSHIBA 600HQ, third-generation equip TCT, Japan] at Minia University Hospital, El-Minia, Egypt. The acquisition settings were 120 kv, 100 mA and 1.5 seconds, thickness of 3 mm. The images were started at the level of the distal third of the metatarsus and continuing distally in a row below the distal interphalangeal joint. The official nomenclature used in this study was adopted according to (Nomina Anatomica Veterinaria, 2012).

3. RESULTS

Dissection has revealed that, in the hind foot, the deep metatarsal fascia together with the ossa metatarsalia (III and IV) form the metatarsal canal (McLeod, 1958) which contains the tendons of the digital flexors, the interosseous medius, the vessels and nerves. Topographically the tendons of the digital flexors are divided into a superficial and a deep layer representing the superficial and deep digital flexor muscles respectively

Tendineum m. flexor digitorum superficialis:

The digital flexor tendon is represented in the hind foot of the buffalo by two tendons, superficial and deep, separated from each other by the deep layer of the metatarsal fascia. The superficial tendon follows a downward subcutaneous course between the two layers of the metatarsal fascia up to the middle of the metatarsus, where it perforates the deep fascia and blended with the deep tendon of the muscle.

On the other hand, the deep tendon of the muscle proceeded under the deep metatarsal fascia lodged in a special groove formed by the elevated plantar borders of the deep digital flexor tendon. Within the middle third of the metatarsus, the fibers of the superficial and deep tendon of the superficial digital flexor unite into a -short powerful uniform tendon. The latter tendon divided after a short distance proximal to the metatarso-phalangeal articulation into two diverging limbs, one for each digit (Fig. 1&2). Each of these branches; limbs, receives a strong tendinous band of the superficial part of the middle interosseous muscle as it

approached to the fetlock joint forming a tendinous canal; sleeve; through which the corresponding branch of the tendon of the deep digital flexor muscle passes up to the middle of the proximal phalanx. At this site, each branch divides into three fascicules, one central and two collaterals. The central fasciculus is the most powerful of the three fascicules and constitutes the main insertion of the muscle. Its fibers proceed down the dorsal aspect of the deep digital flexor tendon to terminate on the tuberositas flexoria on the plantar aspect of the middle phalanx blending with the plantar ligaments of the proximal interphalangeal joint. The collateral fascicule; axial and abaxial; diverge in a slight peripheral direction to terminate on the corresponding proximal protuberance on the side of the tuberosities flexoria.

Manica flexoria:

It was observed that just proximal to the metatarsophalangeal articulation that the superficial digital flexor tendon forms a ring like structure which wraps around the deep digital flexor tendon, this structure is know as manica flexoria (Fig. 1)

Tendineum m. flexor digitorum profundus:

The tendon of the deep digital flexor muscle is much thicker and stronger than that of the superficial digital flexor muscle. It passes down the plantar aspect of the metatarsal region between the deep tendons of the superficial digital flexor muscle plantarly and the middle interosseous muscle dorsally. About one fingerbreadth proximal to the metatarso-phalangeal articulation the deep flexor tendon was splits into two branches; one for each of the digit, each of these branches proceeds down the groove formed by the corresponding sesamoid bones and the metatarso-intersesamoidean ligament, then through the tube like cuff formed by the superficial flexor tendon and the middle interosseous muscle. Thereafter the tendon emerges between the terminal branch of insertion of the superficial flexor tendon, to continues its course down the flexor aspect of the middle phalanx and the distal sesamoid bone .Along its course, the tendon of the deep digital flexor muscle detaches some of fibers to the middle phalanx as well as to the interdigital ligament and it finally attached to the flexor tubercle of the distal phalanx of the corresponding digit (Fig. 1&2).

Fig.1: Diagrammatic representation of the superficial and deep digital flexor tendon in the hind foot of the buffalo. 1-Tendon of M.flexor digitorum superficialis, 2-Diverging limbs of (1), 3-Tendon of M. flexor digitorum profundus, 4-Insertion of (3), 5- M.interosseus medius

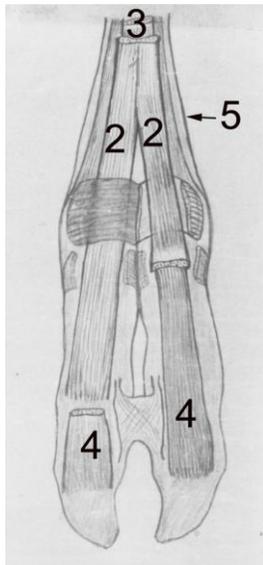


Fig . 2: Photograph of the hind foot of the buffalo, dissected plantar aspect, showing the course and termination of the superficial and deep digital flexor tendon 1- Superficial digital flexor tendon, 2- Deep digital flexor tendon, 3- M. interosseous medius,4- Manica flexoria. A- Os metatarsalis

Vaginae synovialis tendinum digitorum Pedis:

Examination of the tendon of the superficial and deep digital flexor muscles has revealed that the tendons of both muscles are enclosed in an extensive complex common digital sheath measuring about 8-10 cm.in length. It begins on a level about 1-2 cm proximal to the metatarsophalangeal articulation and enclose tendons of both the superficial and deep digital flexor muscles, along their course down the groove formed by the proximal sesamoid bones together with the tarso-intertesesamoidean

On distension, through an injection mass, the common digital synovial sheath herniates proximally, on the dorsal aspect of the deep digital flexor tendon as far as the junction between the middle and the distal two thirds of the metatarsus. Moreover, it forms four irregular pouches extending along the dorsolateral border of the flexor tendon. The largest and most proximal of these pouches lies within the distal fourth of the metatarsus, dorsolateral to the deep flexor tendon. On a level with the metatarso- phalangeal articulation a second pouch can be demonstrated dorsolateral to the superficial flexor tendon, occupying the interval between the superficial and deep portions of the middle interosseous muscle. It extends along the proximal border of the plantar annular ligament and encompasses the plantar aspect of the superficial flexor tendon. The third pouch is located on the abaxial side of the proximal interphalangeal joint, in The metatarsal bone as well as from the plantar tarsal ligament. Within the distal third of the

ligament, and the plantar aspect of the distal sesamoideam ligaments, to the interval between the terminal diverging fascicule of insertion of the two branches of the superficial digital flexor tendon at the middle of the proximal phalanx (1.5 cm distal to the proximal sesamoid bone).Thereafter the sheath continues distally, enclosing only the tendon of the deep digital flexor muscle up to the middle of the second phalanx , where it terminates in a blind diverticulae surrounding the enclosed tendon (Fig.3& 4).

the interval between the plantar annular ligament and the distal annular ligaments. The fourth pouch lies distal to the interdigital ligament being covered by the deep digital flexor tendon. From the aforementioned results , it may be deduced that the largest and most proximal of the four pouches , formed by the synovial sheath of digital flexor tendons ,is the preferred site for , injection into the sheath .About two fingers breadth proximal to the accessory digital (dewclaws) the needle is inserted in horizontal transverse direction for about 2 cm (Fig.3& 4).

M. interosseous medius:

Is represented by a well developed musculo-tendinous band deriving its origin from the distal row of the tarsal bones and the proximal part of the plantar aspect of metatarsal region, the middle interosseous muscle is resolved into two parts, superficial and deep.

The superficial part diverges caudally and joins the tendon of the superficial flexor muscle to form the Manica flexoria through which the deep digital flexor tendon passes down the metatarsus. Near the distal end of the metatarsus the deep part of the muscle splits into three branches, strong middle and two feeble collateral branches. The middle branch trifurcates into an interdigital and two peripheral portions. The two latter portions terminate on the abaxial sesamoid bones of both digits.

The majority of the fibers of the interdigital portion terminate on the apical parts of the axial sesamoid bones of the two digits, while the remaining fibers proceed through the proximal part of the interdigital space as the interdigital part of the middle interosseous muscle. The latter detaches few fibers to the articular capsule and the axial collateral ligaments of the metatarsophalangeal articulations then terminates into two bands, one for each digit. Each of these two bands terminates, on the dorsal aspect of the proximal phalanx, by joining the proper extensor tendon of the corresponding digit. Concerning the collateral branches of the middle interosseous muscle, it is observed that, the constituent of each branch can be resolved into two strata, superficial and deep. The shorter fibers of the deeper stratum terminate on the apical part of the abaxial sesamoid bone, while the longer fibers of the superficial stratum proceeds cranially to gain the dorsal aspect of the proximal phalanx where they join the lateral extensor tendon of the corresponding digit (Fig. 1-5). It may be relevant to point out that, the tendon of both digital flexor muscles together with the greater part of the synovial sheath enclosing them are bounded, throughout their course down the corresponding digit, by three retaining bonds. The proximal band is represented by the plantar annular or superficial metatarsal which retains the tendons of both flexor muscles within the groove formed by the sesamoid bones and the metatarsointer sesamoid ligament. The middle band is represented by the digital annular ligament, which retains also the tendons of both flexor muscles to the plantar aspect of the proximal phalanx. The distal band is represented by the distal interdigital ligament, which binds the tendons of the deep digital flexor muscle, only, to the plantar aspect of the middle

phalanx and the flexor aspect of the distal sesamoid bone.

CT and 3 D reconstruction:

Particularly, identifiable anatomical structures were labeled with their analogous corresponding CT images. Metatarsal bones were the densest tissue in the CT of the hind foot and appeared as the whitest quadrilateral hyper dense with a well defined dark shaded medulla, the superficial and deep digital tendons were seen with various gray scales on the CT images. The synovial fluid was well defined radiolucent hypo dense smoothly margined. Moreover, CT scan provides an excellent depiction of the three branches of the interosseous medius tendon; central plate as well as the principle abaxial branches (Fig. 6). In this study the 3 D volume rendering the different structure in the foot, bones, and tendons provide a clear view of the arrangement of the structures in their natural position (Fig. 5)

Fig .3: X-Ray radiograph of the hind foot the buffalo showing digital tendon sheath after distension with aradio-opaque substance. Lateromedial View 1- Vaginae synovialis tendinum digitorum Pes, 2- Middle plantar pouches between annular ligaments, 3- distal plantar pouch, 4- Proximal pouch around deep digital flexor tendon. a-Os metatarsale, b-phalanx proximalis, c- Phalanx midia, d- Phalanx distalis, e- Ossaseasamoidea proxilais

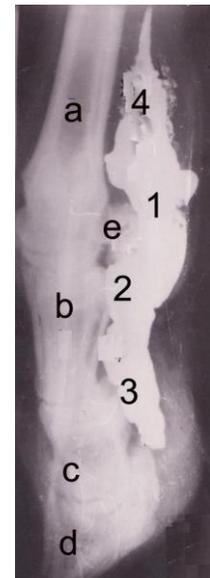


Fig .4: Photograph of the hind foot of the buffalo, plantar aspect, showing the digital tendon sheath, after distension with gum milk latex.1- Proximal pouch around deep digital flexor tendon, 2- Pouch between M. inserosseous medius and superficial digital flexor tendon, 3- Proximal plantar pouches around the superficial digital flexor tendon, 4- Manica flexoria, 5- Vagina synovialis tendinum digitorum Pes, 6- Middle plantar pouches between annular ligaments,7- distal plantar pouch

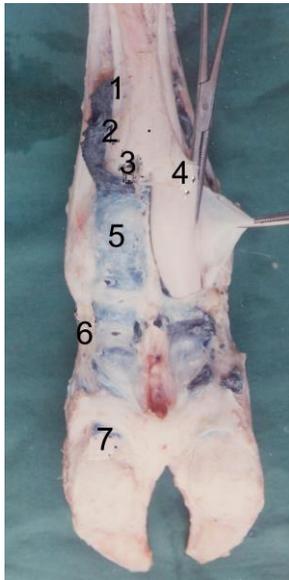
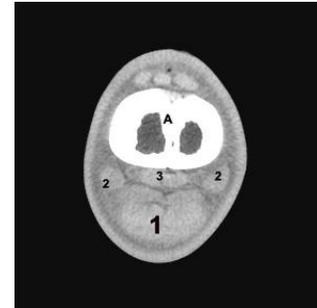


Fig. 5: CT image of the metatarsal bone in the buffalo, at the distal third in level just dorsal to the fetlock joints. A-fused third and fourth metatarsal bone, with bony septum and medullary cavities,1- superficial digital flexor tendon, 2- deep digital flexor tendon, 3- M. interosseous medius

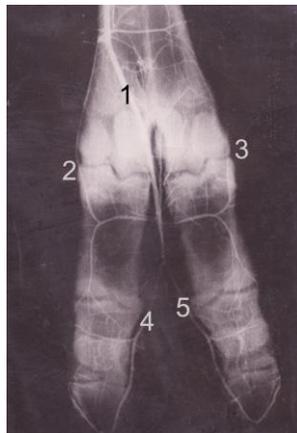


Arterial blood supply

The saphenous artery continues down the plantar aspect of the foot and splits into medial and lateral plantar digital arteries. At the level of metatarso-phalangeal joint, they become plantar abaxial proper digital artery III and plantar abaxial proper digital artery IV respectively. An interdigital artery exists that connects the dorsal common digital artery and the plantar common digital artery III by passing through the interdigital space. The plantar common digital artery III divides at the level of metatarso-phalangeal joint into plantar axial proper digital III and plantar axial proper digital IV (Fig.6).

Fig. 6: X-Ray radiograph of the hind foot of the buffalo showing the distribution of arterial blood supply

1-plantar common digital artery III, 2- plantar abaxial proper digital III, 3- plantar abaxial proper digital IV,4- plantar axial proper digital III,5- plantar axial proper digital IV



4. DISCUSSION

Dissection has revealed that, in the buffalo as also in other ruminants and equines (Bradely, 1946 ; Mcleod, 1958; Raghavan and Kachroo, 1964 ; Sisson and Grossman , 1967; May , 1970; Sisson , 1975; and Seiferle et al 1986) the superficial flexor tendon about the junction of the middle and distal third of the metatarsal joins the superficial part of the middle interosseous muscle to form a fibrous canal for the passage of the corresponding branch of the deep digital flexor tendon . However, in the camel, the tendon of the corresponding muscle forms an incomplete tendinous canal through which the deep one passes (Lesbre , 1903 and Ereisha ,1982) Regarding the termination of the superficial flexor tendon it is observed that each branch is inserted by three fasciculae on the plantar aspect of the second phalanx . A similar concept was expressed by (Raghavan and Kachroo,1964). (Sisson and Grossman, 1967). (Sisson, 1975) and (Seiferle et al, 1986) in other ruminants, but it is to add that, in buffalo these fasciculae have intimate contact with the plantar ligaments of the pastern joint. On the other hand ,(Mcleod, 1958), in ox;(May, 1970) , in sheep;(Ereisha, 1982; Malie and Bezuidenhout, 1987), in camel; and (Bradly, 1946; Taylor, 1959; Sisson, 1975), in equines proved that each branch of the bifurcated superficial flexor tendon terminated by two slips on the plantar aspect of the second; middle phalanx.

The results obtained on the general morphological features of the deep digital flexor tendon of the buffalo, resemble greatly those recorded on the corresponding tendon of the other ruminants (Habel, 1955; May , 1970; Sisson, 1975; Raghavan and Kachroo,1964) and camel (Ereisha, 1982). Moreover, the present finding has

revealed that this tendon, near its termination is protected by the distal interdigital ligament. It is to add that, the attachment of the subtarsal ligament to the deep flexor tendon in equine (Bradely, 1964; Sisson, 1975) cannot be observed in buffalo and this may aid in the kneeling of latter animal. The latter statement was also proved by (Ereisha, 1982) in camel. The common digital tendon sheath of the flexor tendon , as revealed in the present work, began proximal to the metatarso-phalangeal joint and ended slightly above the distal interphalangeal joint A result which correspond to that observed by (Seiferle et al., 1986)in other domestic animal as well as by Ereisha, 1982) in the camel. In addition, the determination of the best approach for injection the synovial sheath was detected. The most suitable site is adopted by introducing the needle horizontally in its proximal blind sac, two fingers above the dew-claws. The vinculum tenon identified in the present study was supported by the finding of (Waible et al.,2001). It may be suggested here that, this structure of the digital flexor tendon as also given by opinion of (Stanek, 1988).

The origin, pattern of termination of the middle inter osseous muscle, revealed in the present study, resemble greatly that recorded on the corresponding muscle of the ox (Langer and Nickel, 1953; Nickel et al., 1986) It is to added that, in the buffalo, some fibers of the muscle gain attachment to the articular capsule and collateral ligaments of the metatarsophalangeal articulation.

It is relevant to point out that CT scan is necessary for identifying anatomical structure of animal. We like to state that Ct images provide excellent spatial resolution and good discrimination between hard and soft tissue in animal. The latter statement was supported with (Peterson and Bowman, 1988)

With respect to the blood supply, it is reported that saphenous artery of buffalo unlike that of dog an horse, is divided into medial and lateral plantar branches in accordance with that given by (Dyce and Wensing, 1971). Similar to that recorded by (Ghoshal,1975) in bovine, a branch from the medial plantar continues as plantar common digital artery III, the latter supplies the axial surface of the two main digits as axial proper III and IV. The same author and (Koch, 1965 and 1970) agreed with this study in considering the abaxial proper digital arteries III an IV the

continuation of medial and lateral plantar arteries along the outer side of the main digits.

4. REFERENCES

- Bradely, O.C 1946. The topographical anatomy of the limbs of the horse 2nd ed. W.G en & Son Ltd Edinburgh.
- Dyce, K. M., Wensing, J. G. 1971. Essentials of bovine anatomy. Philsdelphia, Lea and Febiger.
- Ereisha, A. 1982. Some anatomical studies on the region of the manus of the one humped camel with special reference to tendon sheaths and ligaments. M.V.Sc (Anatomy).
- Ghoshal, N. G. 1975. Heart and arteries. In: "Sisson and Grossman's The Anatomy of Domestic Animals (GETTY, R.)". Vol. I. 5th edition, W. B. Sanders Co.,Philadelphia.
- Habel, R. 1955. Guide to the dissection of the cow. 3rd ed T.W. Edawards, Michigan.
- Koch, T. 1965 and 1970; 1st and 2nd ed.: "Lehrbuch der Veterinaer Anatomie B and III: Die grossen Versorgung and steurungs system. Jena Germany,VEB Gustav Fischer Verlag.
- Kossaibati, M.A. and R.J. Esslemont, 2000. The incidence of lameness in 50 dairy herds in England. In: Proceedings 11th International Symposium on disorders of the ruminant digit, Parma, Italy, September, 3-7, 2000, pp: 160-162.
- Langer, P., Nickel, R. 1953. Nervenversorgung des Vorderfusses beim Hind. Deutsche Tierärztliche Wochenschrift 60:307-309.
- Lesbre, m.1903. Recherches Anatomiques surles Camelidees. Archices Museum D, Histoirid. Naturales, Lyon.
- Malie, M., Bezuidenhout, A. 1987. Anatomy of the dromedary camel Ist ed Calarendon Press. Oxford
- May, N. 1970. The anatomy of the sheep 3rd Ed. Univ . of Queensland press.St. Iuncia queensland.
- Mcleod, W. 1958. Bovine Anatomy. 2nd Ed Burgess Minneapoles.
- Nickel, R., Schummer, A. and Seiferle, E. 1961. Lehrbuch der Anatomie der riaustiere. II. Auflage. Band I. eprengungsapparat. Berlin, Germany, Paul Parey.
- Nielsen, E. 1968. Die Schleimbeutel und Sehenscheiden der Gliedmassen des schweines. Zentbl.Vet. Med. 15A, 562-561.
- Nomina Anatomica Veterinaria, 2012. International committee on veterinary gross anatomical nomenclutre, General assemble of the world association of veterinary anatomists 6th edition, Gent, Belgiura
- Ottaway,C., Worden, A. 1940. Bursae and tendon sheaths in the horse. Vet. Rec. 52,477-483.

- Peterson, P., Bowman, C. 1988. Computed tomography anatomy of the distal extremity of the horse. *Vet. Radiol.* 29. 206-208.
- Raghavan D., Kachroo. 1964. *Anatomy of ox*, 1st ed. Indian council of agriculture research New delhi.
- Seiferle, E, Frewein, J., Wilkens, H. and Wille, K. 1986. *Active locomotor system of the Domestic Mammals* Vol. 1. Verlag Paul. Parey Berlin, Hamburg.
- Sisson, S. 1975. *Equine mycology & ruminant myology* in *Sisson and Grossman, s the anatomy of the DomseticAnimals*, 5th ed Rev. by R. Getty W/ B. Saunders company, Philadelphia London. Toronto.
- Sisson, S., J. Grossman 1967. *Anatomy of the Domestic animals* .4th ed. W.B. Saunders Company. Philadelphia and London
- Stanek, C. 1988. Morphologische, funktionelle, chemische und klinische Untersuchungen zu den Erkrankungen der Fesselbeugeschnenscheide des Rindes, *Wien Tiererztliche Wochenschrift*, v.75, p.170-180
- Waible, H. H.; Rehage, J. and Lorenzi P. 2001. Zur angewandten Anatomie des distalen Vinculum tendinis in der Fesselbeugeschnenscheide der Beckengliedmaße des Rindes. *Deutsche Tierärztliche Wochenschrift*, Alfeld, v. 108: 261-263