



## Arterial Blood Supply and Angiography of the Fore Foot in One- Humped Camel (*Camelus dromedarius*)

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### ABSTRACT

The present study was conducted on eight fresh forelimbs to investigate a detailed anatomical description of the arterial blood supply in adult dromedary camel's foot. Anatomical and angiographic techniques were used in order to give detailed data about the origin and pattern of distribution of these arteries. Moreover, this data serves other researchers in comparison with different animals. The specimens injected with red colored gum milk latex for anatomical dissection and urograffin injection for angiographic purposes throughout the median artery. The main arterial blood supply of camel's digit was derived from common palmar digital artery, palmar metacarpal artery, in addition to smaller branches detached from the dorsal metacarpal artery.

**Key words:** Anatomy, Camel, Arteries, Foot.

### INTRODUCTION

Camel has a unique foot structure than other animals, it walks on large and wide pads that bear its heavy weight in slippery sand desert and walk for long time, so camel foot considered as significant structure for additional studies. Most of researches were carried out on joints, ligaments, tendons and bones of the camel's foot (Dehgheni *et al.*, 2011; Nourinezhad *et al.*, 2011 and Abu-Seida *et al.*, 2012). Also, the previous studies performed on the affections of the soft tissues of foot causing lameness. Pododermatitis is the most common affection in camels because of the majority of soft nature foot pad that easily punctured by sharp objects (Zabady, 1999).

The arterial blood supply of the dromedary camel fore foot not detailed described before, while those of horse and cattle were reported by (Getty, 1975). Bactrian camel described as a diagram by (Jian-Lin *et al.*, 2000). Our research aims to study detailed arterial distribution and its anatomical relation with surrounding structures for further understanding the physiological specification of its foot.

Angiography is technique for study the normal structure, estimate size and diameter of vessels, wall integrity and distribution. Moreover, it considers a diagnostic method for pathological condition such as ischaemia, traumatic, congenital malformation and thrombosis (Dehgheni *et al.*, 2011).

### MATERIALS AND METHODS

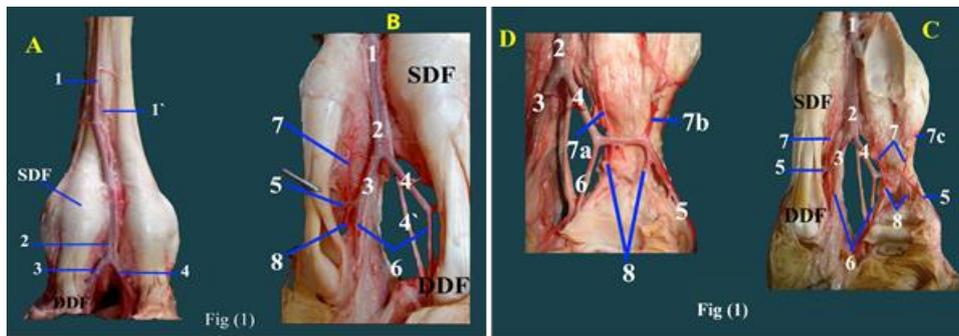
Eight foot of camel's fore limbs obtained from the slaughtering house were used. The foos were washed

through the palmar metacarpal artery via a saline solution (0.9%), after that four fresh foos injected with a red gum milk latex to show the distribution of the arterial supply, and left for 3 days in the refrigerator before the dissection. One fresh foos injected with a 50-gm lead oxide powder dissolved in a 100-gm solution of red gum milk latex. Other foot injected directly with the urograffin solution for X-ray's purposes. The exposure factors were 100 cm FFD, with 15 mAs and 55 KV. Cross sections were applied throughout two fore foos by using a bone saw at 6 levels; (the distal extremity of metacarpal bones, fetlock joint, proximal end of first phalanx, middle of first phalanx, distal end of first phalanx and pastern. The thickness of each cross ranged from 2.5 to 4 cm. Foos were dissected and photographed using Sony digital camera 14 megapixel, 5X.

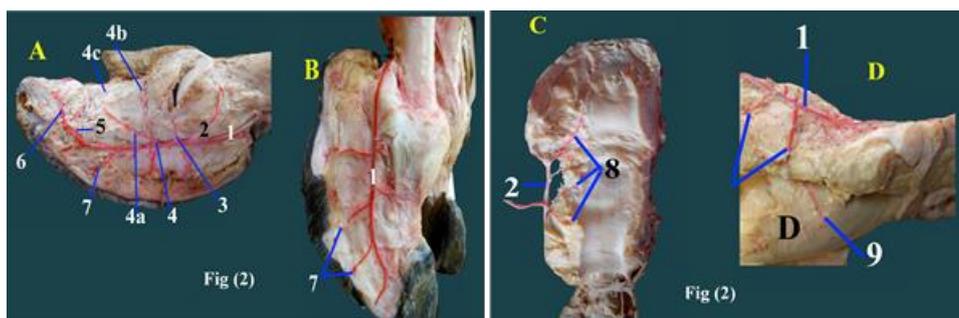
### RESULTS

The fore foot of the one-humped camel was supplied by common palmar digital artery, palmar metacarpal artery, and fine branches derived from the dorsal metacarpal artery.

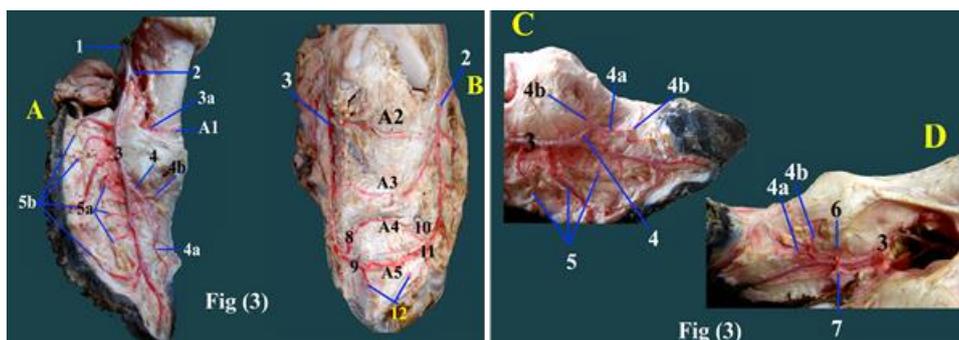
**Common palmar digital artery III:** (Fig. 1, 6 / 2), was the direct extension of median artery at the distal third of metacarpus; it passed distally, with the corresponding vein and nerve. It divided at the interdigital space into medial and lateral branches. The medial branch (Fig. 1, 6 / 3) passed to the first phalanx of the third digit, under covering with the superficial and deep digital flexor tendons, where it divided into axial palmar proper digital artery and abaxial palmar



**Fig. 1(A-B-C-D):** A photograph showing the branches of common palmar digital artery of camel's foot (Palmar view); SDF- Superficial digital flexor tendon, DDF- Deep digital flexor tendon. 1- Median A., 1'- Median N., 2- Common palmar digital III A., 3- Medial branch of common palmar digital A., 4- Lateral branch of common palmar digital A., 4'- Lateral branch of median N, 5- Abaxial palmar proper digital A., 6- Axial palmar proper digital A., 7- Proximal abaxial palmar branches of first phalanx, 7a- Medial branch of proximal abaxial palmar A., 7b- Lateral branch of proximal abaxial palmar A., 7c- Dorsal branch of lateral branch of proximal abaxial palmar A., 8- Distal abaxial palmar branches of first phalanx.



**Fig. 2 (A-B-C-D):** A photograph showing the branches of abaxial palmar proper digital artery of the foot in the camel. A & B- Lateral view, C- Palmar view, D- Palmarolateral view. 1- Abaxial palmar proper digital A., 2- Abaxial dorsal branch of first phalanx, 3- Abaxial intra-articular branches, 4- Dorsal abaxial branches of second phalanx, 4a- The anastomosing branch, 4b- Proximal dorsal arch of the second phalanx, 4c- The distal dorsal arch of second phalanx, 5- Coronary branch of abaxial A., 6- Dorsal abaxial branch of third phalanx, 7- Abaxial digital tori branches, 8- Palmar abaxial branches of second and third phalanx, D- Digital cushion, 9- Palmar branch of digital cushion.

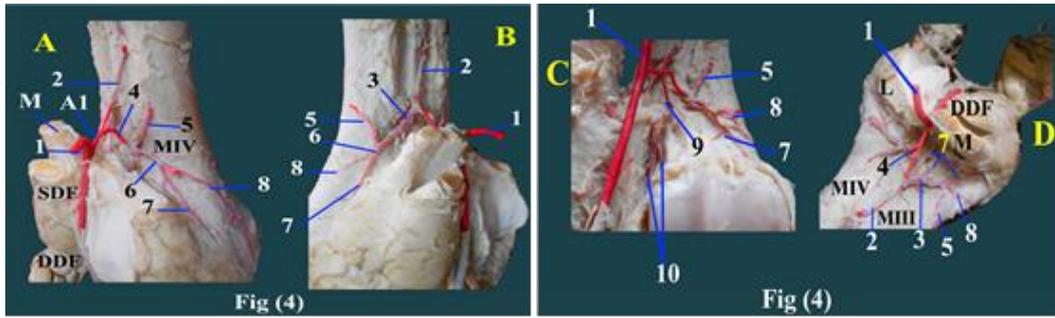


**Fig. 3 (A-B-C-D):** A photograph showing the branches of axial palmar proper digital artery of the foot in camel. A, C & D- Medial view, B- Dorsal view. 1- Medial branch of common palmar digital A., 2- Abaxial palmar proper digital A., 3- Axial palmar proper digital A., 3a- Dorsal branch of axial proper digital A, 4- Dorsal axial branches of second phalanx, 4a- The descending branch, 4b- Anastomosing branch., 5- axial digital tori branches, 5a- Fine branches, 5b- Long branches, 6- Axial intra-articular branch., 7- Cutaneous branch of axial palmar digital A., 8- Coronary branch of axial A., 9- Dorsal axial branch of third phalanx, 10- Coronary branch of abaxial A., 11- Dorso-axial branch of third phalanx., 12- Terminal branches; A1- Dorsal distal arch of the first phalanx, A2- Proximal dorsal arch of second phalanx, A3- Distal dorsal arch of second phalanx, A4- Coronary arch, A5- Dorsal arch of third phalanx.

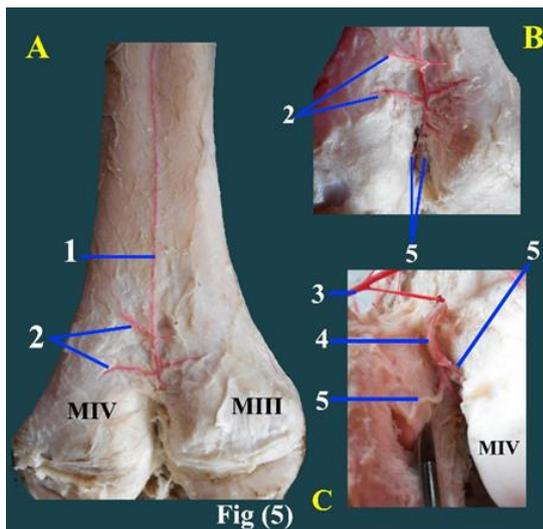
proper digital one at the proximal distal third of first phalanx. It supplied the third digit. While the lateral branch (Fig. 16/4) had the same origin, distribution and the branches were similar to the medial one and it supplied the fourth digit.

**Abaxial palmar proper digital artery:** (Fig. 1, 6 /5 & 2/1), arose from medial and lateral palmar digital artery; it passed between the first phalanx and the digital flexor tendons till reach the abaxial aspect of the digit. At the

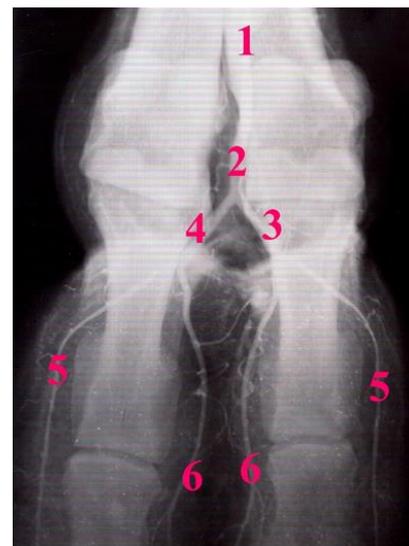
palmar surface of first phalanx it gave off; the proximal abaxial palmar branches, distal abaxial palmar branches and abaxial dorsal branch, then it reached the lateral aspect of second and third phalanges. At the level of the second phalanx, it detached abaxial intra-articular branches, dorsal abaxial branches and palmar abaxial branches. At the third phalanx it gave off a coronary branch, palmar abaxial branches and dorsal abaxial branch. At the second and third digit it terminated by several abaxial digital tori branches.



**Fig. 4(A-B-C-D):** A photograph showing the branches of the palmar metacarpal artery of the foot in camel. A- Lateral view & B- Medial view, C- Palmar view, D- Palmarolateral view. SDF- Superficial digital flexor tendon, DDF- Deep digital flexor tendon. M- Medial branch of suspensory ligament, L- Lateral branch of suspensory ligament, MIII- Third metacarpal bone, MIV- Fourth metacarpal bone. AI- anastomotic arch, 1- Median A., 2- Palmar metacarpal A., 3- Medial branch of palmar metacarpal A., 4- Lateral branch of palmar metacarpal A., 5- Cutaneous branch., 6- Distal abaxial metacarpal A.; 7- Palmar branch of distal abaxial metacarpal A., 8- Descending anastomosing branch of distal abaxial metacarpal A., 9- Distal perforating palmar branch, 10- Axial branches of distal perforating palmar branch.



**Fig. 5 (A-B-C):** A photograph showing the dorsal metacarpal artery of the foot in camel. A- Dorsal view, B- Distal extremity of third and fourth metacarpus. MIII- Third metacarpal bone, MIV- Fourth metacarpal bone. 1- Dorsal metacarpal A., 2- Axial branches of dorsal metacarpal A, 3- Palmar metacarpal A, 4- Distal perforating branches of palmar metacarpal A, 5- Axial branches of distal perforating A



**Fig. 6:** X- rays on the foot of the camel showing the main arterial supply. 1- Median A., 2- Common palmar digital III A., 3- Medial branch of common palmar digital A., 4- Lateral branch of common palmar digital A., 5- Abaxial palmar proper digital A., 6- Axial palmar proper digital A.

**Proximal abaxial palmar branches of first phalanx** (Fig. 1/7), were two arteries ran proximally at the palmaromedial and palmarolateral surface of first phalanx; as a medial and lateral proximal abaxial palmar branches. The medial branch (Fig. 1/7a) ran to the superficial part of sesamoid ligament. The lateral one (Fig. 1/7b) perforated the capsule of fetlock joint and gave off a dorsal branch that ran dorsoproximally and anastomosed with the descending branch of distal abaxial metacarpal branch (Fig. 1/7c).

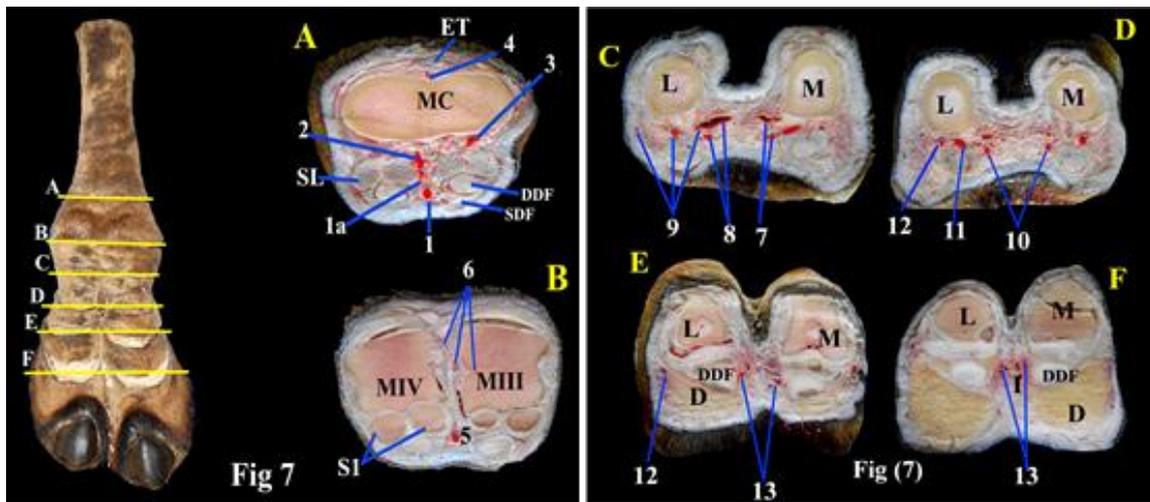
**Distal abaxial palmar branches of first phalanx** (Fig. 1/8), were three arteries ran distally within the pastern joint and covered by the medial and lateral branch of superficial digital flexor tendon.

**Abaxial dorsal branch of first phalanx** (Fig. 2/2), was fine artery arose at the distal half of first phalanx, ran dorsally beneath the common digital extensor tendon, till merge with dorsal axial branch of first phalanx of axial proper, forming the dorsal distal arch of the first phalanx (Fig. 3/A1).

**Abaxial intra-articular branches** (Fig. 2/3), were about 3-4 fine branches entered the pastern joint.

**Dorsal abaxial branches of second phalanx** (Fig. 2/4), were detached abaxially at the proximal extremity of middle phalanx, it supplied the pastern joint. It sent an anastomotic branch (Fig.2/4b) traveled on the dorsal aspect of the second phalanx, just below the pastern it anastomosed with the similar branch of dorsal axial artery, forming the proximal dorsal arch of the second phalanx (Fig.3/A2), and it also gave off a descending branch (Fig.3/4a) ran distally to supply the coffin joint and gave further anastomotic branch (Fig.3/4b& 2/4a) to unite with it's fellow of dorsal axial artery to form the distal dorsal arch of second phalanx (Fig.3/A3).

**Coronary branch** (Fig. 2/5 & 3/10), arose from the abaxial palmar proper digital, passed dorsally, then axially at the coronary border of the third phalanx to be anastomosed with the corresponding axial one, just dorsal to the coffin joint forming coronary arch (Fig. 3/A4).



**Fig 7:** A photograph showing cross sections at different levels of the foot in camel. A- B- C- D- E- F SDF- Superficial digital flexor tendon, DDF- Deep digital flexor tendon, ET- Extensor tendon, MIII- Third metacarpal bone, MIV- Fourth metacarpal bone, M- III first phalanx, L- IV first phalanx, S1- proximal sesamoid bones, SL- suspensory ligament, D- Digital cushion, MC- metacarpal bone, 1- Median A., 1a- Anastomotic arch, 2- Palmar metacarpal A., 3- Medial branch of palmar metacarpal A., 4- Dorsal metacarpal A., 5- Common palmar digital A., 6- Axial branches of dorsal metacarpal A., 7- Medial branch of common palmar digital A. & V, 8- Lateral branch of common palmar digital A. & V, 9- Proximal branches of abaxial proper digital A., 10- Axial proper palmar digital A., 11- Abaxial proper palmar digital A., 12- Abaxial digital tori, 13- Axial digital tori.

**Dorsal abaxial branch of third phalanx** (Fig. 2/6), detached from the abaxial palmar proper digital artery, crossed the dorsal surface of the third phalanx, anastomosing with the dorsal axial one, forming the dorsal arch of third phalanx (Fig. 3/A5), through which 2-3 small terminal branches (Fig. 3/12) furnished to the third phalanx.

**Abaxial digital tori branches** (Fig. 2/7), were 6-7 branches were given from the abaxial palmar proper digital artery at the second phalanx to the third phalanx. They ran in a distal direction and entered the digital cushion, where they detached fine palmar branches (Fig. 2/9).

**Palmar abaxial branches of second and third phalanx** (Fig. 2/8), were small branches arose from the abaxial palmar proper digital artery and ramified to the digital cushion and finished in the palmar surface of the II and III phalanges of the digit.

**Axial palmar proper digital artery** was the second branch detached from medial and lateral palmar digital artery, coursed axially at the interdigital space with lateral and medial palmar digital nerve. It gave off the dorsal axial branch of first phalanx, dorsal axial branch of second phalanx, axial intra-articular branch, cutaneous branches, dorsal axial branches of third phalanx, coronary artery and axial digital tori branches (Fig. 1, 6/6 & 3/3).

**Axial dorsal branch of first phalanx** was fine artery arose at the distal half of first phalanx, ran dorsally in contact with the bone (Fig. 3/3a), beneath the common digital extensor tendon till merge with dorsal abaxial branch of first phalanx forming the dorsal distal arch of the first phalanx (Fig. 3/A1).

**Axial intra-articular branches** (Fig. 3/6), were a fine branch detaching from the axial palmar proper digital artery to be enter the pastern joint.

**Cutaneous branch** (Fig. 3/7), called Interdigital branches, were small fine branches distributed to the interdigital ligament, supplied the skin of interdigital septum.

**Axial digital tori branches** (Fig. 3/5), called the distal axial branches of digital cushion were 8-10 branches emerging from the axial palmar proper digital artery. Six fine branches distributed to sole bad (Fig. 3/4a) and four long branches distributed to digital cushion (Fig. 3/4b).

**Dorsal axial branch of second phalanx** (Fig. 3/4), it gave off a descending branch (Fig. 3/4a) and an anastomotic branch (Fig. 3/4b). The dorsal axial branches of second (Fig. 3/4) and third (Fig. 3/9) phalanx and coronary artery (Fig.3/10) had the same pattern of distribution as abaxial branches and forming dorsal arches as documented above.

**Palmar metacarpal artery III** (Fig. 4/2), was the direct continuation of the deep palmar arch of the radial artery, that extended along the palmar surface of the metacarpus, covering by the suspensory ligament. It gave off the medial, lateral and distal perforating palmar branches at the distal extremity of the metacarpus. Then, it passed in between the two branches of suspensory ligament and flexor tendons to be anastomosing with median artery forming anastomotic arch (Fig. 4/A1).

The medial and lateral branches (Fig. 4/3, 4), had the same branches and distribution, the medial branch (Fig. 4/3) originated from the palmar metacarpal artery at the level proximal to the lateral one by about 0.5-1 cm. The medial branch supplied third digit, while the lateral one (Fig. 4/4) distributed to fourth digit.

**Medial branch** (Fig. 4/3), was detached from the palmar metacarpal artery, just above the palmar pouch of fetlock joint of III digit, passed abaxially between the suspensory ligament and the third metacarpal bone, where it gave off a cutaneous branch and distal abaxial

metacarpal artery. The cutaneous branch (Fig. 4/5) supplied the skin and suspensory ligament at the distal extremity of metacarpus.

**Distal abaxial metacarpal branch** (Fig. 4/6), it gave off a palmar branch supplied the palmar pouch, joint capsule and collateral ligament of fetlock joint with fine branch (Fig. 4/7) and also gave a descending anastomosing branch (Fig. 4/8) to join the dorsal branch of lateral proximal abaxial palmar branches.

**Distal perforating palmar branch** (Fig. 5/4), derived from the palmar metacarpal artery extended, distally over the palmar surface of the metacarpal bone and passed through the intertrochlear notch of cannon bone, where it gave two axial branches (Fig. 5/5) supplying the axial collateral ligament of fetlock joint and coursed dorsally to merge with dorsal metacarpal artery.

**Dorsal metacarpal artery** (Fig. 5/1), arose from the dorsal carpal rete; passing over the dorsal surface of metacarpus, covered by the common and lateral digital extensor tendons, it gave off 4-6 axial branches (Fig. 5/2) at the distal fifth of metacarpus, it merged with distal perforating palmar branch.

**Cross sections of the foot** were taken throughout the foot at several intervals. The first cross was applied on the distal third of the metacarpal bone, where showing the dorsal metacarpal artery covered by extensor tendon and located at the dorsal aspect of the metacarpal bone (Fig. 7A/4). Three structures placed palmarly; the median artery (Fig. 7A/1), palmar metacarpal artery, (Fig. 7A/2) and an anastomotic arch located in-between the two arteries (Fig. 7A/1a).

The second cross was taken at the level of the fetlock joint, have an axial branch of the dorsal metacarpal artery dorsally (Fig. 7B/6) and common palmar digital artery palmarly in the interdigital space (Fig. 7B/5).

The third one applied at the level of the proximal extremity of the first phalanx, included the division of the common palmar digital into medial branch (Fig. 7C/7) and lateral branch (Fig. 7C/8). The proximal branches of abaxial proper digital artery were also appeared (Fig. 7C/9). The fourth cross was at the mid of the first phalanx and showing the division into axial (Fig. 7D/10) and abaxial proper palmar digital arteries (Fig. 7D/11). The last two crosses applied on the distal extremity of the first phalanx and at the pastern joint respectively, viewing the axial (Fig. 7/13) and abaxial digital tori (Fig. 7/12).

## DISCUSSION

The arterial supply of the foot in the dromedary camel was derived from the common palmar digital artery III, the palmar metacarpal artery, in addition to fine branches from the dorsal metacarpal artery that similar to (Human Research Group, 1984) in the water buffalo, while (Smuts and Bezuidenhout, 1987) in the dromedary camel stated that, it supplied by the common palmar digital artery II, the palmar and dorsal metacarpal arteries. (Wang *et al.*, 2000) in Bactrian camel only reported the common palmar digital artery III and the palmar metacarpal artery III. (Getty, 1975) in ox mentioned that the digit supplied by the

common digital arteries II, III and IV, palmar metacarpal arteries II, III and IV, dorsal metacarpal artery III.

The common palmar digital artery III passed along the palmomedial aspect of the metacarpus and divided into medial and lateral proper palmar digital arteries at the inter digital space, each one gave off an axial and abaxial proper palmar digital arteries which gave several branches to fetlock, pastern and coffin joint similar results were observed by (Smuts and Bezuidenhout, 1987) in the dromedary camel, (Wang *et al.*, 2000) in Bactrian camel and (Human Research Group, 1984) in the water buffalo.

The dorsal surface of the digit characterized by presence of a five dorsal arches, the dorsal distal arch of the first phalanx, the proximal & distal dorsal arch of the second phalanx and the coronary & the dorsal arch of third phalanx. These arches formed over the dorsal surface of the first, second and third phalanx as a result of anastomoses of the dorsal branches of the axial and abaxial proper digital arteries at the different levels of phalanges this results similar to (Wang *et al.*, 2000) in Bactrian camel except the coronary arch.

The coronary artery arose directly from axial and abaxial palmar proper digital artery while it detached from the dorsal axial and abaxial branch of third phalanx in Bactrian camel (Wang *et al.*, 2000).

Several terminated palmar branches distributed from the abaxial proper palmar digital artery to the palmar surface of the second and third phalanx and no anastomotic branches were recorded in this study, on the other hand (Wang and Cuisheng, 1998) in Bactrian camel, revealed the presence of anastomosis between abaxial distal metacarpal branch and proximal dorsoabaxial proximal phalangeal branch forming superficial palmar distal arch and anastomosis between proximal palmoaxial and palmoabaxial proximal phalangeal branch forming sub-sesamoidean arch.

The camel characterized by presence of a several axial and abaxial digital tori, that it different than other domestic animals due to the camel adapted with the dry environmental condition so it needed a large number of blood supply in the foot. About 6-7 abaxial digital tori arose from the abaxial proper palmar digital artery, they distributed all over the second and third phalanx to digital cushion. A 7-9 abaxial digital tori present in Bactrian camel (Wang *et al.*, 2000) and these tori lesser in number in the ox and buffalo (Cui-Yan, 1996).

In the current study were an 8-10 axial digital tori emerging from the axial palmar proper digital artery, while a 6-7 axial digital branches distributed to the digital cushion in Bactrian camel recorded by (Wang *et al.*, 2000). In the present study a 4 long branches and 6 smaller one, that's not recommended in Bactrian camel.

In the recommended study the palmar metacarpal artery divided into medial and lateral branches, the medial branch had the same pattern of distribution similar to the lateral one, but only originated at level higher than the lateral branch, while the medial and lateral branches originated at the same level in the Bactrian camel (Wang and Cuisheng, 1998).

In the current study identifying the distribution of the arterial supply of the foot through a number of cross sections were performed on the foot of the camel. Studying and description of each section showing the progress of the

arteries in different regions of the foot, also showing the distribution of the arteries to bone even to the bone marrow, that's not recorded in any of available literatures.

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