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Deep plantar arteries of some mammals, with special reference to the plantar metatarsal arteries.

Masashi Horie*

Takuro Murakami[†]

Akio Kikuta[‡]

*Okayama University,

[†]Okayama University,

[‡]Okayama University,

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Masashi Horie, Takuro Murakami, and Akio Kikuta

Abstract

The plantar metatarsal arteries of some mammals were studied. In the dog, raccoon dog and cat, the second proximal perforating branch was fully developed and produced the plantar metatarsal arteries. These plantar metatarsal arteries ran on the plantar surfaces of the interosseous muscles along the metatarsal bones or intermetatarsal spaces, and gave rise to the digital arteries of the second to fifth toes. In the rabbit, a branch of the medial plantar artery ran transversely on the plantar surfaces of the metatarsal bones at a level distal to the bases of these bones, and produced the plantar metatarsal arteries. These plantar metatarsal arteries ran deep in the interosseous muscles along the metatarsal bones or intermetatarsal spaces, and joined with the digital arteries which were derived from the medial plantar artery. The plantar metatarsal arteries could be classified into four kinds of arteries (sM, sI, dM and dI) in relation to the interosseous muscles and metatarsal bones. This classification largely coincides with that of the human hand and foot (Murakami, 1969, 1971), the monkey hand and foot (Nakai et al., 1987; Hinenoya et al., 1987), and the forepaws of some animals, including the dog and cat (Murakami et al., 1987).

KEYWORDS: hindpaw, deep metatarsal arteries, plantar metatarsal arteries, proximal and distal perforating branches, deep plantar arch

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Deep Plantar Arteries of Some Mammals, with Special Reference to the Plantar Metatarsal Arteries

Masashi Horie*, Takuro Murakami and Akio Kikuta

Department of Anatomy, Okayama University Medical School, Okayama 700, Japan

The plantar metatarsal arteries of some mammals were studied. In the dog, raccoon dog and cat, the second proximal perforating branch was fully developed and produced the plantar metatarsal arteries. These plantar metatarsal arteries ran on the plantar surfaces of the interosseous muscles along the metatarsal bones or intermetatarsal spaces, and gave rise to the digital arteries of the second to fifth toes. In the rabbit, a branch of the medial plantar artery ran transversely on the plantar surfaces of the metatarsal bones at a level distal to the bases of these bones, and produced the plantar metatarsal arteries. These plantar metatarsal arteries ran deep in the interosseous muscles along the metatarsal bones or intermetatarsal spaces, and joined with the digital arteries which were derived from the medial plantar artery. The plantar metatarsal arteries could be classified into four kinds of arteries (sM, sI, dM and dI) in relation to the interosseous muscles and metatarsal bones. This classification largely coincides with that of the human hand and foot (Murakami, 1969, 1971), the monkey hand and foot (Nakai *et al.*, 1987; Hinenoya *et al.*, 1987), and the forepaws of some animals, including the dog and cat (Murakami *et al.*, 1987).

Key words : hindpaw, deep metatarsal arteries, plantar metatarsal arteries, proximal and distal perforating branches, deep plantar arch

The deep layer of the human hand is generally regarded as being supplied by the palmar metacarpal arteries (1, 2). Murakami classified the palmar metacarpal arteries in relation to the interosseous muscles and metacarpal bones into (i) the superficial palmar metacarpal (sM) arteries descending on the palmar surfaces of the interosseous muscles along the metacarpal bones, (ii) the superficial palmar intermetacarpal (sI) ar-

teries descending on the palmar surfaces of the interosseous muscles along the intermetacarpal spaces, (iii) the deep palmar metacarpal (dM) arteries descending deep in the interosseous muscles along the metacarpal bones, and (iv) the deep palmar intermetacarpal (dI) arteries descending deep in the interosseous muscles along the intermetacarpal spaces (3). This classification system is also applicable to the human foot (4), the monkey hand (5) and foot (6), and also the forepaws of some animals such as

*To whom correspondence should be addressed.

the dog and cat (7). The present paper describes these four kinds of arteries in the hindpaws of some animals, including the dog and cat.

Materials and Methods

An aged dog (*Canis familiaris*), an aged raccoon dog (*Nyctereutes viverrinus*), an aged cat (*Felis domestica*) and an aged rabbit (*Oryctolagus cuniculus*) were obtained from the Ritsurin Park Zoo (Takamatsu, Kagawa) upon their death. They were fixed with 10% formalin by vascular perfusion. After immersion in an ethanol bath for a year or longer, the left hindpaws of these animals were dissected.

Results

The first toes of the dog, raccoon dog, cat and rabbit were so small (dewclaw) that we omitted their arteries from our observations.

In all our animals, the dorsal pedal artery arose from the cranial tibial artery and gave off the second to fourth dorsal metatarsal arteries which descended on the dorsal surfaces of the interosseous muscles. In the dog, raccoon dog and cat, the proximal perforating branch (P2) of the second dorsal metatarsal artery was fully developed and formed the deep plantar arch (DA) on the plantar surfaces of the interosseous muscles (In) (Figs. 1-3). In the raccoon dog and cat, this proximal perforating branch (P2) further formed the catella plantaris proximalis (CP) which ran deep in the inter-

osseous muscles (In) at a level distal to the bases of the second to third or fourth metatarsal bones (Figs. 2 and 3).

The medial and lateral plantar arteries (MP and 1p) arose from the plantar branch of the saphenous artery and descended respectively along the medial and lateral borders of the sole (Fig. 4). In the rabbit, the medial plantar artery (MP) was particularly well developed and gave off the plantar digital arteries (c2-c4) of the second to fifth toes (T2-T5) (Fig. 4). In addition, a branch of the medial plantar artery (Mp) anastomosed into a branch of the lateral plantar artery (1p) and formed the catella plantaris proximalis (CP) which ran deep in the interosseous muscles (In) between the second and fifth metatarsal bones at a level distal to the bases of the metatarsal bones (Fig. 4).

In the dog, raccoon dog and rabbit, the plantar digital arteries (c2-c4) were thicker than the dorsal digital arteries (d2-d4) (Figs. 1-3). In the cat, however, the former arteries were thinner than the latter arteries (d2-d4) (Fig. 4).

In the dog and raccoon dog, the dorsal metatarsal arteries were poorly developed and terminated near the metatarsophalangeal joints. Thus, in these animals, the dorsal digital arteries (d2-d4) arose from the plantar metatarsal arteries (Figs. 1 and 2) (see below). In the cat, the second dorsal metatarsal artery (D2) was well developed and formed the second dorsal digital artery (d2) (Fig. 3). In the rabbit, the dorsal digital arteries arose from the dorsal metatarsal arteries.

Abbreviations used. T2-T4, second to fifth toes; CD, catella plantaris distalis; CP, catella plantaris proximalis; DA, deep plantar arch; MP, medial plantar artery; Cn, contrahentes muscles; In, interosseous muscles; Lm, lumbrical muscles; P2, second proximal perforating branch; dm, metatarsal ascending branches; dp, distal perforating branches; 1p, lateral plantar artery; pi, medial plantar digital artery of the second toe; pf, lateral plantar digital artery of the fifth toe; c2-c4, second to fourth plantar digital arteries; d2-d4, second to fourth dorsal digital arteries; sM2-sM5, second to fifth superficial plantar metatarsal arteries; sL2-sL4, second to fourth superficial plantar intermetatarsal arteries; dM2-dM5, second to fifth deep plantar metatarsal arteries; dL2-dL4, second to fourth deep plantar intermetatarsal arteries.

In all our animals, the plantar metatarsal arteries arose from the deep plantar arch (DA) or catella plantaris proximalis (CP) (Figs. 1-4). By their relationship to the interosseous muscles (In) and metatarsal bones, the plantar metatarsal arteries could be classified into: (i) the second to fifth superficial plantar metatarsal (sM2-sM5) arteries descending on the plantar surfaces of the interosseous muscles along the second to fifth metatarsal bones, (ii) the second to fourth superficial plantar intermetatarsal (sI2-sI4) arteries descending on the plantar surfaces of the interosseous muscles along the second to fourth intermetatarsal spaces,

(iii) the second to fifth deep plantar metatarsal (dM2-dM5) arteries descending deep in the interosseous muscles along the second to fifth metatarsal bones, and (iv) the second to fourth deep plantar intermetatarsal (dI2-dI4) arteries descending deep in the interosseous muscles along the second to fourth intermetatarsal spaces (Figs. 1-4).

The sM, sI, dM and dI arteries were independent vessels, but their development varied in each case. Poorly developed sM, sI, dM and dI arteries terminated only in the mid-region of the metatarsus. In contrast, the well developed sM, sI, dM and dI arteries reached the metatarsophalangeal joints or descended under these joints to connect with the palmar or dorsal digital arteries. The origins and terminations of these four types of arteries in each animal are described.

Dog (Fig. 1). The proximal perforating branch (P2) of the second dorsal metatarsal artery formed the deep plantar arch (DA) which produced the sI2, sI3 and sI4 arteries. These sI arteries divided near the metatarsophalangeal joints into the plantar and dorsal digital arteries (c2-c4 and d2-d4). The dorsal digital arteries gave off the distal perforating branches (dp) which anastomosed with each other on the plantar surfaces of the metatarsal bones at a level proximal to the heads of the metatarsal bones and formed the catella plantaris distalis (CD). The medial plantar digital artery of the second toe (pi) arose from the medial end of the catella plantaris distalis (CD) (or the medial distal perforating branch of the second dorsal digital artery, d2). The lateral plantar digital artery of the fifth toe (pf) arose from the lateral end of the catella plantaris distalis (CD) (or the lateral distal perforating branch of the fourth dorsal digital artery, d4). The catella plantaris distalis (CD) further gave off short branches (dm) which ascended deep in the interosseous

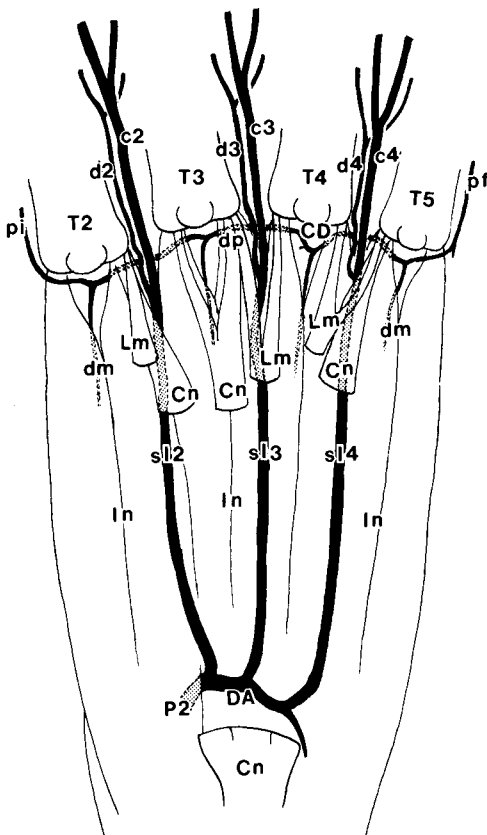


Fig. 1 A diagram showing the arterial pattern in the deep planta of the dog (*Canis familiaris*) (hindpaw, view from the plantar side). For abbreviations, see text and footnotes.

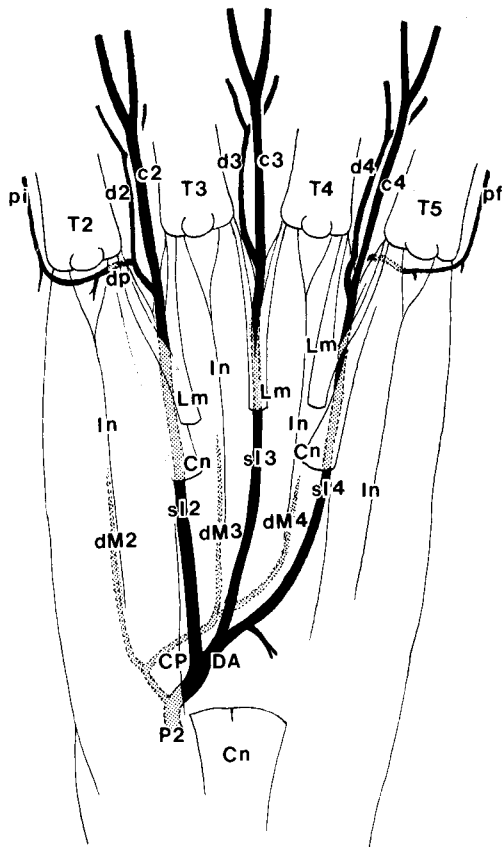


Fig. 2 A diagram showing the arterial pattern in the deep planta of the raccoon dog (*Nyctereutes viverrinus*) (hindpaw, view from the plantar side). For abbreviations, see text and footnotes.

muscles (In) along the second to fifth metatarsal bones.

Raccoon dog (Fig. 2). The proximal perforating branch (P2) of the second dorsal metatarsal artery formed the deep plantar arch (DA) and catella plantaris proximalis (CP). The catella produced the poorly developed dM2, dM3 and dM4 arteries. The deep plantar arch produced the sI2, sI3 and sI4 arteries which divided near the metatarsophalangeal joints into plantar digital and dorsal digital arteries (c2-c4 and d2-d4). The medial plantar digital artery of the second toe (pi) arose from the medial distal perforating branch (dp) of the second dorsal metatarsal artery. The lateral plantar dig-

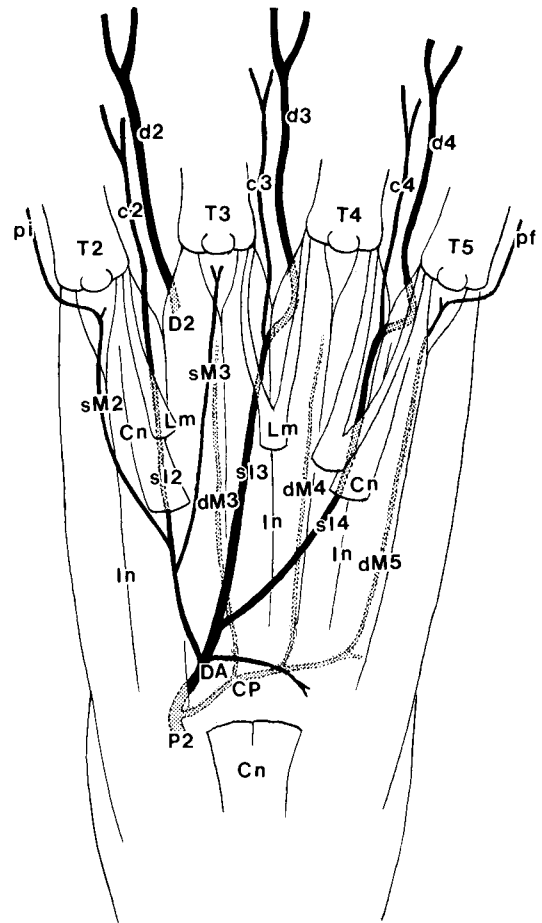


Fig. 3 A diagram showing the arterial pattern in the deep planta of the cat (*Felis domestica*) (hindpaw, view from the plantar side). For abbreviations, see text and footnotes.

ital artery of the fifth toe (pf) arose from the lateral distal perforating branch of the fourth dorsal digital artery (d4).

Cat (Fig. 3). The proximal perforating branch (P2) of the second dorsal metatarsal artery formed the deep plantar arch (DA) and catella plantaris proximalis (CP). The deep plantar arch produced the sM2, sI2, sM3, sI3 and sI4. The sI3 and sI4 arteries divided near the metatarsophalangeal joints into dorsal and plantar digital arteries (d3-d4 and c3-c4). The catella plantaris proximalis yielded the poorly developed dM3 and dM4 arteries and the well-developed

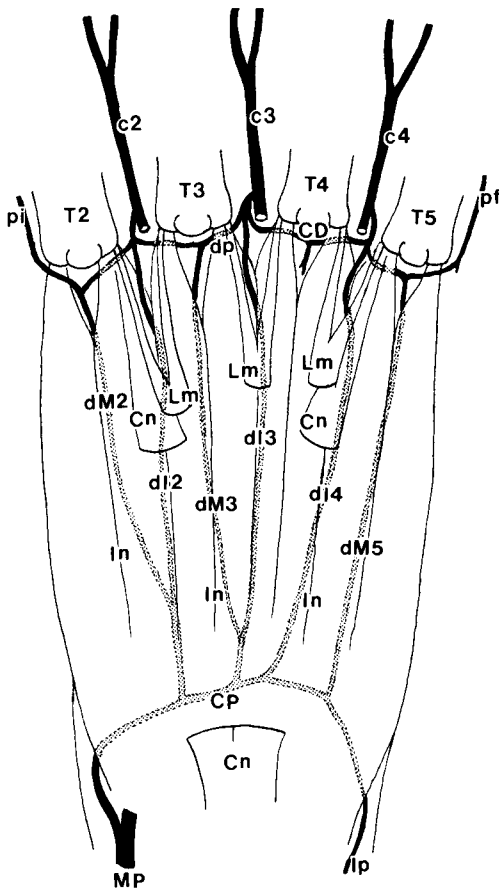


Fig. 4 A diagram showing the arterial pattern in the deep planta of the rabbit (*Oryctolagus cuniculus*) (hindpaw, view from the plantar side). For abbreviations, see text and footnotes.

dM5 artery. The medial plantar digital artery of the second toe (pi) arose from the sM2 artery. The lateral plantar digital artery of the fifth toe (pf) arose from the dM5 artery.

Rabbit (Fig. 4). The catella plantaris proximalis (CP, see above) produced the dM2, dI2, dM3, dI3, dI4 and dM5 arteries. The dM2, dM3 and dM5 gave off the distal perforating branches (dp) and formed the catella plantaris distalis (CD) together with the dI2, dI3 and dI4 arteries, to continue into the plantar digital arteries of the second to fifth toes (c2-c4). The medial plantar digital artery of the

second toe (pi) arose from the medial end of the catella plantaris distalis. The lateral plantar digital artery of the fifth toe (pf) arose from the lateral end of the catella plantaris distalis.

Discussion

This paper describes the basic blood vascular architecture of the plantar and dorsal layers of the hindpaws and their digits of the dog, raccoon dog, cat and rabbit. Except for the rabbit, the proper plantar and dorsal digital arteries arise near the metatarsophalangeal joints from the plantar metatarsal arteries. The rabbit hindpaw blood vasculature arises from the plantar digital and dorsal metatarsal arteries. The vascular pattern of the dog, raccoon dog and cat is unusual and has not been observed in any mammal (3-7). The vascular pattern of the rabbit is usual and has been demonstrated in man and other mammals, including the monkey (3-7).

This paper shows that the basic blood vascular architecture of the deep layer of the hindpaw of the dog, raccoon dog, cat and rabbit is similar to that of the human foot. The blood vascular system of the deep planta in these animals, as in the human foot (4), is composed of the superficial and deep arteries. The superficial (sM and sI) arteries descend on the plantar surfaces of the interosseous muscles or on the dorsal surfaces of the contrahentes muscles, and the deep (dM and dI) arteries run deep in the interosseous muscles. The main difference is that in these animals, except the rabbit, the second proximal perforating branch is fully developed and forms the deep plantar arch, though in the human hand the first proximal perforating branch usually forms the deep plantar arch (4, 8). In the monkey foot, the catella plantaris proximalis is usually formed

deep in the interosseous muscles by the first to fourth proximal perforating branches (6, 9) though it is rarely formed in the human foot (4). The catella plantaris proximalis was observed in the raccoon dog, cat and rabbit. As described above, the catella plantaris proximalis of the raccoon dog and cat is formed by a branch of the second proximal perforating branch. In contrast, the catella plantaris proximalis of the rabbit was formed by the deep plantar branches of the medial and lateral plantar arteries. This difference may be due to the fact that in the rabbit, the second proximal perforating branch was poorly developed. In the monkey foot, the catella plantaris distalis is usually formed on the plantar surfaces of the interosseous muscles and metatarsal bones at the distal end of the metatarsus by the distal perforating branches (9). This catella plantaris distalis was observed in the dog and rabbit, though it was not noted in the raccoon dog and cat. It is considered that in the raccoon dog and cat, the distal perforating branches are too thin to form the catella plantaris distalis. In the monkey hand, the catellae palmares proximalis et distalis corresponding to the catellae plantares proximalis et distalis are usually formed (5, 9). In the human hand and foot, these catellae are rarely formed (3, 4). Also in the forepaws of lower mammals, such as the dog and rabbit, the catellae palmares proximalis et distalis are rarely formed though they are usually formed in the cat (7).

This paper moreover shows that the plantar metatarsal arteries of the dog, raccoon dog, cat and rabbit can be classified, as in man (4), into four kinds of arteries (sM2-sM5, sI2-sI4, dM2-dM5 and dI2-dI5) in relation to the interosseous muscles and metatarsal bones. In the dog, raccoon dog and cat, the sI arteries are fully developed and give rise to the proper plantar and dorsal digital arteries. In the rabbit, these

superficial arteries, including the sM arteries, are poorly developed though the deep (dM and dI) arteries are developed to the extent that they connect with the catella plantaris distalis. In the dog, raccoon dog, and cat, the deep (dM and dI) arteries are poorly developed. However, these arteries, particularly dM arteries, are important in producing nutrient vessels to the shafts of the metatarsal bones. In the human hand and foot, the main arteries in the deep palm and planta are the sM arteries, though the sI, dM and dI arteries can give rise to the digital arteries (3, 4). In the monkey hand and foot, the main arteries are the sM and dM arteries though they rarely give rise to the digital arteries (5, 6). In the dog, small branches (dm, Fig. 1) arise from the catella plantaris distalis and ascend along the plantar surfaces of the metatarsal bones. It is considered that these branches compensate for the poorly developed dM arteries.

In man, the plantar articular nerves of the second to fifth metatarsophalangeal joints arise from the deep plantar branch of the lateral plantar nerve and descend on the plantar surfaces of the interosseous muscles in close association with the sM arteries (4). In the animals of the present study, as in man, the plantar articular nerves of the metatarsophalangeal joints arise from the deep plantar branch of the lateral plantar nerve and descend in close association with the sM arteries which are poorly developed. In the human hallux, the plantar articular nerve of the metatarsophalangeal joint arises from the medial plantar nerve and descends in close association with the sM1 artery (4). In the present study, we did not observe the arteries and nerves of the first toe or hallux since they were too thin to dissect out for observation.

Few authors have studied the position and course of the plantar arteries in animals. Nishi (9, 10) and Koch (11) have studied the

hands and feet of some monkeys and described two kinds of arteries; aa. metacarpicae volares and interosseaes volares in the monkey hand, and aa. metatarsae plantares and interosseaes plantares in the monkey foot. Judging from their descriptions and illustrations, their aa. metacarpicae volares and metatarsae plantares correspond to our sM arteries, and their aa. interosseaes volares and plantares to our dI arteries. Our recent studies of some monkeys and lower mammals, including the dog and cat, have shown that the sI and dM arteries occur together with the sM and dI arteries (5-7). The dog plantar metatarsal arteries in the textbook by Miller *et al.* (12) apparently correspond to our sI arteries, judging from their positions on the plantar surfaces of the interosseous muscles and from their courses in the intermetatarsal spaces.

References

1. Johnston TB and Whillis J: The ulnar artery; in Gray's Anatomy, Descriptive and Applied. Longmans, Green and Co., London/New York/Toronto (1949) pp 766-771.
2. Romanes GJ: Arterial arches of hand; in Cunningham's Textbook of Anatomy. Oxford University Press, London (1964) pp 892-893.
3. Murakami T: On the position and course of the deep palmar arteries, with special reference to the so-called palmar metacarpal arteries. *Okajimas Folia Anat Jpn* (1969) **46**, 177-199.
4. Murakami T: On the position and course of the deep plantar arteries, with special reference to the so-called plantar metatarsal arteries. *Okajimas Folia Anat Jpn* (1971) **48**, 295-322.
5. Nakai T, Kikuta A and Murakami T: Deep palmar arteries of monkeys, with special reference to the palmar metacarpal arteries. *Acta Med Okayama* (1987) **41**, 223-228.
6. Hinenoya H, Kikuta A and Murakami T: Pedal arteries of monkeys, with special reference to the plantar metatarsal arteries. *Acta Med Okayama* (1987) **41**, 267-274.
7. Murakami T, Kikuta A and Nakai T: Deep palmar arteries of some mammals, with special reference to the palmar metatarsal arteries. *Okajimas Folia Anat Jpn* (1987) **64**, 193-202.
8. Adachi B: Arterien der Fußsohle; in *Das Arteriensystem der Japaner. Band II.* Maruzen Co., Kyoto (1928) ss 260-292.
9. Nishi S: Über die Arterien des Affenfusses. Eine typologisch-anatomische Studie. *Jpn J Med Sci I. Anatomy* (1943) **11**, 127-148.
10. Nishi S: Über die Arterien des Affenhand. Ein Beitrag zur vergleichenden Angiologie. *Jpn J Med Sci I. Anatomy* (1939) **7**, 385-393.
11. Koch K: Das Verhalten der Arterienbögen in der Vola manus und Planta pedis bei Affen. *Z Anat Entwicklungsgesch* (1939) **110**, 81-97.
12. Miller ME, Christensen GC and Evans HD: Arteries of the hindpaw; in *Anatomy of the Dog.* WB Saunders Co., Philadelphia/London (1964) pp 371-378.

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