Deep Palmar Arteries of Some Mammals, with Special Reference to the Palmar Metacarpal Arteries.

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Summary: In the dog, raccoon dog, cat and rabbit, the second proximal perforating branch was fully developed forming the deep palmar arch. The catella volaris proximalis was only observed in the rabbit. The palmar metacarpal arteries arose from the deep palmar arch or catella volaris proximalis, and descended in the deep palm to finally connect with the palmar digital arteries at the end of the metacarpus. Regardless of their origin and termination, the palmar metacarpal arteries could be classified into four kinds of arteries: (1) sM arteries descending on the palmar surface of the interosseous muscles along the metacarpal bones, (2) sI arteries descending on the palmar surface of the interosseous muscles along the intermetacarpal spaces, (3) dM arteries descending deep in the interosseous muscles along the metacarpal bones, and (4) dI arteries descending deep in the interosseous muscles along the intermetacarpal spaces. These findings are consistent with those of the human hand and foot (Murakami, 1969, 1971).

It is well known that the deep layer of the human metacarpus is supplied by palmar metacarpal arteries. Murakami (1969) classified these metacarpal arteries in relation to the interosseous muscles and metacarpal bones: (1) superficial palmar metacarpal (sM) arteries descending on the palmar surface of the interosseous muscles along the metacarpal bones, (2) superficial palmar intermetacarpal (sI) arteries descending on the palmar surface of the interosseous muscles along the intermetacarpal spaces, (3) deep palmar metacarpal (dM) arteries descending deep in the interosseous muscles along the metacarpal bones, and (4) deep palmar intermetacarpal (dI) arteries descending deep in the interosseous muscles

along the intermetacarpal spaces. Such a classification was also applicable to the human foot (Murakami, 1971). The present paper describes these four types of arteries in the forepaw of some animals.

Materials and Methods

Adult dog (*Canis familiaris*), raccoon dog (*Nyctereutes viverrinus*), cat (*Felis domestica*) and 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 forepaw of these animals was dissected in

the dissecting room of Okayama University Medical School.

Results

In the dog, raccoon dog and rabbit, the

proper palmar digital arteries of the forepaw digits including the first digit arose from the palmar digital arteries which was connected to palmar branch of the ulnar artery (Fig. 1, 2, 4). In the cat, the palmar branch of the ulnar artery was poorly developed and sup-

Fig. 1. A diagram of palmar view of the vascular pattern in the deep layer of the dog forepaw. Abbreviations: see Table 1.

Fig. 2. A diagram of palmar view of the vascular pattern in the deep layer of the raccoon dog forepaw. Abbreviations: see Table 1.

plied only the radial proper palmar digital artery of the first digit and the ulnar proper palmar digital artery of the fifth digit; thus the remaining proper palmar digital arteries arose from the palmar metacarpal arteries

in the deep palm (Fig. 3) (see below).

In all our animals, the dorsal branch of the radial artery was the origin of dorsal metacarpal arteries and proximal perforating branches at the proximal ends of the

Fig. 3. A diagram of palmar view of the vascular pattern in the deep layer of the cat forepaw. Abbreviations: see Table 1.

Fig. 4. A diagram of palmar view of the vascular pattern in the deep layer of the rabbit forepaw. Abbreviations: see Table 1.

Table 1. Abbreviations in Figures 1 – 4

Ad	: adductor pollicis muscle
Cn	: contrahentes muscles
Fl	: flexor pollicis brevis muscle
In	: interosseous muscles
Lm	: lumbrical muscles
ab	: abductor digiti minimi muscle
fl	: flexor digiti minimi brevis muscle
F1 – F5	: first – fifth fingers
c2 – c4	: palmar digital arteries (second – fourth common palmar digital arteries)
p1 – p4	: first – fourth proximal perforating branches
da	: deep palmar arch
ri	: radial proper palmar digital artery of the second finger
rm	: deep palmar branch of the ulnar artery
rt	: radial proper palmar digital artery of the first finger
um	: ulnar proper palmar digital artery of the fifth finger
ut	: ulnar proper palmar digital artery of the first finger
dI1 – dI4	: first – fourth deep palmar intermetacarpal arteries
dM1 – dM5	: first – fifth deep palmar metacarpal arteries
sI1 – sI4	: first – fourth superficial palmar intermetacarpal arteries
sM1 – sM5	: first – fifth superficial palmar metacarpal arteries
arrowhead	: anastomoses between the deep palmar arch and catella volaris proximalis

intermetacarpal spaces. The dorsal metacarpal arteries ran on the dorsal surface of the interosseous muscles and gave rise to the proper dorsal digital arteries which were finer than the palmar digital arteries. The proximal perforating branches penetrated the interosseous muscles at a level just distal to the base of the metacarpal bones. One of these perforating branches, the second was fully developed and passed through the second intermetacarpal space, forming the deep palmar arch on the palmar surface of the interosseous muscles with the deep palmar branch of the ulnar artery (Fig. 1-4). In the rabbit, the third and fourth proximal perforating branches were well developed and formed the catella volaris (palmaris) proximalis (Fig. 4) (see below). The deep palmar branch of the ulnar artery was not observed in the cat (Fig. 3).

The palmar metacarpal arteries arose from the deep palmar arch or catella volaris proximalis (Fig. 1-4). By their relationship to the interosseous muscles and metacarpal bones, the palmar metacarpal arteries

except those in the pollex (see below) could be classified into: (1) the second to fifth superficial palmar metacarpal (sM2 – sM5) arteries descending on the palmar surface of the interosseous muscles along the second to fifth metacarpal bones, (2) the second to fourth superficial palmar intermetacarpal (sI2 – sI4) arteries descending on the palmar surface of the interosseous muscles along the second to fourth intermetacarpal spaces, (3) the second to fifth deep palmar metacarpal (dM2 – dM5) arteries descending deep in the interosseous muscles along the second to fifth metacarpal bones, and (4) the second to fourth deep palmar intermetacarpal (dI2 – dI4) arteries descending deep in the interosseous muscles along the second to fourth intermetacarpal spaces.

In the pollex, the adductor pollicis muscle was small or poorly developed so that the first deep palmar intermetacarpal (dI1) and first superficial palmar intermetacarpal (sI1) arteries descended respectively along the radial and ulnar margins of this muscle (Figs. 2, 3). The first deep palmar meta-

carpal (dM1 or princeps pollicis) artery descended along the first metacarpal bone, being covered by the adductor pollicis and flexor pollicis brevis muscles (Figs. 1, 4). The first superficial palmar metacarpal (sM1) artery descended on the palmar surface of the adductor pollicis and flexor pollicis brevis muscles along the first metacarpal bone (Fig. 2).

The sM, sI, dM, and dI arteries were independent vessels, but their development varied in each case. The poorly developed sM, sI, dM and dI arteries terminated only in the mid-region of the metacarpus. In contrast, the well developed sM, sI, dM and dI arteries reached the metacarpophalangeal joints or descended over these joints to connect with the palmar digital arteries. The well developed sM, sI, dM and dI arteries are described.

Dog (Fig. 1)

The dorsal branch of the radial artery gave off a well developed second proximal perforating branch. This branch produced the dM2 artery and gave rise to the deep palmar arch. This palmar arch received the poorly developed deep palmar branch of the ulnar artery, and gave off the dM1, sI2, sI3, sM4 and sI4 arteries. The sI2, and sI3 and sI4 arteries continued into the palmar digital arteries. The other arteries terminated near the metacarpophalangeal joints.

Raccoon dog (Fig. 2)

The dorsal branch of the radial artery gave off a well developed second proximal perforating branch. This branch yielded the dM2 artery and gave rise to the deep palmar arch. This palmar arch received the poorly developed deep palmar branch of the ulnar artery, and gave off the sM1, sI1, sI2, sI3, sI4 and sM5 arteries. The sI1, sI2, sI3 and

sI4 arteries continued into the palmar digital arteries. The other arteries terminated near the metacarpophalangeal joints.

Cat (Fig. 3)

The dorsal branch of the radial artery gave off a well developed second proximal perforating branch. This branch produced the dI1 and dM1 arteries and gave rise to the deep palmar arch, which gave off the dI2, dI3, dI4 and sM5 arteries. The dI1, dM2, dI2, dI3 and dI4 arteries were fully developed and gave rise to the palmar digital arteries.

Rabbit (Fig. 4)

The dorsal branch of the radial artery gave off the first, second, third and fourth proximal perforating branches. The first perforating branch gave rise to the dM1 artery. The second perforating branch was well developed and gave rise to the deep palmar arch. This palmar arch received the poorly developed deep palmar branch of the ulnar artery, and gave off the sI2, sI3, and sI4 arteries. The third and fourth perforating branches anastomosed into the deep palmar arch. The third and fourth perforating branches also formed the catella volaris proximalis between the second and fifth metacarpal bones, together with a branch of the second perforating branch. This catella gave off the dM2, dM3, dM4 and dM5 arteries. The sI2, sI3, sI4 and dM5 arteries continued into the palmar digital arteries. The other arteries terminated near the metacarpophalangeal joints.

Discussion

This paper describes the basic vascular architecture of the palmar and dorsal layers of the forepaw and its digits of the dog,

raccoon dog and rabbit. The structure is similar to the human hand. In these animals as in man (Adachi, 1928; Murakami, 1969), the proper palmar digital arteries (main arteries of the fingers) and the proper dorsal digital arteries (accessory arteries of the fingers) arise respectively from the palmar digital arteries and dorsal metacarpal arteries. In contrast, the cat forepaw blood vascular pattern differs somewhat. In this animal, the proper palmar digital or palmar digital arteries arise from the palmar metacarpal arteries. Such palmar digital arteries with deep origin have occasionally been reported in the human hand (Murakami, 1969). In the human foot, it has been frequently observed that the palmar metacarpal arteries with deep origin gave rise to the palmar digital arteries (Murakami, 1971).

This paper also shows that the basic blood vascular architecture of the deep layer of the forepaw of the dog, raccoon dog, cat and rabbit is similar to structure in the human hand. The blood vascular system of the deep palm in these animals as in the human hand (Murakami, 1969) is composed of the superficial and deep arteries. The superficial (sM and sI) arteries descend on the palmar surface of the interosseous muscles or on the dorsal surface 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 the second proximal perforating branch is fully developed and forms the deep palmar arch, though in the human hand the first proximal perforating branch usually forms the deep palmar arch (Adachi, 1928; Murakami, 1969). In the monkey hand, the catella volaris proximalis is usually formed deep in the interosseous muscles by the first to fourth proximal perforating branches (Nishi, 1939) though it is rarely formed in the human hand (Murakami,

1969). In animals studied here, the catella volaris proximalis was observed only in the cat. In the monkey hand, the catella volaris distalis is usually formed on the palmar surface of the interosseous muscles and metacarpal bones at the distal end of the metacarpus by the distal perforating branches (Nishi, 1939). As in man (Murakami, 1969) this distal catella is poorly developed in animals studied here since the distal perforating branches are poorly developed.

This paper moreover shows that the palmar metacarpal arteries of the dog, raccoon dog, cat and rabbit as in man (Murakami, 1969) can be classified into four kinds of arteries (sM1 – sM5, sI1 – sI4, dM1 – dM5 and dI1 – dI4) in relation to the muscles and bones (see above). In the dog, raccoon dog and rabbit, the sI arteries are well developed and connect with the palmar digital arteries. In the cat, the dI arteries are fully developed and give rise to the palmar digital arteries. In the dog, raccoon dog, cat and rabbit, it is rather rare that the sM and dM arteries are sufficiently developed to connect with the digital arteries. However, the dM arteries are important in producing nutrient vessels to the shafts of the metacarpal bones. Our recent study has shown that in some monkeys such as *Hylobates lar* and *Cynopithecus niger*, dM arteries constantly anastomose into the catella volaris distalis. The details of these findings will be reported elsewhere. In the human hand, the main arteries in the deep palm are the sM arteries, though the sI, dM and dI arteries can give rise to the palmar digital arteries (Murakami, 1969). In the human foot, the main arteries in the deep planta are also the sM arteries (Murakami, 1971).

In man, the palmar articular nerves of the second to fifth metacarpophalangeal joints arise from the deep palmar branch of the ulnar nerve and descend on the palmar surface of the interosseous muscles in close

association with the sM arteries (Murakami, 1969). In our animals here as in man, the palmar articular nerves of the metacarpophalangeal joints arise from the deep palmar branch of the ulnar nerve and descend in close association with the sM arteries. In the human pollex, the palmar articular nerve of the metacarpophalangeal joint arises from the median nerve and is accompanied by the sM1 artery (Murakami, 1969). In the animals here as in man, the palmar articular nerve of the first metacarpophalangeal joint arises from the median nerve and descends in close association with the sM1 artery. This was clearly observed in the raccoon dog.

Few authors have studied the position and course of the palmar metacarpal arteries in animals. Nishi (1939, 1943) and Koch (1939) have studied the hands and feet of some monkeys and described two kinds of arteries; aa. metacarpicae volares and interosae volares in the monkey hand, and aa. metatarsae plantares and interosae plantares in the monkey foot. Judging from their description and illustrations, their aa. metacarpicae volares and metatarsae plantares correspond to our sM arteries, and their aa. interosae volares and plantares to our dI arteries. Our recent study of the *Hylobates lar*, *Cynopithecus niger* and other monkeys has shown that the sI and dM arteries occur together with the sM and dI arteries. Details of these findings will be

reported elsewhere. The dog palmar metacarpal arteries in the text book by Miller et al. (1964) apparently correspond to our sI arteries, judging from their positions on the palmar surface of the interosseous muscles and their course in the intermetacarpal spaces.

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