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Scanning Electron Microscopic Study of the Capillary Loops in Human Hand Skin

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ABSTRACT. The microvasculature of the ball of the finger of an 85-year-old man was examined by means of scanning electron microscopy of resin casts. Each papilla had a loop of capillary vessels with ascending limbs, a hairpin turn and descending limbs. After the loop passed a hairpin turn, the descending limbs were 1.3 times larger than the ascending limbs. Three patterns of capillary loops were observed in this area: (1) a single loop pattern, with a straight or coiled structure, (2) a complex loop pattern, in which the capillary loops were formed out of not just one capillary vessels, but out of two or three vessels. Each capillary vessel arose and divided into several branches at the papillae and they became descending limbs, (3) an intermediate pattern between type (1) and (2).

I believe that changes in the papillae due to aging cause these differences.

Key words : capillary loop — resin cast — human hand skin — scanning electron microscope

The vasculature of the skin of the hand in Primates, an order which includes man, has been studied by others,[1-5] but such studies have been unable to provide a three-dimensional picture of the architecture of the vasculature of the skin. In 1978, Inoue[6] examined the vasculature of human amputated fingers by means of scanning electron microscopy of resin casts, but it was not reported in detail because of the limited materials.

In my previous study,[7] I examined the capillary loops of the skin of the hand of Japanese monkeys using scanning electron microscopy of resin casts. In this study, the microvasculature of the ball of the human finger was observed and the capillary loops were examined in minutest detail dimensionally.

MATERIALS AND METHODS

An 85-year-old man without any skin disease who had been dead 48 hours was used in this study. The radial artery and vein were cannulated and irrigated with a normal saline solution containing heparin (irrigating pressure under 100 mmHg).

For scanning electron microscopy, Mercox (Dainihon Ink Co. Ltd., Tokyo Japan, principally composed of acrylate monomer) was injected through the radial artery until the radial vein was filled with the injected resin. After this the resin was polymerized for 2 to 3 hours, the wrist was removed and

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macerated completely in a 20% aqueous potassium hydroxide solution for 3–4 days, and then the casts were washed in running water. Next, they were washed in a microwave box and rinsed. After thorough rinsing, the casts were air dried and the ball of the finger was cut out. The dried casts of the vessels were mounted, coated with gold-palladium, and examined with a scanning electron microscope (model S-570 Hitachi).

RESULTS

By using the corrosion casting method, the architecture of the vasculature of the human hand skin could be easily demonstrated. Identification of the arteries and venules was determined by examining the subpapillary venules, which exhibited prominent endothelial nuclear impressions, and was confirmed by examination of the digital arteries.

With regard to the ball of the human finger, the width of the epidermal ridge was 280 microns on average. In contrast, the width of the epidermal groove was 67 microns on average (Table 1).

TABLE 1. Width (epidermal ridge and groove), dimensions and height of capillary loops

width	
epidermal ridge	260~320 (280)
epidermal groove	50~ 80 (67)
dimensions	
ascending limb	4.1~11.5 (7.4)
descending limb	6.6~13.2 (9.7)
height	60~140 (89.6)

(average, microns)

The capillary loops in the epidermal ridge exhibited an irregular arrangement. The arterial capillary network, which follows the epidermal groove, was observed in the superficial layer of the subpapillar arterial capillary network (Fig. 1, arrow C).

Each papilla had a loop of capillary vessels with ascending limbs, a hairpin turn, and descending limbs. The dimension of the descending limbs was 9.7 microns on average, while that of the ascending limbs was 7.4 microns. The descending limbs were 1.3 times larger than the ascending limbs. The height of the capillary loops ranged from 60 to 140 (89.6 on average) microns (Table 1).

The structure of the capillary loops of the ball of the finger was classified into the following three patterns.

1) A single loop pattern

The capillary loops for each ascending limb and descending limb were formed out of one capillary vessel and generally ascended straight-forwardly in the papillae (Fig. 1, arrow A). Otherwise, they exhibited a spiral shape in the papillae (Fig. 1, arrow B).

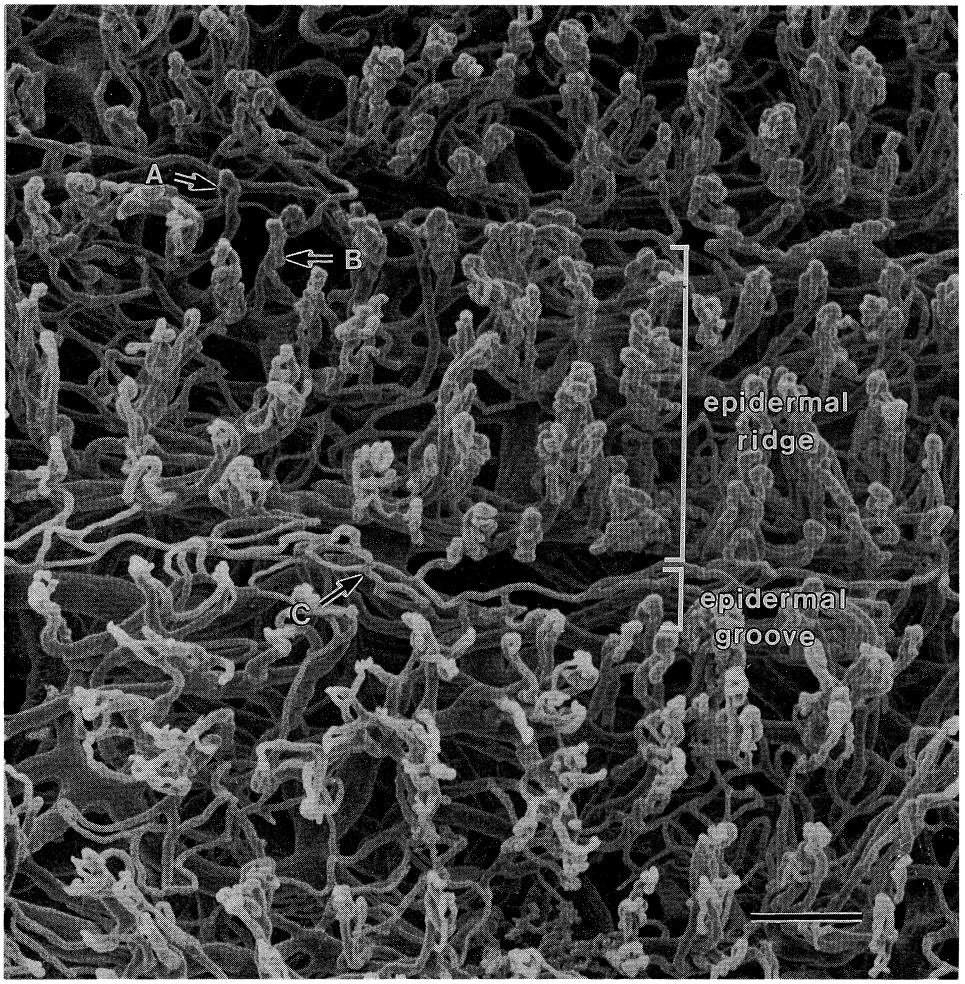

Fig. 1. The ball of the finger (taken from an angle of 45 degrees and following the epidermal ridges)
Scale : 100 microns
Arrow A : straight structure
Arrow B : coiled structure
Arrow C : arterial capillary network

2) A complex loop pattern

These capillary loops were formed out of several capillary vessels. Each capillary vessel arose and divided into several branches in the papillae, and these became descending limbs (Fig. 2, arrow A).

3) Intermediate pattern

These capillary loops exhibited a comparatively simple structure, formed out of one or two capillary vessels. These capillary vessels arose and divided into several branches at the papillae.

The capillary loop indicated by Fig. 3 had a comparatively simple structure, formed by two capillary vessels arising from the arterial capillary network (arrows A, B). One capillary vessel (arrow A) diverged into two branches in the papilla. One branch arose like arrow A, turned over and became the

descending limb. The other directly connected with the descending limb after divergence. In the other capillary vessel (arrow B), on the other hand, the descending limb connected with the ascending limb after a hairpin turn.

The structure of the capillary loop shown in Fig. 4 was formed by one capillary vessel which arose from the arterial capillary network. The capillary vessel diverged into two branches in the papilla and each branch turned into a descending limb. These descending limbs anastomosed with each other and flowed into the subpapillary venule.

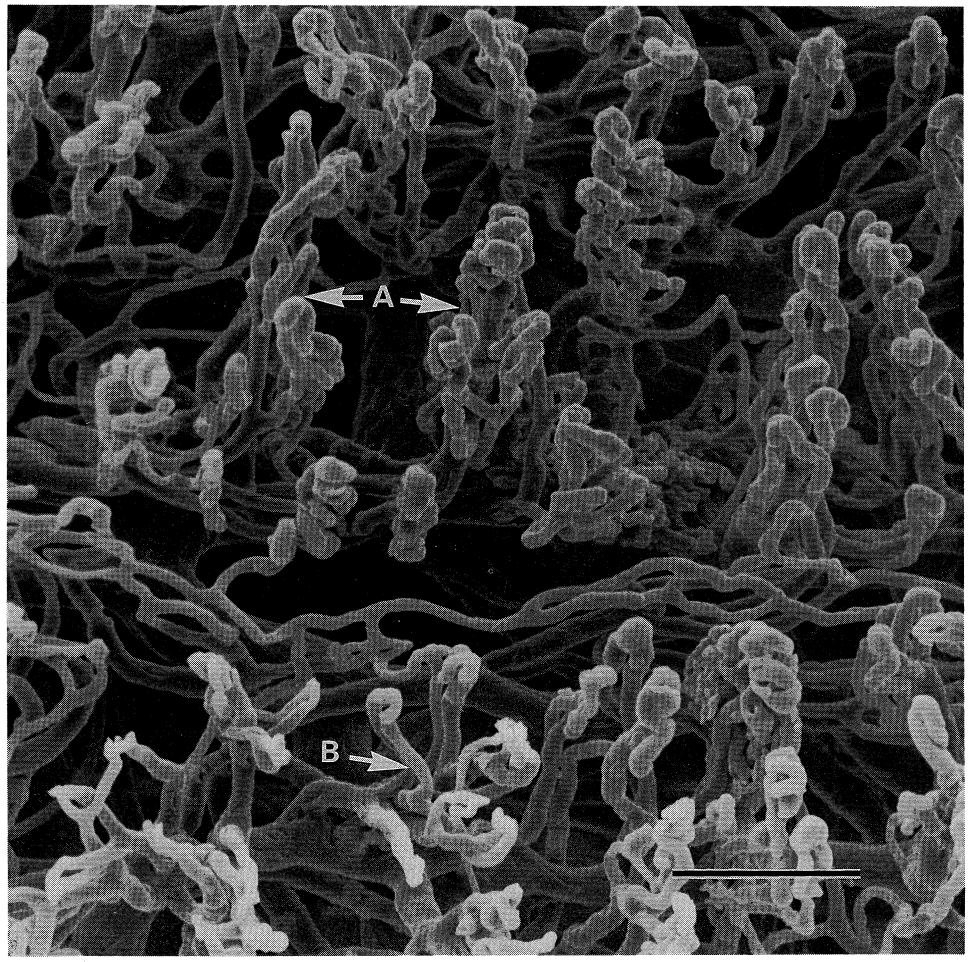

Fig. 2. A magnification of Figure 1
Scale : 100 microns
Arrow A : complex loop structure
Arrow B : Each capillary loop had a simple structure, but the root was crowded.

DISCUSSION

The skin has been observed to have double capillary loop lines or occasionally a 4th loop line in the epidermal ridges, which regularly follow the lines

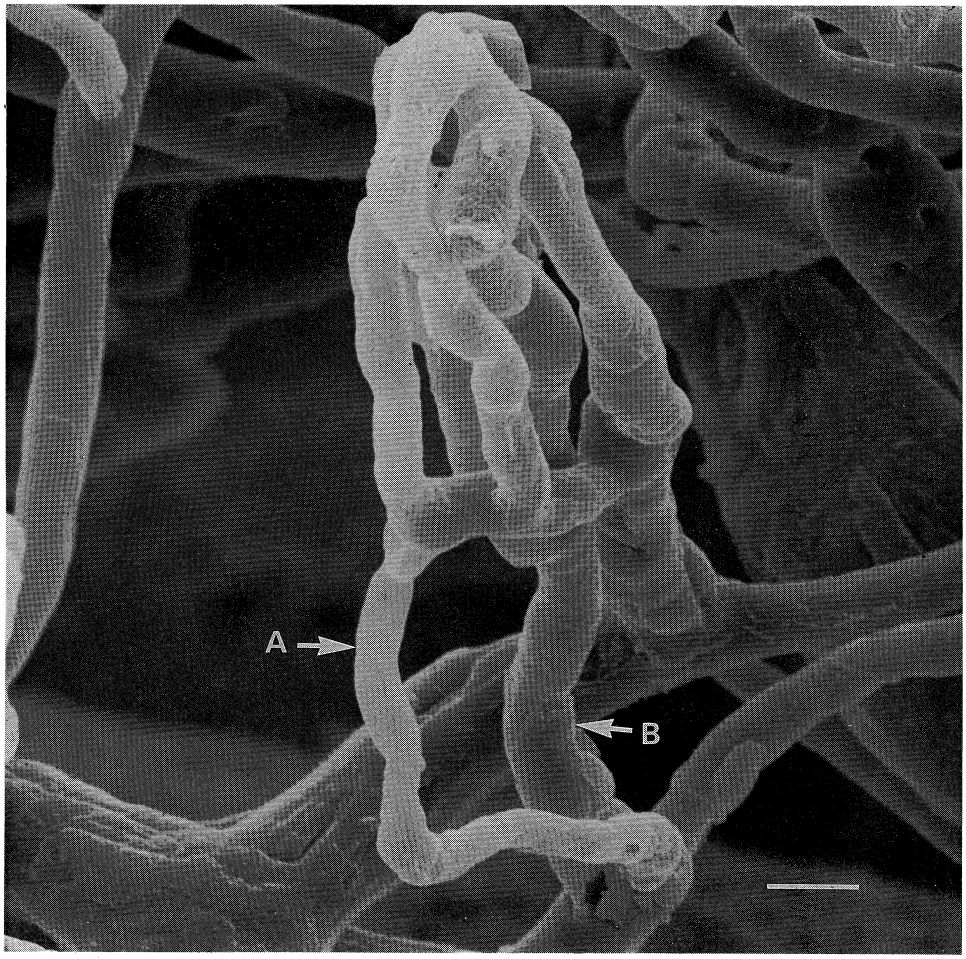

Fig. 3. A magnification of type 3
Scale : 10 microns
Arrows A, B : arterial capillary vessels which formed the capillary loop

of the fingerprint.[4,8] In 1979, Okajima[9] reported that the dermal papillae under an epidermal ridge in the thumb apex of a fetus in the eighth gestational month were arranged in a double row, while those of human adults were larger in number and their arrangement was crowded. In the materials of my study, the epidermal ridges were 4 times wider than the epidermal grooves and the arrangement of the capillary loops was irregular in the epidermal ridges. This, I believe, may be regarded as a transition due to age as suggested by Okajima.[9]

With regard to the structure of the capillary loops in human hands, Maruyama observed that there were many ascending and descending limbs with a slightly winding shape.[4] In a study of an amputated human finger, Inoue noted that they had a spiral shape.[6] Many detailed structural points, however, remain obscure. Capillary loops with a very simple structure such as those observed in my study (Fig. 1, arrows A, B) were also described by Maruyama and Inoue, but I also found some loops of a complex type (Figs. 2,3,4).

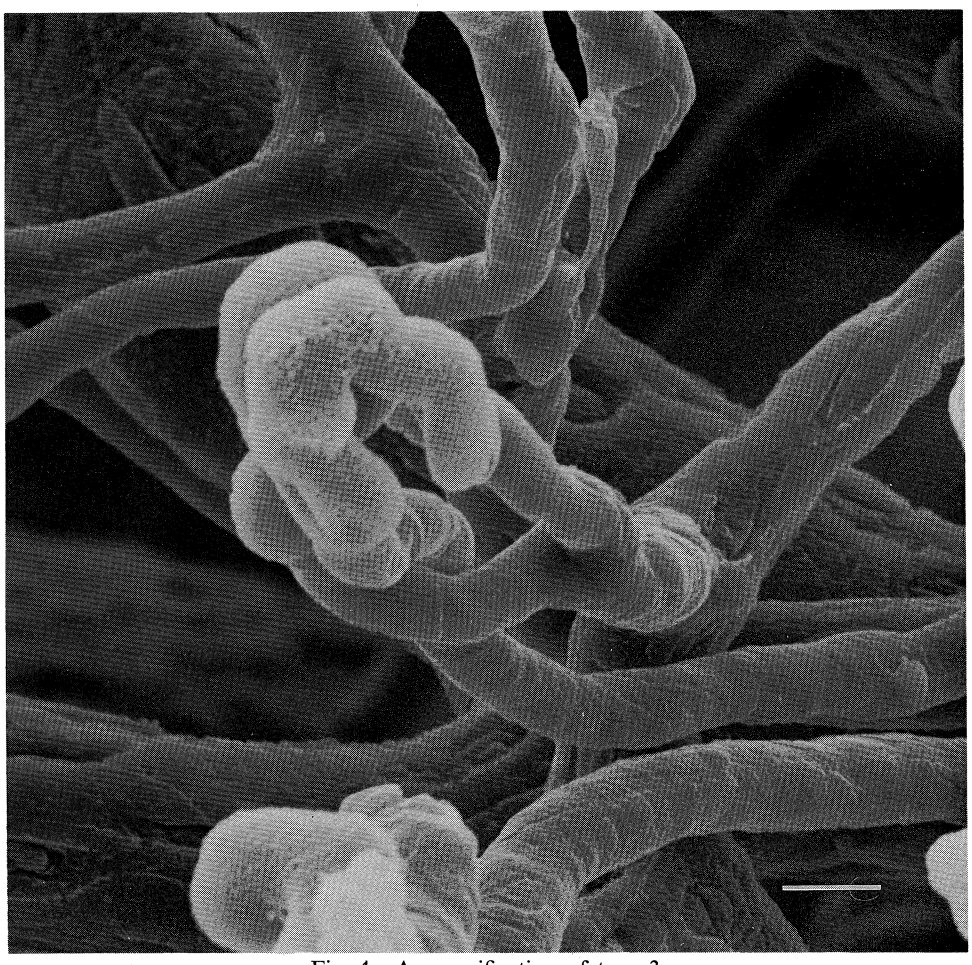

Fig. 4. A magnification of type 3
Scale : 10 microns

In my previous study,[7] I examined the capillary loops of the hand of the Japanese monkey. In the Japanese monkey, I reported the existence of capillary loops of a complex type (Fig. 5) and, in the lateral side of the finger, the existence of a subepidermal arterial capillary network in the superficial layer of the subpapillar arterial capillary network. It was concluded that the subepidermal arterial capillary network in the Japanese monkey was the equivalent of the arterial capillary network which follows the epidermal groove in human (Fig. 1). Moreover, the capillary loops in the Japanese monkey were found to be quite similar to those in humans (Fig. 2, arrow A), especially in their arrangement in double lines in the epidermal ridges.

The basic structure of the capillary loops of the ball of the finger of the human hand is complicated, but as the branches of the loops extend throughout the ball of the finger, becomes simple due to proliferation of the papillae, which I consider a phenomena of aging. I think that the mixture of small and large capillary loops is due to the proliferating papillae which exist in various phases. I believe the form shown in Fig. 2, arrow B is the proliferating phase

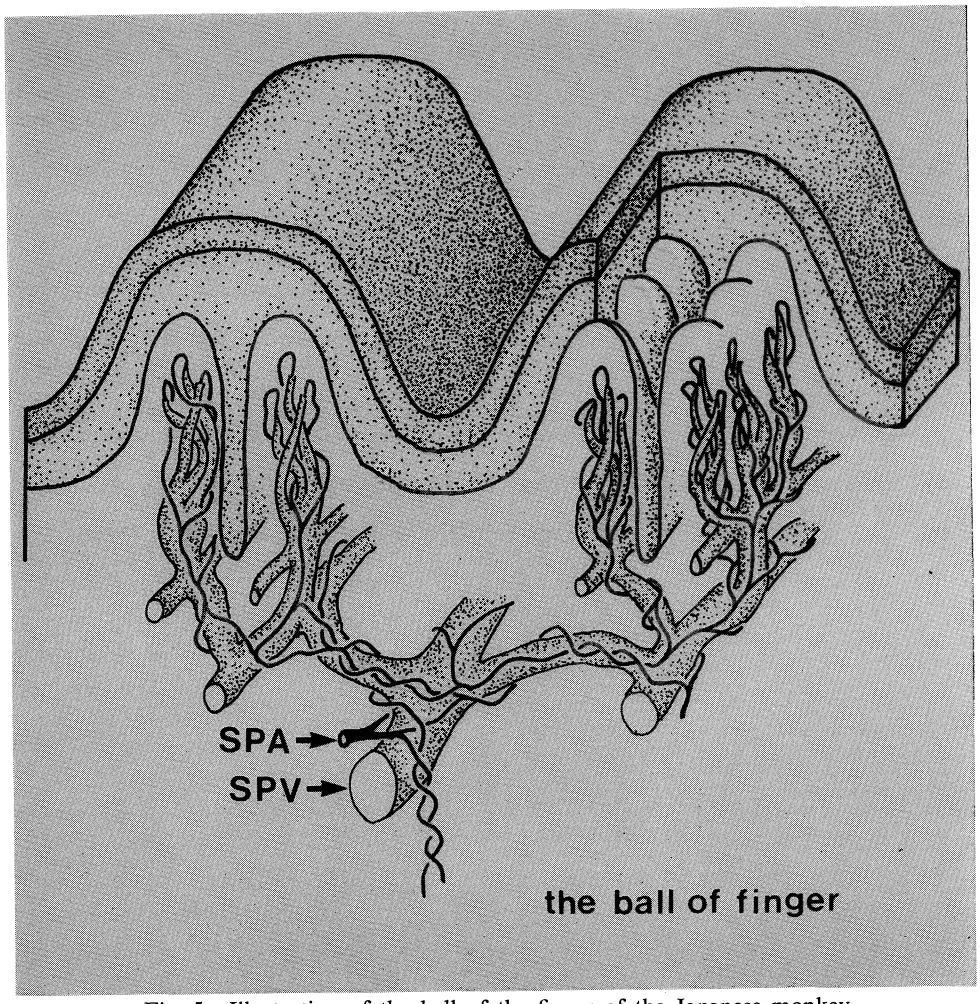

Fig. 5. Illustration of the ball of the finger of the Japanese monkey

of the basic structure of the capillary loop attending the proliferation of the papillae. Such changes in the capillary loops might allow for vertical mobility of the skin without injury to the vessels and might maintain blood flow at a normal level in spite of external pressure applied vertically to the skin surface.

Here I have reported new data and observations on the capillary loops of the ball of the human finger. In the future, I hope to make comparisons of other parts of human skin at various ages.

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