# Study of the Anatomical Bases of a Perforator Flap from the Hypothenar Eminence

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**ABSTRACT.** The perforators of the deep branch of the ulnar artery, which nourish the skin overlying the proximal portion of the abductor and flexor digiti minimi muscles, were studied in 60 hand of cadavers by three dimensional angiography following injection of barium sulfate.

The deep branch of the ulnar artery gave off 0 to 5 skin perforating arteries. These perforating arteries could be divided into two types. The first type was characterized by branching of the perforator from the proximal portion of the deep branch of the ulnar artery, and its spreading directly to the subcutaneous tissues and skin. The average distance between the distal margin of the pisiform and the site of these proximal perforators was 5.7 ($\pm$3.4) mm. The second type was characterized by branching of the perforator from a more distal portion of the deep branch of the ulnar artery, and it divided with the abductor digiti minimi muscle perforator and ran distally. The portion of the distal perforators which emerged from the deep fascia was 25.8 ($\pm$4.7) mm from the distal margin of the pisiform.

This finding provides the basis for a new perforator flap from the proximal portion of the hypothenar eminence.

In hand surgery, post-traumatic losses of the palmar aspect of the hand i.e., the palm, wrist and finger are frequent. These losses can present difficulties in reconstruction leading to functional and cosmetical limitations. Ideal repair of these regions is coverage with skin possessing characteristics similar to the original skin. Based on this assumption, various skin flaps from the palm have been reported. In introducing the concept of the perforator flap, it is neccesary to determine specific information concerning the vascular anatomy of the donor site. In this study, the author investigated the anatomical basis for the perforator flap from the hypothenar eminence, which is nourished by perforators from the deep branch of the ulnar artery.

**Key words: perforator flap — hypothenar muscle — abductor digiti minimi muscle**

## MATERIALS AND METHODS

Sixty adult human hands from cadavers were used in this study. The subject group consisted of 22 men and 10 women, with a mean age at death of 78 years.

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## EMBALMING TECHNIQUE

Within 48 hours after the death of the abovementioned subjects, an arterial embalming technique was employed to prepare the materials.[1] This technique consisted of pre-embalming treatment with a blood clot disperser (pH-A solution and cell conditionar, Champion Co., Ltd., USA), removal of blood clots, draining of blood, and arterial embalming with an embalming apparatus via both the axillary and femoral arteries. The embalming fluid consisted of 95% ethyl alcohol (7.6 l), 35% formalin (1.3 l) as a fixative, diethylene glycol (2.7 l) as a preservative, liquefied phenol (1.3 l) as a mold preventative, and water (8.0 l).

## THREE-DIMENSIONAL ARTERIOGRAPHS

Following embalming, a volume of 10 to 15 ml of radiopaque substances (barium sulfate) was injected into the axillary by means of a syringe with hand pressure. Stereoscopic arteriographs were made with Kodak X-Omat XTL at a focal spot-to film distance of 80 cm. The focal spot position was shifted 30 mm to the left and right of the center of the hand to create a pair of stereoarteriographs. The arterial patterns were analyzed stereoscopically by a Nikon Stereoscope (Model II).

In six speciments, injection of a silicon rubber compound (Microfil®) was selectively made into the deep ulnar artery to demonstrate the area stained. To visualize small veins, injection of the silicon rubber compound was performed retrogradely into the ulnar cutaneous vein from the wrist in six specimens.

By employing three-dimensional analysis of arteriographs with the embalming thchnique described above, it has been possible to identify arteries as small as approximately 60 $\mu$m in diameter, and there has been no confusion regarding the arteriovenous plexus.

After the arteriographs were examined, subsequent anatomic dissection of the hypothenar region was performed on a number of specimens. The diameter of the perforator from the deep ulnar artery and the distance between the site of this perforating artery and the distal margin of the pisiform were measured.

## RESULTS

The hypothenar skin was nourished by blood vessels perforating the underlying hypothenar muscles or fascia. These vessels usually arose from the ulnar palmar digital artery of the little finger and the superficial and deep branches of the ulnar artery (Fig 1).

The distal half of the ulnar aspect of the hypothenar eminence was supplied by perforating branches emerging from the ulnar palmar digital artery. This area was located over the distal half of the abductor digiti minimi muscles. The proximal half of the ulnar aspect of the hypothenar eminence was supplied by perforating arteries emerging from the hypothenar muscles which mostly branched from the deep branch of the ulnar artery. These vascular territories on the hypothenar eminence overlapped on the hypothenar eminence (Fig 2).

The deep branch of the ulnar artery, lying proximal to the deep branch of the ulnar nerve, was found in all specimens. The average distance between the

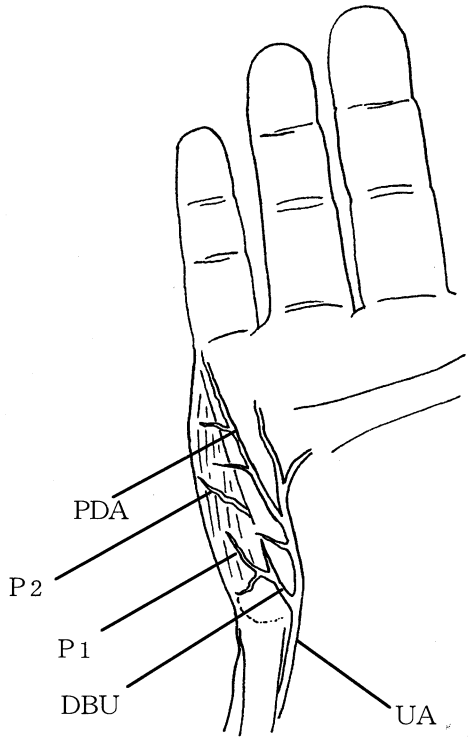



Fig 1. UA : Ulnar artery, DBU : Deep palmar branch, $P_1$, $P_2$ : Skin perforator, PDA : Palmar digital artery

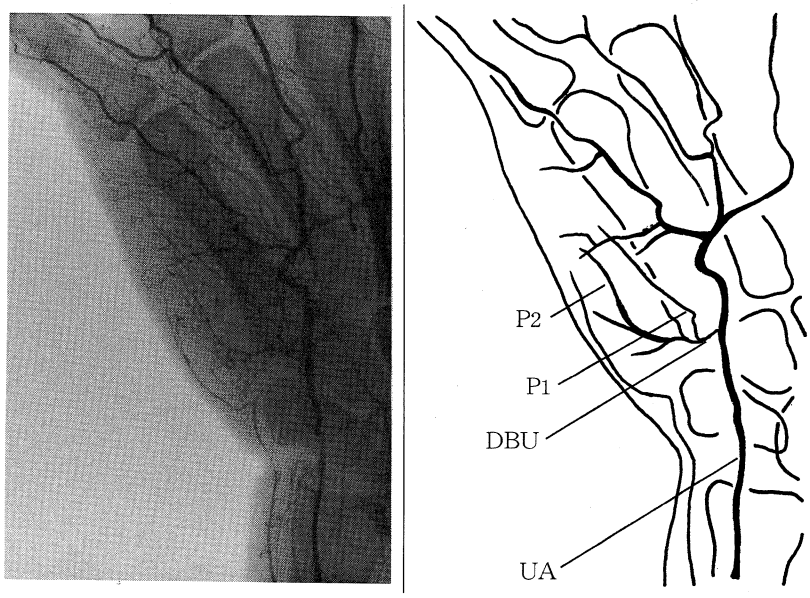
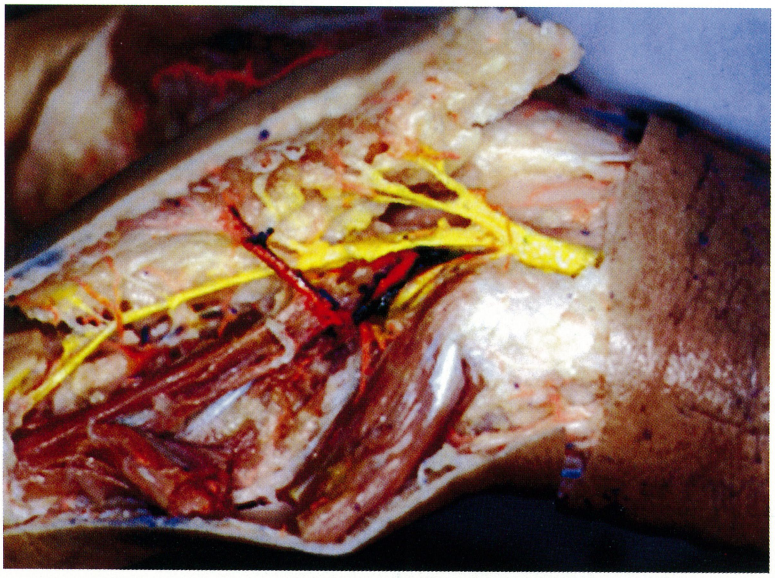



Fig 2. X-ray finding of the hypothenar region.
UA : Ulnar artery, DBU : Deep palmar branch, $P_1$, $P_2$ : Skin perforator
The proximal half of the ulnar aspect of the hypothenar eminence was mostly supplied by perforating arteries branching from the deep branch of the ulnar artery.

TABLE 1.

| | location of perforator* Average (S.D.) mm | mean diameter Average (S.D.) mm |
|---|---|---|
| $P_1$ (n=63) | 5.7 (±3.4) | 0.83 (±0.19) |
| $P_2$ (n=51) | 25.8 (±4.7) | 0.85 (±0.16) |

*Distance between the origin of the deep branch of the ulnar artery and the distal margin of the pisiform.



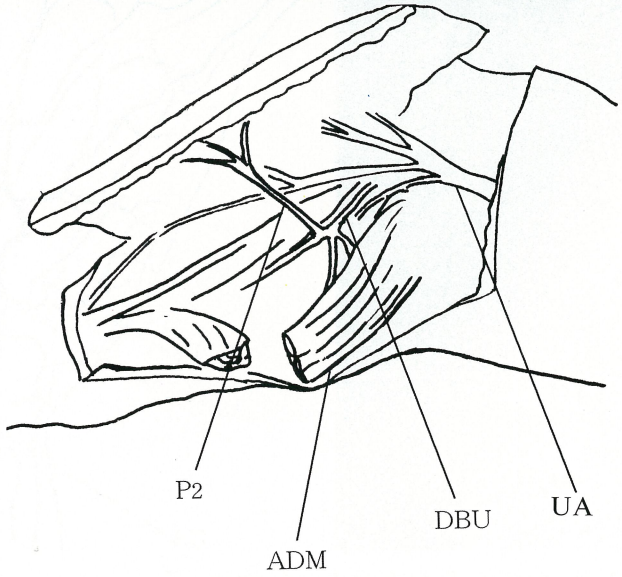



Fig 3. UA : Ulnar artery, DBU : Deep palmar branch,
ADM : Abductor digiti minimi muscle
$P_2$ : Distal skin perforator
Note that the distal perforator emerges as a septocutaneous perforator.

distal margin of the pisiform and the site of origin of the deep branch of the ulnar artery from the ulnar artery was 3.3 mm (±4.0). The deep branch of the ulnar artery gave off 0 to 5 skin perforating arteries. These perforating arteries divided into two types. The first type was characterized by the branching of the perforator from the proximal portion of the deep branch of the ulnar artery and its spreading directly to the subcutaneous tissues and skin. It was found in 83.3% of the hands. The average distance between the distal margin of the pisiform and the site of these proximal perforators ($P_1$) was 5.7 (±3.4) mm (n=63). The average diameter of the base of there perforators was 0.83 (±0.19) mm (n=63). The second type characterized by branching of the perforator from the more distal portion of the deep branch of the ulnar artery, and it divided with the abductor digiti minimi muscle perforator and ran distally. It was found in 63.3% of the hands. The portion of the distal perforators ($P_2$) which emerged from the deep fascia was 25.8 (±4.7) mm (n=51) from the distal margin of the pisiform. The average diameter of the base of these perforators was 0.85 (±0.16) mm (n=51) (Table 1).

In 84.4% of the distal perforating arteries from the deep branch of the ulnar artery, septocutaneous perforators were found between the abductor and flexor digiti minimi muscles. The perforators supplied the hypothenar muscles and its overlying skin (Fig 3). In these specimens, the perforating arteries to the hypothenar skin from the deep branch of the ulnar artery had vascular connections with perforating arteries from the ulnar palmar digital artery of the little finger. In the other 15.6%, the distal perforating arteries from the deep branch of the ulnar artery were found to be musculocutaneous perforators, supplying the abductor digiti minimi muscle and its overlying skin. In 36.7% of the hands, a distal skin perforator from the deep branch of the ulnar artery was not found and only a muscle perforator was identified. In these cases, there were perforating arteries branching at the ulnar artery proximal site to the bifurcation of the ulnar palmar artery of the little finger. The perforators of this portion were classified into four patterns (Fig 4).

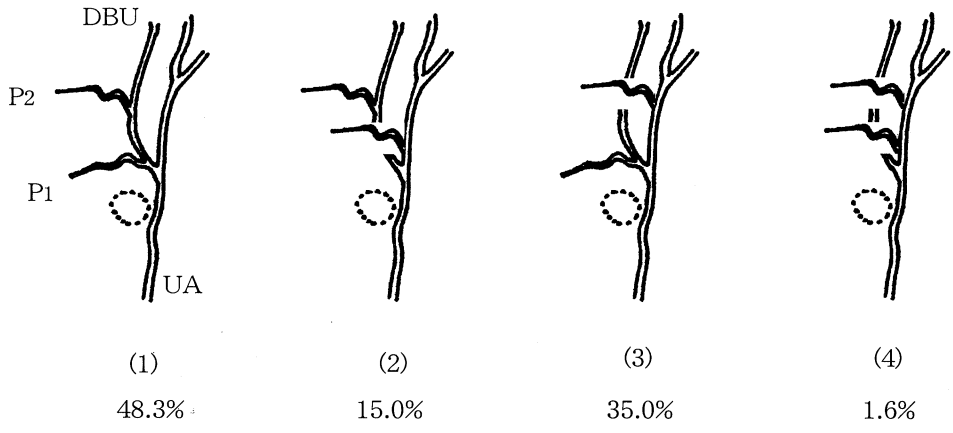



Fig 4. UA : Ulnar artery, DBU : Deep palmar branch,
$P_1$, $P_2$ : skin perforator
The patterns of this portion of the perforators are classified into four types

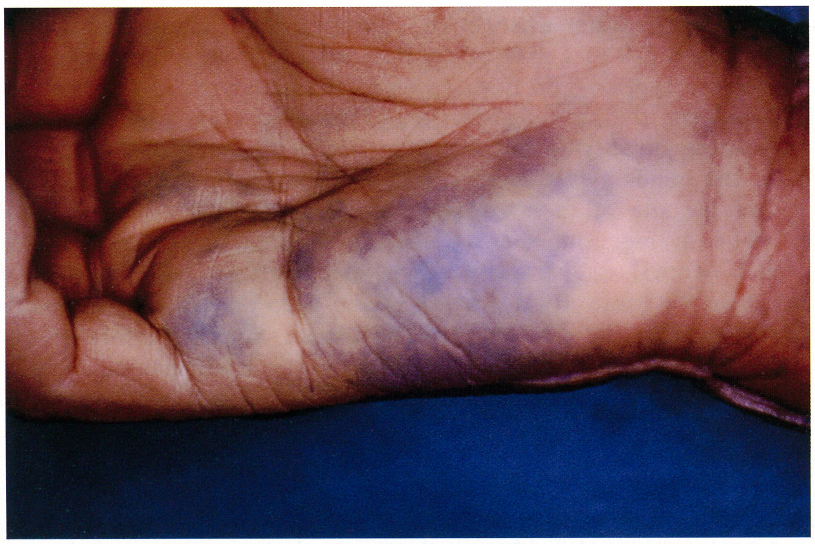


Fig 5. Selective injection of the silicon rubber compound into the deep branch of the ulnar artery demonstrates that the proximal skin overlying the abductor digiti minini muscle was stained.

Selective injection of the silicon rubber compound into the deep branch of the ulnar artery demonstrated that the proximal skin overlying the abductor digiti minimi muscle was stained (Fig 5).

The venous flow from these parts of the skin was supplied by superficial cutaneous veins and a comitant vein of the perforators. The superficial cutaneous veins drained to the ulnar cutaneous vein. The comitant vein of the perforators first drained to the comitant vein of the deep branch of the ulnar artery and finally to the comitant vein of the ulnar artery.

Sensory innervation of the proximal part of the hypothenar eminence was provided by the palmar cutaneous branches of the ulnar nerve.

## DISCUSSION

Coleman and Anderson[2] studied the superficial and deep palmar arches of the palm in human subjects and made a statistical classification of the variations. Adachi[3] similarly classified the arteries in the Japanese. Yamamoto[4] has described the arterial system of the hand using three-dimensional arteriographs, and Karlsson and Niechajew,[5] Luzsa,[6] Janevski[7] and Edward[8] studied the angiography of the upper limb and reported their findings. Ikeda *et al*[9] also reported on the arterial patterns in the hand based on a three-dimensional analysis.

Most of the literature contains gross anatomical observations of the hypothenar eminence. There have been few studies regarding the blood supply of the skin of the hypothenar eminence. Salmon[10] described the cutaneous arteries of the hypothenar eminence arising from the ulnar artery and ulnar palmar digital artery of the little finger. Chase *et al*[11] reported that the skin above the hypothenar muscles was nourished by perforating arteries from the

muscular artery, which penetrated the fascia to reach the skin. Omokawa *et al*[12] examined the vascular anatomy of the hypothenar eminence of the hand in detail. They emphasized that the perforating branches emerging from the ulnar palmar digital atrery. There is little information about the perforators of the proximal part of the hypothenar eminence branching from the deep branch of the ulnar artery.

The blood supply of the hypothenar muscles is mainly provided by branches from the deep branch of the ulnar artery. The deep branch of the ulnar artery accompanying the deep branch of the ulnar nerve originates at the level of the distal margin of the pisiform. Based on these findings, the abductor digiti minimi muscle flap has been clinically used for opponent plasty[13] and for coverage of the median nerve following the scar formation after carpal tunnel release.[14] Chase *et al*[11] clinically used this flap for both skin cover and opponent plasty as a musculocutaneous flap.

Various local flaps harvested from the palm of the hand have been described. Kojima[15] described the skin of the hypothenar eminence as being nourished by the arteries just under the skin or the branches perforating muscles or fascia. They also reported taking a reverse digital artery island flap from the hypothenar eminence. However, one of the disadvantages of this flap is sacrifice of the ulnar palmar digital artery of the little finger. Following these anatomical findings, Kinoshita *et al*[16] concluded that the hypothenar skin was nourished mainly by an arterial network formed by branches from the ulnar palmar digital artery of the little finger and the hypothenar branches. Clinically they used some subcutaneous pedicle flaps based on the branches of the ulnar palmar digital artery of the little finger.

Omokawa *et al*[12] reported that the hypothenar eminence could be divided into three territories according to the type of nutrient artery : the distal half of the ulnar aspect of the hypothenar eminence being supplied by fasciocutaneous perforators arising from the ulnar palmar digital artery of the little finger, the proximal half of the ulnar aspect being supplied by musculocutaneous perforators emerging from the hypothenar muscles, and the radial border of the hypothenar area being supplied by perforators mainly arising from the superficial palmar arch through the palmar aponeurosis. They also reported that the deep branch of the ulnar artery gave off septocutaneous perforators between the abductor and flexor digiti minimi muscles in 50%, while in the other 50% the deep branch of the ulnar artery gave off musculocutaneous perforators. In the present study, in only 15.6% did the deep branch of the ulnar artery give off musculocutaneous perforators.

The deep branch of the ulnar artery gave off 0 to 5 skin perforating arteries. These perforating arteries could be divided in two types. The first type was characterized by branching of the perforator from the proximal portion of the deep branch of the ulnar artery, and its spreading directlly to the subcutaneous tissues and skin. It was found in 83.3% of the hands. The second type was characterized by branching of the perforator from a more distal portion of the deep branch of the ulnar artery, and it divided with the abductor digiti minimi muscle perforator and ran distally. Selective injection of the silicon rubber compound into the deep branch of the ulnar artery demonstrated that the proximal skin overlying the abductor digiti minimi muscle was stained. From the anatomical findings of present study, it was

concluded that the proximal portion of the hypothenar eminence could be a suitable donor site of a perforator flap.

The proximal portion of the hypothenar eminence consists of a thin and durable compartment located over the proximal portion of the abductor and flexor digiti minimi muscles. This area has constant neural participation from the palmar cutaneous branch of the ulnar nerve.[17] A perforator flap from hypothenar eminence could be used as a sensory flap.

With the recent development of supra-microsurgery, the concept of "perforator flap" has been established. Perforator flaps are fed by small perforating vessls. In 1989, Koshima and Soeda[18] first described inferior epigastric skin flaps without the rectus abdominis muscle. Since then, various perforator flaps developed, including the gluteal perforator flap,[19] latissimus dorsi muscle perforator flap,[20] and posterior tibial perforator flap.[21]

Several flap donor sites are now available for reconstruction of palmar skin defects of the hands. The proximal half of the ulnar aspect of the hypothenar eminence, which is located over the abductor and flexor digiti minimi muscles, provides a feasible donor site for a skin flap. It has similar characteristics to the palmar skin. The hypothenar skin has been used by Lie and coworkers as a donor site for full-thickness skin graft.[22] A perforator flap harvested from hypothenar eminence could be used with almost the same morbidity as the donor site of a full thickness skin graft. This perforator flap is based on the perforators branching from the deep branch of the ulnar artery. The sensory potential of this flap is assured by including the palmar cutanetus branch of the ulnar nerve. When only the skin is needed, a pertorator flap could take the place of a musculocutaneous flap. And when only soft tissues are needed, it could be used as an adipofascial flap.[23] Also, using the supra-microsurgery technique, the flap could be transferred as a free perforator flap. With harvesting at the level of the deep branch of the ulnar artery, the vascular pedicle could be used as a flowthrough vascular anastomosis.

This perforator flap has limited indications when compared to other flaps, but it may be useful in special conditions.

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