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CASE REPORT
Hand/Peripheral Nerve

Intraoperative Use of Indocyanine Green Fluorescence Angiography during Distally Based Radial Artery Perforator Flap for Squamous Cell Carcinoma of the Thumb

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Summary: Distally based radial artery perforator flap (DBRAPF) is useful for hand defects; however, the location of the perforator varies among individuals. Preoperative evaluation has been a problematic issue when performing this flap. A 64-year-old man developed squamous cell carcinoma on an old burn scar at the dorsal thumb and was referred to our clinic for further treatment. After wide resection of the tumor, including the long and short extensors of the thumb, we reconstructed the defect with DBRAPF. At that time, near-infrared fluorescence angiography with indocyanine green (ICG) was used to identify the position of the perforator. After injecting ICG intravenously, we could observe its uptake at approximately 5 cm proximal to the styloid process. We designed a 10×6 cm island flap with that uptake as pivot point. During flap elevation, the perforator could be confirmed at the point of uptake; the flap was then transferred to the defect by rotating the pedicle at the identified point. The vascularity of the flap could also be checked intraoperatively through ICG angiography. The tip of the flap that showed weak ICG fluorescence indicated epidermal necrosis. Nevertheless, the entire flap was viable and enabled good functionality without tumor recurrence and metastasis after 5 years. Using ICG angiography, DBRAPF could be performed smoothly, easily, and safely. *(Plast Reconstr Surg Glob Open 2015;3:e310; doi: 10.1097/GOX.0000000000000281; Published online 19 February 2015.)*

Distally based radial artery perforator flap (DBRAPF) is useful for hand defects and enables preservation of the radial artery, which has been sacrificed for reverse forearm flap.[1–3] However, the location of the perforating branch, which forms the pivot point of the flap, varies among individuals[2,4–6]; thus, preoperative evaluation of the perforator location is a problematic issue for this flap.[4] Doppler ultrasound is difficult to use for this purpose because it detects the radial artery itself.[4] Even with multidetector computed tomography (MDCT), it is difficult to evaluate the dominant perforator, especially for thin flaps[7]; moreover, MDCT can only be performed at a limited number of institutions.[8] Matei et al[8] proposed that intraoperative vascular ex-

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ploration was superior to preoperative evaluation for locating the perforator and reported a procedure with no preoperative evaluation. However, not all surgeons are familiar with this technique, and preoperative evaluation would be somehow required for a smooth operative procedure.

In this study, we aimed to use indocyanine green (ICG) fluorescence angiography to identify the perforator for DBRAPF in the treatment of a squamous cell carcinoma on the thumb. This report describes DBRAPF and its usefulness with ICG angiography.

CASE PRESENTATION

The patient, a 64-year-old man, sustained a burn on his right hand at 2 years old and subsequently developed a scar on the dorsal aspect of his right thumb. Approximately 4 months before consult, a gradually enlarging mass appeared on the scar. As the mass exhibited a cutaneous horn measuring 2 cm, the patient visited a local hospital and underwent local resection. The defect was reconstructed by a skin graft. Histological findings of the initial resection showed a well-differentiated squamous cell carcinoma, similar to verrucous carcinoma, with a positive margin (Fig. 1). The patient was then referred to our department for wide resection.

At the first visit to our clinic, we noted a skin graft measuring 3 cm in diameter and a burn scar extending to the wrist from the dorsal aspect of the thumb base. We performed wide resection that included the long and short extensors of the thumb and the burn scar site (Fig. 1). Histological examination of the wide resection likewise revealed a well-differentiated, atypical, squamous epithelial mass under the skin graft; sentinel lymph node biopsy was negative. The 8×5 cm skin defect was initially covered with artificial dermis, and upon confirmation of a negative margin, reconstruction was planned 2 weeks after wide resection.

DBRAPF was selected for reconstruction. Near-infrared fluorescence angiography with ICG [photodynamic eye (PDE); Hamamatsu photonics, Hamamatsu, Japan] was used to identify the position of the perforator vessels. We intravenously injected 2.5 mL of ICG and observed the wrist with PDE (**See Video 1**, **Supplemental Digital Content 1**, which displays ICG angiography around the area of the perforator, ***http://links.lww.com/PRSGO/A91***). Approximately 1 minute later, ICG uptake was observed at an area approximately 5 cm proximal to the styloid process (Fig. 2; **Video 1**, **Supplemental Digital Content 1**, which displays ICG angiography around the area of the perforator, ***http://links.lww.com/PRSGO/A91***); this was presumed to be the location of the perforator. We designed the skin flap using this area as the pivot point (Fig. 3).

The perforating vessel was observed between the muscles, at the same site of ICG uptake, and extending over the fascia in a dendritic shape (**Video 1**, **Supplemental Digital Content 1**, which displays ICG angiography around the area of the perforator, ***http://links.lww.com/PRSGO/A91***). With a 4-cm-wide pedicle, we elevated the flap under the fascia and transferred it to the defect by rotating the pedicle at the pivot point. While elevating the flap, we were able to confirm with PDE that an axial vascular net-

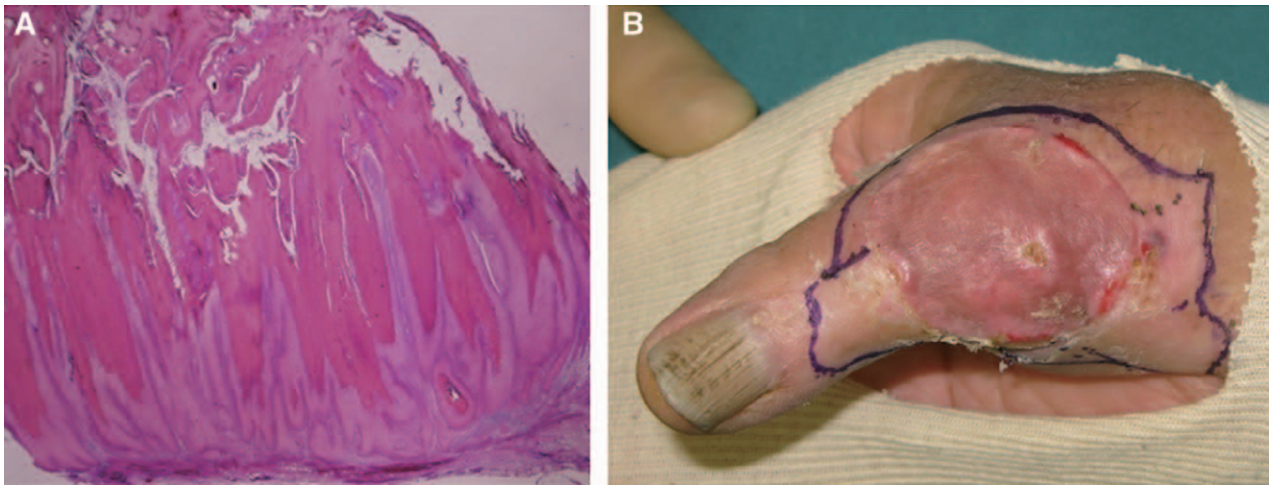
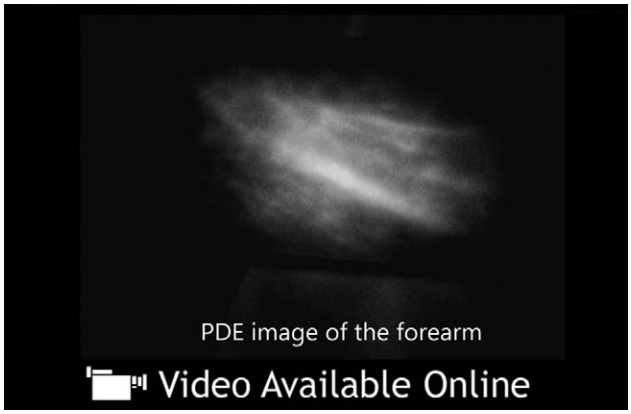


Fig. 1. Pathological imaging at local hospital and incision design at wide resection. A, Histological findings of the mass exhibited a cutaneous horn of 2 cm in size and demonstrated well-differentiated squamous cell carcinoma similar to verrucous carcinoma, and surgical margin was positive on the radial side and deep stump. B, Major resection was performed 5 mm toward the ulnar and 10 mm toward the radial side from the skin graft over proximal phalanx and first metacarpal bone due to positive margin on the radial side and deep stump. Burn scars were included for resection.



Video 1. See video, Supplemental Digital Content 1, which displays ICG angiography around the area of the perforator, ***http://links.lww.com/PRSGO/A91***.

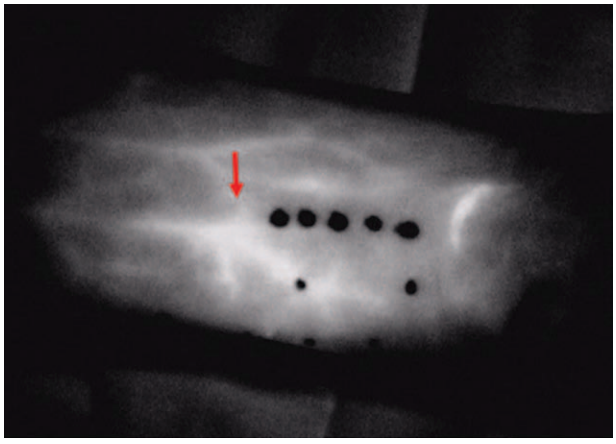


Fig. 2. ICG angiography around the wrist. Increased ICG uptake (red arrow) was observed approximately 5 cm proximal to the styloid process.

Fig. 3. Flap design for reconstruction. A 6×10 cm skin flap was designed using the point with increased uptake (red arrow) as the pivot point.

work had formed on the fascia. Vascular circulation of the entire flap was also evaluated with PDE; overall, the skin flap showed a certain degree of fluorescence, except that the distal edges showed weak expression (Fig. 4) that eventually developed epidermal necrosis. Nevertheless, the entire flap below the dermis was viable and epithelialization was obtained conservatively within a few weeks.

There has been no recurrence or metastasis of the tumor for 5 years. Furthermore, opposable function of the thumb has been maintained and the patient can use it comfortably in his daily life (Fig. 4).

DISCUSSION

DBRAPF was first reported by Chang et al[1] in 1988 as an effective perforator flap procedure that can preserve the radial artery, which is the main artery of the forearm. The rich vascular network of this flap forms in the deep fascia and subcutaneous tissue, making it useful as adipofascial flaps as well.[2,5] Jeng and Wei[5] reported that a skin flap measuring up to 14×6 cm on the proximal third of the forearm could be elevated to reach the finger, and Koshima et al[2] reported that the entire dorsal aspect of the forearm could be used as an adipofascial flap due to the intersection of the anterior and posterior interosseous arteries in this area. By contrast, Saint-Cyr et al[4] reported that a flap cutaneous territory ranging from 104 to 333 cm^2 can be harvested above the fascia because major vascular networks can be found between the fascia and the dermis.

Yang and Yang[9] have indicated that harvesting a 5-cm-wide flap along the axis of the radial artery was possible up to 10 cm distal to the elbow and that smaller flaps should be used for larger vascular pedicles. The perforator, which forms the pivot point for the flap, was within 0–8 cm of the radial styloid process[2,3,5,6,9]; Saint-Cyr et al[4] proposed that it forms a cluster, 17.6% ± 11.5% proximal to a line that joins the radial styloid process and lateral epicondyle.

We attempted to identify the perforator using ICG fluorescence angiography with PDE. This highly safe and useful technique, including sentinel lymph node biopsy and lymphatic venous anastomosis, is being applied widely in the medical field.[10] For skin flap evaluation, Azuma et al[11] first reported this technique for identifying the position of the perforator vessel of the anterolateral thigh flap. It has recently been frequently used for intraoperative evaluation of flap vascularity during breast reconstruction.[12] Onoda et al[7] compared ICG with MDCT and Doppler ultrasound and found that ICG was extremely useful for perforator detection in skin flaps that are <8 mm thick and for evaluating skin flap vascularity.

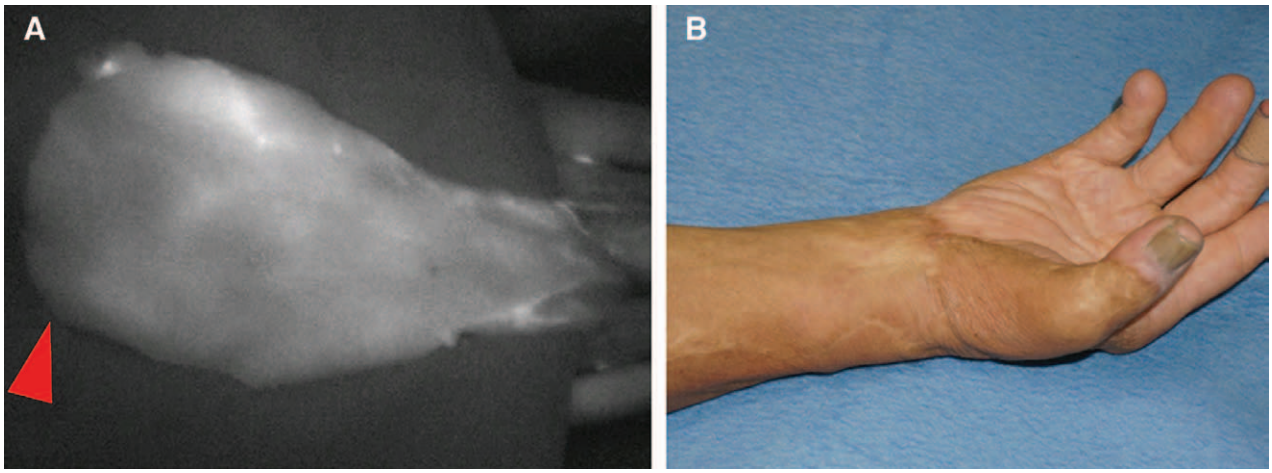


Fig. 4. Intraoperative ICG angiography and postoperative view. A, Vascular circulation of the flap surface was evaluated and showed a certain degree of fluorescence, except for weak expression around the tip of the flap (red arrowhead). B, Five years postoperatively, the flap fits the thumb and enables the patient to use his hand comfortably in his daily life.

In this study, we found that even in the distal forearm, where the radial artery runs very closely to the surface, the perforator could be specifically identified without mistaking it for an accompanying color development in the radial artery trunk. This allowed us to smoothly design the skin flap. Furthermore, ICG administration allowed the intraoperative evaluation of skin flap vascularity, which confirmed some areas of epidermal necrosis. DBRAPF could be more useful when being used as an adipofascial flap because we cannot evaluate vascularity by skin color or any other methods. In addition, this flap would have less stable blood flow than conventional forearm flaps that include the radial artery; therefore, care should be taken while wrapping the defect and while applying some tension on the flap as in our case.

CONCLUSIONS

We used ICG fluorescence angiography to identify the perforator for DBRAPF in the treatment of a squamous cell carcinoma on the thumb. Further research with a larger number of cases is required to determine whether the perforator can be consistently detected by ICG angiography alone. However, our results suggest that it could be an effective ancillary method for evaluating radial artery perforator flap and making this procedure more familiar.

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