A Novel Real-time Navigation System for Lymphaticovenular Anastomosis Using Projection Mapping with Indocyanine Green Fluorescence

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The medical imaging projection system (MIPS), which was developed based on a collaborative effort from Kyoto University, Panasonic Corporation (Osaka, Japan) and Mitaka Kohki Co., Ltd. (Tokyo, Japan), was first reported as a novel real-time surgical navigation imaging device that uses indocyanine green (ICG) emission signals and active projection mapping using a half mirror to match the optical axis of the camera and projector in the projection head.[1] The difference between the object and the projected image is within 1 mm, and the time lag is within 0.1 seconds.[1] Our project group reported its utility in segmental liver resection[1,2] and sentinel lymph node biopsy in breast cancer.[3] We applied the MIPS to lymphaticovenular anastomosis (LVA) surgery for upper extremity lymphedema to simplify the intraoperative cutaneous marking of lymphatic vessels.

The case was a 78-year-old woman who suffered from severe lymphedema of both upper extremities (stage II; International Society of Lymphology) caused by breast cancer surgeries and axial lymph resection. Under local anesthesia and consciousness sedation, multiple LVA surgery was performed. An intradermal injection of 0.1 ml of ICG (2.5 mg/ml Diagnogreen; Daiichi Sankyo Co., Tokyo, Japan) was administered at the second web space of the right hand. The MIPS showed a clear linear projection image on the back of the hand with blue to yellow color gradation (Fig. 1). A 1-cm skin incision and microsurgical dissection detected ICG-contrasted lymphatic vessels (**See figure**, **Supplemental Digital Content 1,** which shows the setting of the MIPS (A) and intraoperative findings from a surgical microscope (B), including a built-in ICG camera view (C); OPMI PENTERO 900; Carl Zeiss Meditec AG, Jena, Germany. **http://links.lww.com/PRSGO/B751**). The projected image smoothly followed the upper extremity movement when viewing the front and back sides of the upper extremities. Late-stage progressive lymphedema resulted in

diffuse or stardust patterns in the forearm and upper arm; however, the projection gain adjustment of the MIPS clarified the linear pattern in the cubital fossa (Fig. 2).

In LVA surgery, ICG lymphography requires macroscopic and microscopic surgical navigation. For microscopic navigation, a built-in ICG camera system shows the lymphatic vessels and their flow. Moreover, a recent ICG videolymphography system[4] and microscope-integrated laser tomography[5] have the potential to make LVA surgery more accurate and certain. However, for macroscopic ICG navigation, which is performed to detect the best position to make the skin incision and LVA for the whole area of an extremity, we still required a conventional ICG camera system (PDE-neo; Hamamatsu Photonics Co., Ltd, Shizuoka, Japan) displayed on monitors, which means that surgeons must shift their vision between the surgical field and the monitor. This is the first report of the intraoperative use of ICG projection mapping for macroscopic surgical navigation to find and mark lymphatic vessels. The accuracy needs to be evaluated by multiple surgical results; however, the MIPS was capable of visualizing lymphatic vessels as linear images for real-time projection mapping navigation in the clinical setting.

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Fig. 1. Intraoperative projection mapping image of the MIPS. ICG fluorescence signals are projected onto the right hand with color gradation.
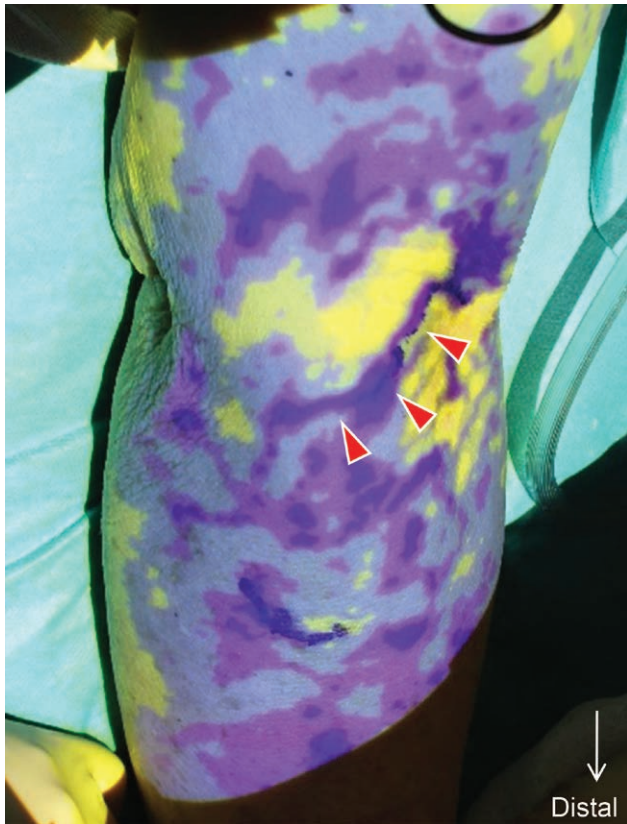
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Fig. 2. Projection mapping image of the MIPS on the right arm. Red arrowheads indicate the linear pattern in the cubital fossa, surrounded by diffuse and stardust patterns at the forearm and the upper arm.

DISCLOSURE:

The authors have no financial interest to declare in relation to the content of this article.

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