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Technology

Real-time Navigation for Vascularized Lymph-node Transplantation Using Projection Mapping with Indocyanine Green Fluorescence

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Summary: The medical imaging projection system (MIPS) is a real-time surgical navigation device using indocyanine green (ICG) emission signals and active projection mapping. The difference between the object and the projected image is within 1 mm, and the time lag is within 0.1 seconds. We herein report the application of the MIPS to vascularized lymph-node transplantation (VLNT) surgery for lower extremity lymphedema to detect inguinal lymph nodes and perform color-coded navigation surgery for lymph-node resection. A left superficial inguinal lymph node was planned to be used as a donor for VLNT to the right lower leg in a 73-year-old woman with lower extremity lymphedema. Under general anesthesia, multiple intradermal injections of 0.1 ml of ICG were administered around the left inguinal donor site. The MIPS showed a clear linear projection image from a lateral injected point connecting to a lateral superficial inguinal lymph node. The left superficial circumflex iliac artery and vein were dissected for vascularized VLNT. Intraoperative real-time MIPS navigation continuously guided the transection plane colored by ICG fluorescence signals without shifting the visual focus from the surgical field. This is the first report of the intraoperative use of ICG projection mapping for VLNT donor-site surgery. The MIPS was able to visualize functional lymph nodes to facilitate minimally invasive donor-site surgery. *(Plast Reconstr Surg Glob Open 2023; 11:e4743; doi: 10.1097/GOX.0000000000004743; Published online 12 January 2023.)*

The medical imaging projection system (MIPS) was developed through collaboration among Kyoto University, Panasonic Corporation (Osaka, Japan), and Mitaka Kohki Co., Ltd. (Tokyo, Japan). Several achievements have been made with this real-time surgical navigation device using indocyanine green (ICG) emission signals and active projection mapping, especially in segmental liver resection surgery[1] and lymph node biopsies in breast cancer.[2] A half mirror is used to match the optical axis of the camera and projector in the projection head.[3] The time lag is within 0.1 seconds. The difference between the object and the projected image is within 1 mm.[4] We previously reported its use in visualizing lymphatic vessels as linear images for lymphaticovenular anastomosis (LVA) surgery.[5] The MIPS was capable of preventing surgeons from shifting their vision between the surgical field and the monitor by real-time projection mapping navigation in the clinical setting. We herein report the application of the MIPS to vascularized lymph-node transplantation (VLNT) surgery for lower extremity lymphedema to detect inguinal lymph nodes and perform color-coded navigation surgery for lymph-node resection.

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CASE

A 73-year-old woman developed bilateral lower extremity lymphedema after artificial joint replacement surgery for bilateral knee osteoarthritis 6 years earlier. The right lower extremity was more severe than the left (stages were late II in right side and I in left side; International Society of Lymphology), so a left superficial inguinal lymph node was planned to be used as a donor for VLNT to the right lower leg. Under general anesthesia,

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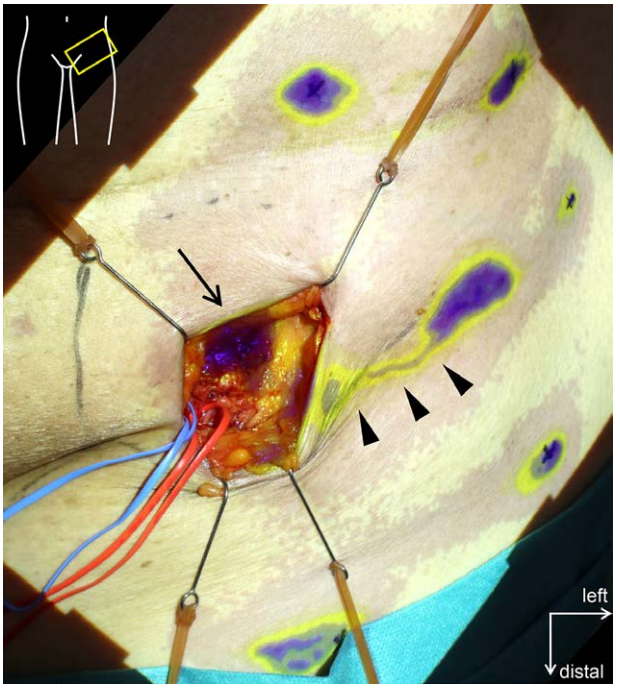

Fig. 1. Intraoperative projection mapping image of the MIPS on the left inguinal area. Black arrowheads indicate the linear image of a lymphatic vessel. The signal connects to the lateral superficial lymph node (black arrow).

multiple intradermal injections of 0.1 ml of ICG (2.5 mg/ml Diagnogreen; Daiichi Sankyo Co., Tokyo, Japan) were administered around the left inguinal donor site. The MIPS showed a clear linear projection image from a lateral injected point connecting to a lateral superficial inguinal lymph node (Fig. 1). The left superficial circumflex iliac artery (SCIA) and vein (SCIV) were dissected for vascularized VLNT. Intraoperative real-time MIPS navigation continuously guided the transection plane colored by ICG fluorescence signals without shifting the visual focus from the surgical field (Fig. 2). (**See Video [online]**, which shows a video of harvesting a lymph node flap. Color gradation indicates the ICG signal projected by the MIPS.) The free superficial groin lymph node flap was harvested with minimum subcutaneous tissue around the SCIA and SCIV (Fig. 3). The lymph node flap was transferred to the inferior right lower leg. The SCIA was microscopically anastomosed to a perforator artery of the medial inferior genicular artery, and the SCIV was anastomosed to an accompanying vein.

DISCUSSION

VLNT is effective for treating lymphedema, but potential donor-site complications, such as persistent iatrogenic lymphoedema, postsurgical lymphocele, and persistent donor-site pain, have been reported.[6] Meticulous lymph node harvesting should be applied to minimize complications.[7] Intraoperative projection mapping with the MIPS allowed for less-invasive lymph node flap surgery by enabling identification of a functional lateral inguinal lymph node, which was speculated to be less invasive for the lymphatic flow from the left lower extremity,[8] and facilitating dissection of the lymph node along the border of the ICG positive

Takeaways

Question: The medical imaging projection system (MIPS) is a real-time surgical navigation device using indocyanine green emission signals and active projection mapping.

Findings: We report the application of the MIPS to vascularized lymph-node transplantation surgery for lower extremity lymphedema to detect inguinal lymph nodes and perform color-coded navigation surgery for lymph-node resection.

Meaning: The MIPS was able to visualize functional lymph nodes to facilitate minimally invasive donor-site surgery.

Fig. 2. Surgery using the MIPS. Operators perform surgery while observing the ICG fluorescence image directly in the surgical field.

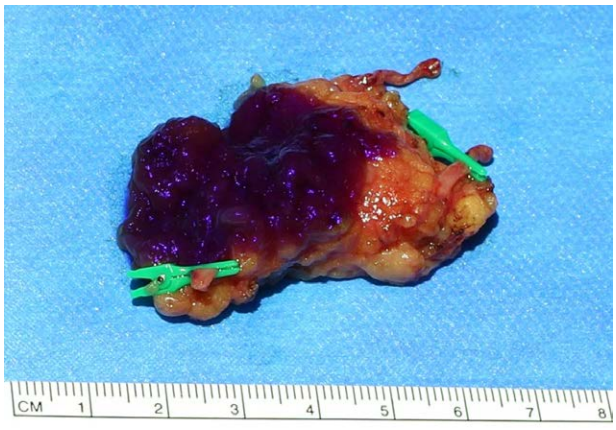

Fig. 3. Lymph node flap. Purple indicates the ICG signal projected by the MIPS.

signal without shifting the visual focus from the surgical field. Compared with LVA, VLNT requires complex intraoperative techniques, which has caused surgeons to apply LVA in the earlier stage of lymphedema, while VLNT is commonly indicated in more advanced cases.[9] However, VLNT has rapidly gained popularity among plastic surgeons because of the initial promising results and its unique technical advantages. The superficial inguinal lymph nodes located along the SCIV are known as the safe zone defined by anatomical landmarks.[10] The MIPS has the potential to avoid the risk of iatrogenic lymphedema by further reduction of invasive range in the safe zone. This is the first report of the intraoperative use of ICG projection mapping for VLNT donor-site surgery. We need to evaluate whether or not the MIPS technique reduces VLNT donor-site complications by further study; however, the MIPS was able to visualize functional lymph nodes to facilitate minimally invasive donor-site surgery.

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