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CASE REPORT
Reconstructive

Thermal Imaging Facilitates Design of a Keystone Perforator Island Flap for a Myxofibrosarcoma Resection Reconstruction: Case Report

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Summary: Lower extremity defects are challenging to reconstruct. The keystone perforator island flap proves useful in difficult cases. Traditionally, a handheld Doppler is used to confirm perforator vessel(s) within the flap but has disadvantages including low sensitivity/specificity. Surgeons can use thermal imaging to localize "hot spots" on the skin, corresponding to perforators. FLIR ONE (FLIR Systems Inc., Wilsonville, OR) is a portable thermal camera with high concordance with computed tomographic angiography. In this case, when faced with handheld Doppler failure, we used intraoperative thermal imaging to continue planning and raising of a complex lower extremity keystone perforator island flap. *(Plast Reconstr Surg Glob Open 2019;7:e2359; doi: 10.1097/GOX.0000000000002359; Published online 5 August 2019.)*

Lower extremity defects pose a challenging problem for reconstructive surgeons. As such, with a comprehensive approach, free tissue transfer is considered by many of the first-line option for reconstruction of lower extremity defects.[1] However, as the understanding of perforator anatomy and methods of localizing pedicles continue to evolve, local perforator-based flaps such as the V-Y advancement flap, propeller flap, bi-pedicled flap, and keystone perforator island flap (KPIF) are becoming reliable options for fasciocutaneous reconstructions.[2] These flaps have been met with comparable results to free tissue transfers and protentional for decreased overall complications.[3] The KPIF described by Behan[4] in 2003 is useful in various anatomic locations ranging from complex wounds of the trunk to areas of higher tension such as the scalp and lower extremity and, when used in the lower extremity, it has lower flap loss and overall complication rates compared with described pedicled propeller flaps and free flaps.

KPIF viability and mobility are directly linked to the preservation of central perforators, and several methods of pedicle localization exist. Computed tomography angiography is recognized as the gold standard for vessel localization; however, intraoperative use is not readily feasible.[5] Doppler angiography is traditionally used and an adjunct in flap design and is readily available in the Oregon; however, despite ease of use, it is fraught with inaccuracy and equipment failure. Indocyanine green fluorescence angiography is a reliable and cost-effective method for assessing tissue perfusion; however, it is invasive with short-lived recordings, posing a challenge in flap design. Thermography, originally described in 1968, is another viable option. Technological advances now allow for increased sensitivity, higher resolution, and portability. Images obtained with smartphone thermal cameras demonstrate high concordance with computed tomography angiography and increased ability to locate perforators over Doppler angiography.[6]

Literature to date has demonstrated the feasibility of using thermal imaging in the detection of perforator hot spots. Our goal is to describe the use of thermography intraoperatively to design a KPIF, demonstrating its functionality and reliability for complex reconstructions when handheld Doppler fails.

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CASE DESCRIPTION

A 69-year-old man underwent radical resection of a 4cm × 5cm myxofibrosarcoma of the right thigh creating a 12-cm diameter × 3-cm deep defect. The defect was turned into a 18cm × 12cm ellipse, and a laterally based KPIF, type IIa, with a 1:1 defect:flap width ratio, was designed. Total flap dimensions were 34cm × 14cm (Fig. 1). We attempted to locate perforators in the anterolateral

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Fig. 1. Full flap designed and the one perforator found by Doppler (>) and the questionable signal.

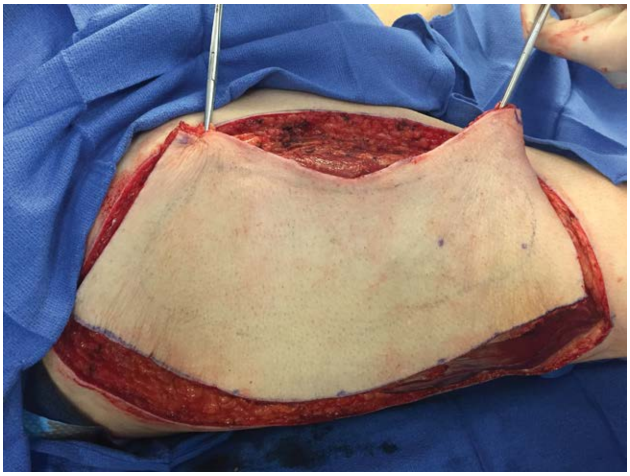

Fig. 3. Flap elevation with wide undermining and preservation of the central perforators.

thigh flap distribution, just posterior to the midpoint of a line between the anterior superior iliac spine and lateral border of the patella, with Doppler angiography. One perforator was identified in the periphery of the flap, and a less reliable signal was heard in the expected more central location. After changing probes/box, we were still unable to definitively identify the expected central perforator. The FLIR ONE Camera (FLIR Systems Inc.), attached to a smartphone, was positioned 70 cm from the lower extremity. With the thermal imaging, we noted "hot spots" at the peripheral perforator as well as the central perforator in question (Fig. 2). Confirming the presence of the central perforator, the KPIF was incised and mobilized to allow for the needed advancement (Fig. 3). The flap was inset in 2 layers and points closed with V-Y advancement flaps. Deep dermal interrupted absorbable sutures and a running absorbable subcuticular suture were used to complete the inset. The wound edges had no tension and demonstrated excellent vascularity. Drains were not utilized, a sterile dressing with mild compression was applied, and the patient was discharged following same day surgery protocols. Pathology demonstrated a pT1, N0, M0 tumor: differentiation score 3, mitotic score 3 (21 mitoses/10 hpf), necrosis score 1 (less than or equal to 50% necrosis), total score 7/8, high-grade sarcoma. Follow-up at 5 months demonstrated a well-healed flap without wound dehiscence, necrosis, or seroma (Fig. 4).

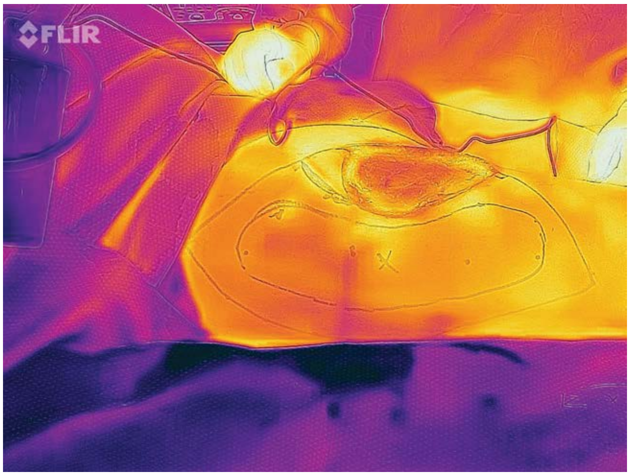

Fig. 2. The > demonstrates the one signal found by Doppler, and the X demonstrates a question of a signal. Thermal imagery demonstrates white hot spots at both of those.

DISCUSSION

The vascular supply of this flap is based on musculocutaneous and fasciocutaneous perforators that are identified premobilization and protected during the dissection by avoiding the central location of the perforators. The advantage of not having to dissect the perforators to their pedicle for mobilization makes the KPIF an expeditious and reliable option for soft-tissue coverage; however, it is critical to identify the central perforators. Traditionally, the handheld Doppler probe is the most readily available and utilized device to localize principal perforators, confirm adequate perfusion, and design the skin paddle accordingly.[7] Unfortunately, the use of preoperative and

Fig. 4. Flap 5 months postoperative.

intraoperative handheld Doppler examination has its disadvantages including inaccuracy in detecting perforators and at times reporting a false-positive signal, or no signal at all.[8] We had a failure of our Doppler necessitating a secondary method of thermal imagining. There are 2 distinct ways to utilize thermal imaging: static imaging and dynamic imaging. Dynamic infrared thermography (DIRT) involves the use of thermal stress on the skin surface and subsequent monitoring of the thermal recovery process. The images representing progressive rewarming indicate a well-developed vascular network as opposed to one that could be compromised.[9] Static thermography involves a single image taken in the area of concern and assessed based on the distribution of hot and cold spots. A limitation of our methods is the use of static imaging versus dynamic imaging. Static imaging has demonstrated comparable results to dynamic images, and although incorporating a cold challenge and using dynamic imaging could improve the reliability of the perforator localization, it would be cumbersome and time consuming. Another limitation is the lower resolution of the FLIR ONE images compared with more extensive thermal imaging equipment.[10] Despite this, the ease of use, accessibility and portability, cost effectiveness, and accuracy make it a reliable tool.

CONCLUSIONS

In this case, we present a novel approach to the planning, design, and raising of a KPIF using portable thermal imaging, in light of handheld Doppler failure, demonstrating the utility of portable thermal imaging to the reconstructive surgeon.

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