Perfusion Dynamics in Pedicled and Free Tissue Reconstruction: Infrared Thermography and Laser Fluorescence Video Angiography

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Introduction

The free flap is the method of choice in reconstruction of large head and neck defects. Successful reconstructive efforts have neared 95-98% within the last decade. Despite improvements in technique, potential microvascular failure remains a devastating outcome. Prior studies have indicated that successful salvage is inversely related to time interval between the onset of ischemic changes and clinical detection. Therefore, postoperative monitoring remains an area of important study. Despite the progressive introduction of various novel techniques, no single technique has been universally implemented.

The primary aim of this study is to evaluate an emerging technology, mobile infrared (IR) thermography, in the assessment of tissue perfusion in comparison to an established system, laser fluorescence angiography.

Methods

Four patients undergoing either pedicled or free flap reconstruction of the head and neck underwent evaluation of tissue perfusion using both a smartphone infrared thermographic camera and indocyanine green fluorescence angiography (ICG-FA) under standardized operating room conditions. Dynamic images were obtained prior to intervention, following flap elevation/harvesting, and postoperatively at the completion of inset. Flap perfusion was measured objectively based on pixel density, fluorescence intensity, and calculated absolute temperature measurements along a line in the midline of the flap extending from the proximal base (pedicle) distally. IR thermal images were analyzed with ThermaCAM Researcher Pro 2.8 SR-1 (FLIR Systems AB). Similarly, fluorescence intensity gradients from ICF-FA images were evaluated with implementation of ImageJ software (National Institute of Health, Bethesda, MD, USA).

Results

Comparison of mean temperature using both methods showed near equivalent thermal recordings (within 0.5 ^{o}C) although ICF-FA displayed greater image resolution.

The average temperature profile through the axial center of a pedicled flap is displayed as an example (Fig.1). The curve in Fig. 2 indicates the average relative fluorescence intensity using ICF-FA through the axial center of the flap following a similar pattern, with a clear decrease distally.

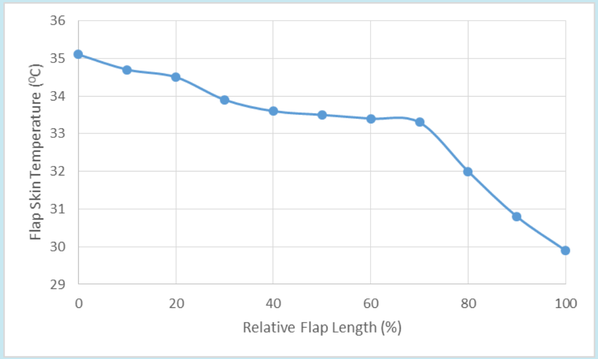

Figure 1. Temperature profile through the axial center of a paramedian forehead flap from it's proximal base to distal end, measured from intraoperative IR images.

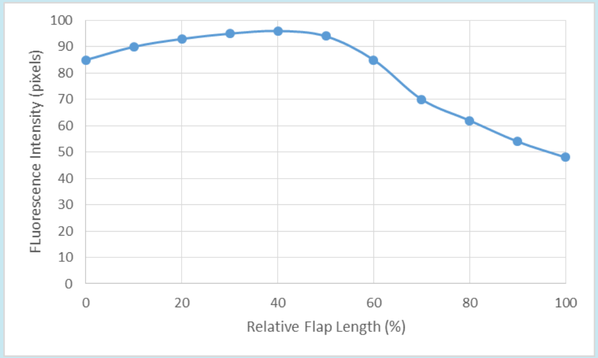

Figure 2. Relative fluorescence intensity (in pixels) through the center of a paramedian forehead flap, measured from intraoperative ICG-FA images.

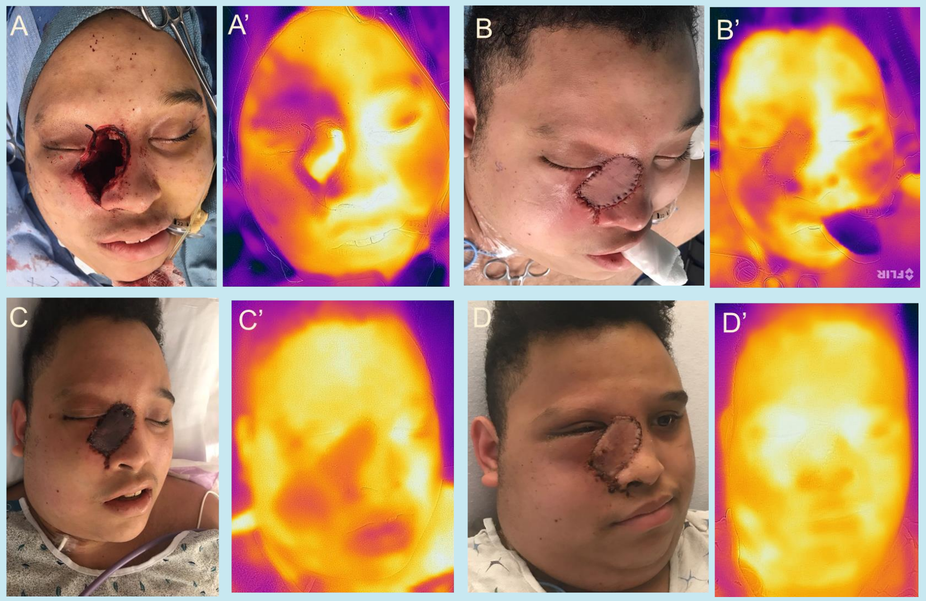

Figure 3. Patient with Ewing sarcoma following maxillectomy and radial forearm free flap reconstruction.

A. Medial maxillectomy defect
A'. IR image of defect
B. Radial forearm reconstruction
B'. Infrared imaging of flap following inset
C. Venous congestion of flap
C'. Corresponding IR image indicating congestion
D. Six hours following revision of anastomosis
D'. IR thermography indicating improved vascular flow as indicated by diffuse increase in thermal signal

Discussion

In addition to reproducibility of perfusion readings in comparison to the ICF-FA system, use of mobile infrared thermography successfully detected early vascular congestion following a radial forearm free flap, allowing for early detection and successful salvage (Fig. 3).

Prior investigations have attributed increased success rates with decreased need for re-exploration to flap monitoring as this may provide valuable information regarding patency of the anastomosis or detect suboptimal flow from kinking or external compression of the pedicle. Our study is unique in that we successfully use dynamic infrared thermography as both a method of intraoperative and postoperative monitoring.

Conclusions

Our pilot study indicates that smartphone-based infrared thermographic cameras may represent a cost-effective method of evaluating tissue perfusion in reconstructive procedures, both in preoperative mapping of the vascular pedicle and as an adjunct to clinical exam in postoperative monitoring of flap viability.

References

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