OPEN
PRS GLOBAL OPEN
IDEAS AND INNOVATIONS
Breast

FlapMap Visual Language System for Vascular Imaging Prior to Microvascular Free Tissue Transfer

Taylor J. Ibelli, BS, MSc*
Farah Sayegh, MD*
Alexander C. Kagen, MD†
Peter W. Henderson, MD, MBA, FACS*

Summary: Preoperative vascular imaging has been shown to be beneficial before free tissue transfer procedures, especially for deep inferior epigastric perforator flap breast reconstruction. Although computerized tomography angiography and magnetic resonance angiogram are increasingly frequently performed, there is no standardized method for recording, analyzing, and communicating the vast amount of clinically relevant information that is obtained from these tomographic imaging studies. Herein, the authors propose a new visual language system for preoperative imaging called "FlapMap," which allows for the creation of a clinically actionable, easily understood, and easily communicated single image that aids in preoperative planning before microvascular free tissue transfer. *(Plast Reconstr Surg Glob Open 2022;10:e4351; doi: 10.1097/GOX.0000000000004351; Published online 2 June 2022.)*

INTRODUCTION

Preoperative imaging is increasingly used in microvascular free tissue transfer to identify relevant clinical anatomy and devise a surgical plan. The most common modalities for such include computed tomographic angiography and magnetic resonance angiography.

One of the procedures for which preoperative imaging is most commonly employed is deep inferior epigastric perforator (DIEP) flap breast reconstruction, where the anterior abdominal wall is imaged to provide an accurate visual representation of the vascular anatomy and surrounding structures. Doing so has been shown to reduce donor site morbidity, reduce operative time, and improve aesthetic and functional outcomes.[1–8]

When preoperative imaging is performed in preparation for any microvascular procedure, including DIEP flap breast reconstruction, there is a plentitude of clinically relevant data, including information about the perforators, adjacent muscle and subcutaneous tissue, underlying vascular pedicle, and superficial venous system. However, this information can easily be obscured by the vast amount of additional extraneous, nonclinically relevant data, and the sheer number of images (often >1000) that are included in these studies. To date, there is no standardized system to describe clinically relevant findings on preoperative imaging. This potentially hinders clinicians' abilities to extract all of the potential information from the preoperative imaging, and impairs the ability of information to easily be communicated between relevant parties (including surgeons, trainees, and radiologists, among others) for both clinical and research purposes.

Therefore, the authors propose a simple, low-cost, standardized visual language system for free tissue transfer, called FlapMap (available for public download and use at http://bit.ly/FlapMaptemplate), that is able to transform complex, voluminous preoperative imaging studies into a clinically actionable, easily understood, and easily communicated single image.

FLAPMAP VISUAL LANGUAGE SYSTEM ELEMENTS

FlapMap is a standardized visual language system that allows clinically relevant information from a large stack of tomographic images to be condensed onto a single, color-coded Cartesian coordinate grid (Fig. 1). The (0,0) reference point should be set at the most logical point for each type of flap (for DIEP flap breast reconstruction, the umbilicus is the most appropriate), with axes marked in centimeters. The key elements of the FlapMap system when used for DIEP flap breast reconstruction are listed below.

*From the *Division of Plastic and Reconstructive Surgery, Icahn School of Medicine at Mount Sinai, New York, N.Y.; and †Department of Radiology, Icahn School of Medicine at Mount Sinai, New York, N.Y.*

Received for publication January 3, 2022; accepted April 4, 2022.

Presented at the American Society of Plastic Surgeons (ASPS) Virtual Plastic Surgery The Meeting, October 9–November 30, 2020; the World Society for Simulation Surgery (WSSS) Annual Meeting, October 19, 2020; the Northeastern Society for Plastic Surgeons (NESPS) Annual Meeting, September 26–7, 2020.

DOI: 10.1097/GOX.0000000000004351

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

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

Vascular Anatomy

Perforators

Each perforator arising from the deep inferior epigastric (DIE) system that is 1 mm or greater in diameter is measured on the X and Y axes relative to the umbilicus, and denoted with a solid black circle. Any of these perforators that are judged to be of sufficient size to support a flap as a single perforator are further denoted with an overlying yellow star.

Pedicle and Branches

The course and branching pattern of the DIE artery vein/venae comitantes in the vicinity of the rectus abdominis muscles are denoted with a thick, solid line. Any portion that runs deep to the rectus abdominis muscle (submuscular) is colored green, any portion that runs within the substance of the rectus abdominis muscle (intramuscular) is colored red, and any portion that runs superficial to the rectus abdominis muscle (subfascial) is colored purple.

Superficial Vein Branches

The course of any dominant-appearing superficial veins (most likely the superficial inferior epigastric veins) is measured at the level 10 cm caudal to the umbilicus and denoted with a thick, dashed blue line.

Muscular Anatomy

Muscles

The widths of both rectus abdominis muscles are measured and denoted on the FlapMap with a light red trapezoid.

Takeaways

Question: To map out vascular data from preoperative imaging studies into an easily interpreted format.

Findings: The authors propose a simple, low-cost, standardized visual language system for free tissue transfer, called FlapMap (available for public download and use at http://bit.ly/FlapMaptemplate),

Meaning: FlapMap visual language system allows for the creation of a clinically actionable, easily understood, and easily communicated single image that aids in preoperative planning prior to microvascular free tissue transfer.

Inscriptions

Any inscription in the lower portion of either rectus abdominis muscle is denoted with a dark red trapezoid.

Surgical History

Pre-existing Surgical Scars

Any pre-existing surgical scars on the lower abdomen (most commonly from cesarean section, appendectomy, or vertical midline laparotomy) are denoted with a thick, solid black line.

Extirpative Plan

The planned side of the mastectomy (and whether it is immediate or delayed) is marked in black text on the corresponding side of the top of the FlapMap.

Three examples of FlapMap for DIEP flap before breast reconstruction are shown in Figure 2. The relative

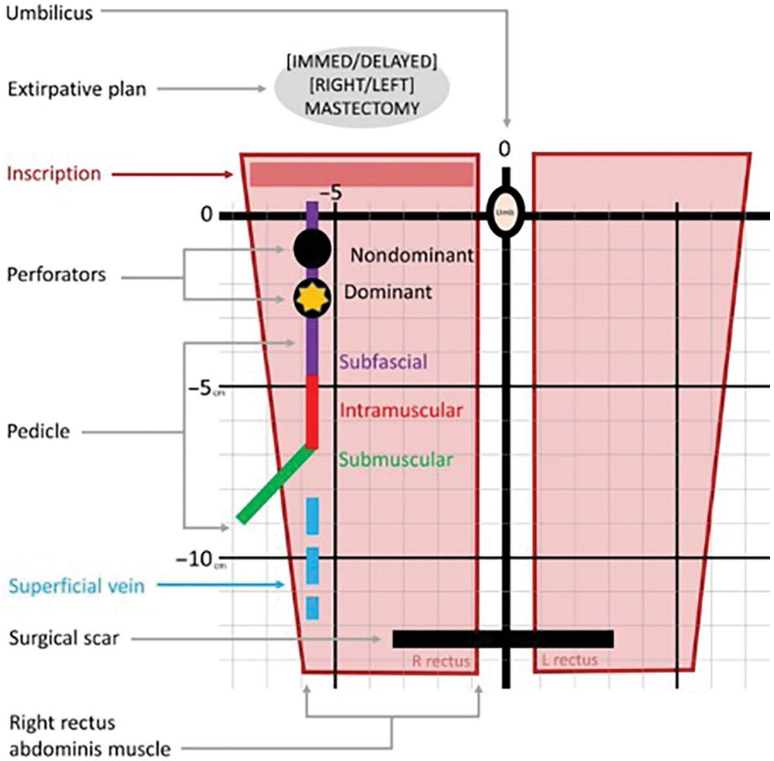

Fig. 1. The elements of the FlapMap visual language system.

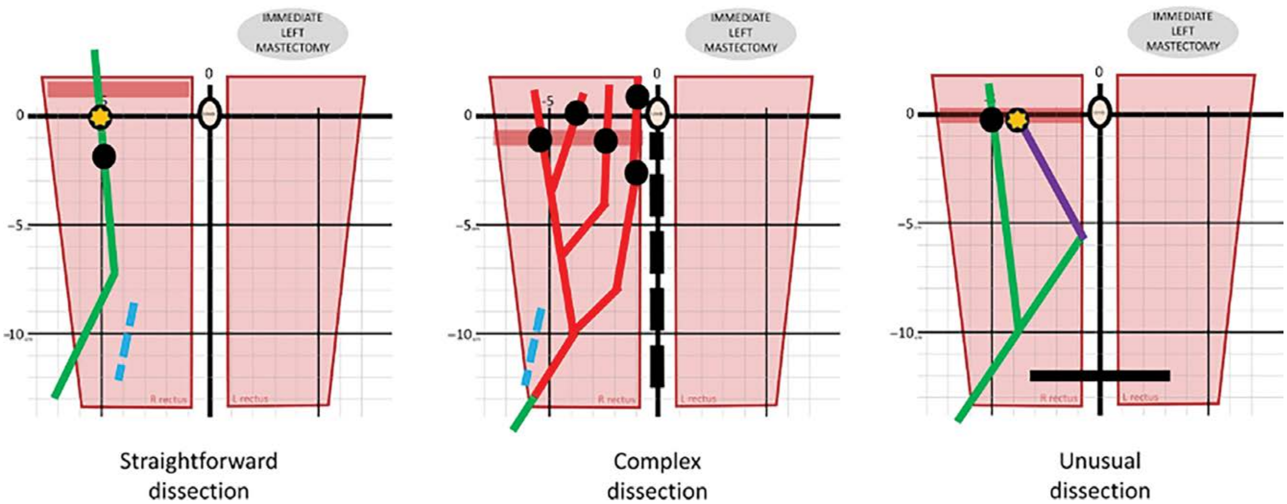

Fig. 2. Examples of FlapMaps that convey flap anatomy and a resulting dissection that is suggested to be straightforward (left), complex (middle), and unusual (right).

complexity of flap dissection is easily conveyed through use of the visual language system (left frame is straightforward, center frame is complex, and right frame is unusual).

LOGISTICS AND CREATION SEQUENCE

Standard computer-based drawing programs (including Microsoft PowerPoint; Redmond, Wash.) can be used. Distance measuring tools are commonly available in image-viewing software, and are invaluable in calculating distances, though it is recommended that measurements are rounded to the nearest 0.5 cm to allow for ease of translation. There can be different sequences and methods for creating FlapMap for DIEP flaps; we have developed a standardized sequence that utilizes both the coronal and axial images, and takes approximately 15 minutes to perform. (**See Video [online]**, which demonstrates how to create FlapMap for DIEP flap breast reconstruction.) In brief, our sequence is as follows. First, we label the side for the mastectomy (left, right, or bilateral). Second, we measure and plot the rectus abdominis muscles and tendinous inscriptions. Third, we locate and plot the superficial inferior epigastric vein. Fourth, we identify clinically relevant perforators. Fifth, we determine and plot the DIE pedicle branching pattern. Sixth, we indicate the relative depth of each DIE pedicle segment. Finally, we confirm perforators and create a preoperative plan by selection of perforator(s) and pedicle. However, each clinician and researcher can develop his or her own way of doing so.

CONCLUSIONS

The FlapMap visual language system for preoperative planning allows the clinically-relevant information from an entire stack of tomographic images to be condensed into a single, standardized image to guide surgical decision making in microvascular free tissue transfer. Though the example of DIEP flap breast reconstruction was used in this description, FlapMap can be utilized for preoperative imaging performed for any type of reconstructive procedure. Use of this system allows for more effective extraction of relevant information from preoperative imaging studies, and for more efficient communication between relevant parties. Future directions include utilizing radiographic software tools to develop an automated process for generating FlapMap images.

Peter W. Henderson, MD, MBA, FACS
10 Union Square East, Suite 2L
New York, NY 10003
E-mail: peter.henderson@mountsinai.org

REFERENCES

1. Schwabegger AH, Bodner G, Rieger M, et al. Internal mammary vessels as a model for power Doppler imaging of recipient vessels in microsurgery. *Plast Reconstr Surg.* 1999;104:1656–1665.
2. Hallock GG. Acoustic Doppler sonography, color duplex ultrasound, and laser Doppler flowmetry as tools for successful autologous breast reconstruction. *Clin Plast Surg.* 2011;38:203–211.
3. Masia J, Navarro C, Clavero JA, et al. Noncontrast magnetic resonance imaging for preoperative perforator mapping. *Clin Plast Surg.* 2011;38:253–261.
4. Davis CR, Jones L, Tillett RL, et al. Predicting venous congestion before DIEP breast reconstruction by identifying atypical venous connections on preoperative CTA imaging. *Microsurgery.* 2019;39:24–31.
5. Masia J, Clavero JA, Larrañaga JR, et al. Multidetector-row computed tomography in the planning of abdominal perforator flaps. *J Plast Reconstr Aesthet Surg.* 2006;59:594–599.
6. Aubry S, Pauchot J, Kastler A, et al. Preoperative imaging in the planning of deep inferior epigastric artery perforator flap surgery. *Skeletal Radiol.* 2013;42:319–327.
7. Mohan AT, Saint-Cyr M. Advances in imaging technologies for planning breast reconstruction. *Gland Surg.* 2016;5:242–254.
8. Hummelink S, Hoogeveen YL, Schultze Kool LJ, et al. A new and innovative method of preoperatively planning and projecting vascular anatomy in DIEP flap breast reconstruction: a randomized controlled trial. *Plast Reconstr Surg.* 2019;143:1151e–1158e.