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Virtual Planning of Profunda Femoral Artery and Superficial Circumflex Iliac Artery Perforator Flaps

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INTRODUCTION

The use of computed tomography angiography (CTA) has been popularized to identify candidate perforators when designing deep inferior epigastric artery perforator (DIEP) flaps.[1] Although much less commonly used, it has also been described for mapping perforators of the superficial circumflex iliac artery perforator (SCIP),[2,3] the profunda artery perforator (PAP),[1] or anterolateral thigh[4] free flaps. It has been reported that preoperative mapping reduces operating time when directly compared with DIEP flap breast reconstruction with no perforator mapping, and that CTA saved more time than ultrasound in theatre (mean reduction of 58 minutes).[5] Apart from identifying perforators and source vessels, preoperative imaging with CTA or MRI is useful to diagnose unexpected pathologies or vascular anomalies.[1]

Adequate use of hardware and software is necessary to obtain optimal perforator data from CTA. Most of the proprietary software are expensive, or not available in many institutions.[6] Moreover, data postprocessing is frequently dependent on the radiologist. If this virtual planning could be done by the surgeon, he/she may gain a "mental map" of the case facilitating work during surgery, as proposed by Olsson et al[6] for fibula free flap virtual planning.

Chae et al have previously reported that the accuracy of the open source software Osirix (Pixmeo, Geneva, Switzerland) was comparable to a proprietary software in mapping DIEP flap perforators, providing an added advantage of being free, easy to use, portable, and potentially a superior quality of 3D reconstructed image.[7] More recently, Leung et al[8] used the software Horos (v. 2.2.0; The Horos Project) to quantify relationships between DIEP flap perforators and their territories of supply in vivo. However, there are no publications on the use of these software for mapping other perforator flaps. The purpose of this article is to describe our technique for perforator mapping when designing PAP and SCIP free flaps using free-share software.

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METHODS

Radiological Setting

CTA is performed on a high-speed VCT 64 multi-slice CT (General Electric Healthcare, Milwaukee, Wis.). The range of the study includes from D12 to the sole of the foot. Images of 0.625-mm thickness were obtained. The radiological study is performed after the administration of a single 110 ml of the nonionic iodinated contrast agent Iopromide 370 mg/ml (Ultravist, Bayer) with a flow of 4 ml/s, placing the region of interest (ROI) at the level of the abdominal aorta (D12). The axial images obtained are processed in the General Electric Advantage 4.4 workstation by the radiologist.

Vascular Reconstruction

Data postprocessing and its review are done by the first author of this study in a systematic, stepwise manner, by using the open-source software HorosTM, v 3.3.6 (GNU Lesser General Public License, version 3). The techniques for both the PAP and the SCIP free flaps are described in videos 1 and 2, respectively. (**See Video 1 [online]**, which displays step-by-step tutorial explaining how the preoperative mapping of the profunda femoral artery perforator flap can be done using the open source software Horos.) (**See Video 2 [online]**, which displays step-by-step tutorial explaining how the preoperative mapping of the superficial circumflex iliac artery perforator flap can be done using the open source software Horos.)

First, the DICOM file with the CTA study of the patient is selected and imported to Horos. For mapping the PAP

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free flap perforators, the 3-dimensional (3D) multi-planar reconstruction mode is selected. The window with the sagittal view is closed, and the axial and coronal images are made bigger using the loupe tool. Then, the maximum intensity projection thick slab is increased. This method allows projecting the voxel with the highest attenuation value on every view throughout the volume onto a 2D image. Maximum intensity projection sections of variable thickness are excellent for assessing the size and location of vessels, which become more visible. Next, we look for the origin of a profunda femoral artery perforator and place the axis of the axial window on top of it. By rotating the axis of the axial window until it is parallel to the main course of the perforator, we can identify this vessel in the sagittal window. Then, the perforator is traced by moving and rotating the axis of the sagittal window; so both the perforator's relationship with the main pedicle of the gracilis muscle, and its course to the skin can be assessed. The ROI tool can be used to create an ROI to mark the exact point where the perforator pierces the deep fascia. If we chose the 3D volume rendering mode, this ROI can be assessed and its position relative to the ischial tuberosity can be measured for later translating this information to the theater. Another useful measurement is the vertical distance from the inferior border of the gracilis muscle in the axial window. Using these 2 coordinates, the perforator can be easily located in the patient. We can also create different ROIs to mark the exact location where the branches of the perforator reach the skin. Hand-held doppler or duplex are useful to confirm the location of the desired perforator and its branches.

For mapping the pedicle and perforator of an SCIP flap, the DICOM file is imported, the axial window is selected, and the IMP is increased as explained earlier. Then, both branches of the superficial circumflex femoral artery are identified and marked using the ROI tool pointer in every image. The same can be done with the superficial cutaneous vein. The vessels can be visualized using the 3D volume rendering mode and distances to anatomic landmarks as the anterior superior iliac spine or the umbilicus can be measured. Also, screenshots of the 3D volume rendering images can be exported to an augmented reality app to superimpose them with the camera and provide a dissection route map, as described by Pereira et al.[3]

CONCLUSIONS

Virtual planning with free share software allows surgeons worldwide to have access to the advantages of this technology on perforator mapping. Data postprocessing of the CTA DICOM file with HorosTM, v 3.3.6 (GNU Lesser General Public License, version 3) is an easy way to obtain 3D maps of the perforators of both PAP and SCIP free flaps.

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