Appendix. Syngo Needle Guidance Navigation Software

The *syngo* Needle Guidance program allows for direct neuronavigation without the need for transfer of the FDCT imaging data to a separate navigation platform. After the scan is completed, 3D head reconstruction is best assessed with 2 mm slice thickness; the volume can be windowed to optimize the visualization of the hematoma and the surrounding parenchymal tissue. After volume preparation, the needle guidance workflow is selected and the Multiplaner reformations (MPRs) are used to find and select desirable entry and target points. With these points identified, the needle trajectory and path can be further analyzed to avoid eloquent tissue, plan the trajectory through the long axis of the hematoma, and ensure as comfortable of a working angle as possible. Prior MR imaging or conventional CT images can also be imported at this stage and fused with the obtained FDCT imaging to facilitate safe trajectory planning.

With the trajectory set, the angiography table is floated for table positioning, placing the 'Y' inside the navigation triangle. Fluoroscopic magnification should be increased in order to reduce the field of view to 11 cm. At this point, the integrated laser crosshairs should be activated to identify the entry point, which can be confirmed with fluoroscopy. Once confirmed, the head should be taped, and the skin prepped and infiltrated with lidocaine. It may be helpful to rotate the table to an oblique position to allow better access, although care should be taken to not move the patient after the FDCT acquisition in relation to the table to maintain navigational accuracy. A 1–2 cm incision is made, a burr hole fashioned with the high-speed electric drill, and the dura opened sharply. The table should then be repositioned to the midline to allow use of the FDCT navigational guidance.

With the table in position, the 4D tab is selected on the workstation. Within this tab, select "Overlay," followed by "3D registration," which will open side-by-side volume rendering

technique (VRT) images from the FDCT. After bringing the C-arm in the posterior-anterior position, a short fluoroscopic image should be captured. Following this, rotate the C-arm into the lateral position (at least 30 degrees) and take another fluoroscopic image. At this point, the obtained 2D images will be overlaid on the VRT images and an automatic registration can be initiated. The table can be manually shimmed to align the VRT and 2D images. While bony landmarks are sufficient for this step, fiducials can provide additional assistance in aligning the FDCT images with the patient. If the automatic registration and alignment is not sufficient, a manual adjustment can be made. Once alignment is acceptable, the 2D-3D fusion can be accepted, which brings the operator automatically back to the needle guidance workflow.

Using overlay graphics, the C-arm should be driven back to the “Bulls Eye” position and can be used to confirm that the burr hole is located at both the fluoroscopic image and laser crosshairs. If needed, a new trajectory and entry point can be obtained on the workstation based on the burr hole location. Prior to EVD placement, it can be helpful to replace the EVD stylet with a stiffer 8-F pigtail drain stylet. Using a long clamp to hold the EVD catheter at the entry site, fluoroscopy is used to match the laser crosshairs with the trajectory of the catheter (Figure 4A). With the crosshairs aligned, the clamp is removed and the catheter is delivered in-line with the laser crosshairs to the specified depth (Figure 4B). Catheter position can be verified with a shorter 5-second Dyna CT or similar acquisition. This is again best visualized with 2 mm slice thickness during workstation reconstruction and can be fused to the original VRT images for comparison. Once in position, the stylet is removed and aspiration is performed with a 10 cc syringe, removing hematoma until resistance is encountered. Prior to concluding the procedure, a 20-second Dyna CT is performed (same parameters as prior FDCT) to quantify the hematoma

evacuation. If satisfactory, the catheter is tunneled, connected to an EVD drainage catheter, and the incision is closed.