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Stereotactic Neuronavigation Based Only on Three-Dimensional Rotational Angiography Using Surface-Based Facial Registration

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Introduction

Cerebrovascular lesions can have complicated abnormal anatomy not completely characterized by CT or MR angiography. 3D rotational angiography provides superior spatial and temporal resolution, but catheter angiograms are not easily registered to the patient, limiting the use of these images as a source for neuronavigation. Digital subtraction angiography (DSA) contains not only vascular anatomy, but also facial surface anatomy data. We report a novel technique to register DSA images using only the surface anatomy contained within the data set without fusing the DSA to other imaging modalities or the use of fiducials.

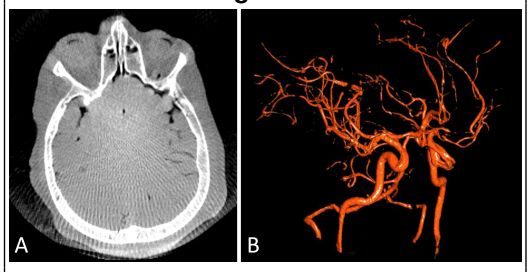
Methods

A DSA scan was obtained of a fixed cadaver head with acquisitions of mask and contrast runs. The right ICA was injected prior to the contrast run with a 45% contrast solution diluted with water-soluble red liquid latex. One week later time, the head was registered to a Stealth navigation system loaded with the DSA images acquired earlier using facial surface anatomy (Figure 1). A right pterional craniotomy was performed and 10 different vascular landmarks were identified and measured for accuracy using the Stealth system. Neuronavigation based only on DSA was also used to treat a patient that presented with a distal lenticulstriate aneurysm.

Results

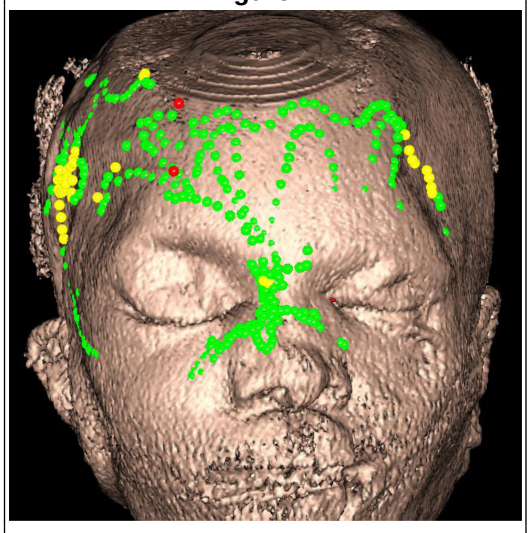
The accuracy of the measurements for the cadaver model was 0.71 ± 0.25 mm, which is superior to the 1.6 – 3.0 mm reported for neuronavigation. The DSA-based navigation assisted surgery for the distal MCA aneurysm aided in aneurysm localization, resulting in a small craniotomy and minimal brain dissection.

Figure 1.



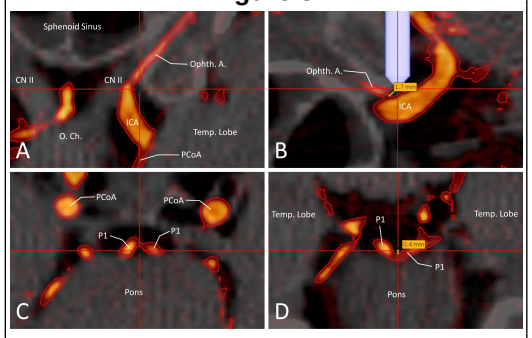
3D DSA acquisition of cadaver model.

Figure 2.



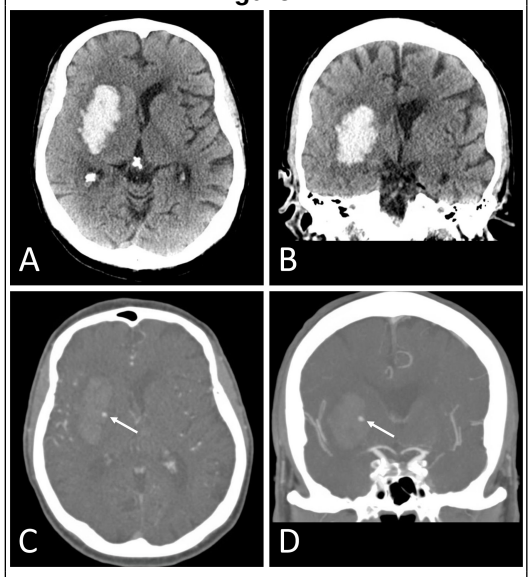
Registration of 3D DSA to the cadaver model using a neuronavigation platform.

Figure 3.



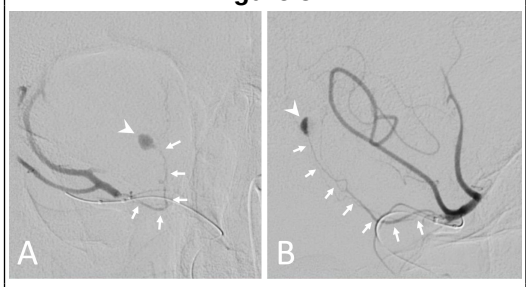
Neuronavigation accuracy measurements during cadaver dissection. Anatomical structires are labeled.

Figure 4.



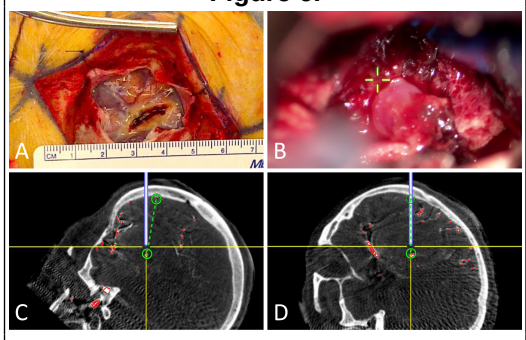
CT and CTA images obtained of a patient presenting with a ruptured distal lenticulostriate aneurysm.

Figure 5.



Arterial DSA of the right M1 showing the distal lenticulostriate aneurysm.

Figure 6.



Surgical repair of the distal lenticulostriate aneurysm with 3D DSA neuronavigation.

Conclusions

This is the first example of frameless neuronavigation based on 3D catheter angiography registered by only surface anatomy data contained within the 3D DSA image set. This is an easily applied technique that is beneficial for accurately locating and reducing the dissection burden of vascular lesions.

Learning Objectives

The reader will learn about a new method to register DSA images to a patient in the operating theater.