Photogrammetry-Based Volumetric Models of Cadaveric Dissections to Characterize Craniometric and Sulcal Points for Surgical Neuroanatomy

Sheantel J. Reihl; Roberto Rodriguez, MD; Vera Vigo, MD; Rina Bonaventura, MD; Olivia Kola; Halima Tabani, MD; Ivan El-Sayed, MD; Adib A. Abla, MD.

1 Department of Neurological Surgery, University of San Francisco California
2 Skull Base and Cerebrovascular Laboratory University of California, San Francisco
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Identification and utilization of craniometric points and sulcal points are invaluable components of surgical planning and intraoperative localization. For junior residents and young neurosurgeons, incorporating this process into a surgical procedure may be challenging without sufficient practice and familiarization with the neuroanatomical structures. Incorporating modeling and 3D technology can be viable options for practice and familiarity outside of the operating room to improve surgical performance and outcomes. We propose photogrammetric 3D volumetric models as valuable complimentary tools for neuroanatomical learning and guided surgical skill building.
METHODS

Key surgical windows identified with craniometric points, were dissected in order to expose the underlying surgical corridors and sulcal points. Using a Nikon D810 SLR camera (Tokyo, Japan) and turntable, 260 images were taken in 360 degrees from three different vertical angles. This was repeated stepwise throughout the procedure from pre-incision, craniotomy, and dissection of the dura. The images were digitally rendered into 3D volumetric models using Agisoft Photo Scan Pro (St. Petersburg, Russia). 32,500,000 tie points were indicated in the images were used to create a dense cloud model. The quality of the 3D volumetric model was evaluated with MeshLab software (Pisa, Italy) through an algorithmic scale of 10 identified craniometric points and their associated sulcal points. In the cadaveric specimen and 3D printed models, complimentary measurements were taken using the Stryker navigation system.
The photogrammetric and 3D volumetric models exhibited a high level of clarity in 360 degrees. The models were qualitatively comparable to the dissected specimen in color and detail. The scaling of the 10 craniometric points obtained through MeshLab, confirmed the reliability of the reconstructed models.
Figure 1. Fronto-temporal view of a dissected cadaveric specimen (left) and 3D volumetric model (right) rendered using the photogrammetric method.
Figure 2. Saggital view of the left hemisphere. The left image represents the cadaveric dissection, and the right image is the 3D volumetric model created from the photogrammetric method.
Figure 3. Posterior view of the dissected cadaveric specimen (left) and the 3D volumetric model (right) rendered using the photogrammetric method.
Neurosurgeons should be knowledgeable about craniometric and sulcal points and experienced with their use as key identifiers for minimally invasive procedures. For junior residents, competency can only be attained through practice and reinforcement within and outside of the operating room. Photogrammetric and 3D printed models offer the opportunity to strengthen neuroanatomical knowledge and, consequently, may be a valuable resource for improving surgical planning and intraoperative localization.
Photogrammetry is a convenient tool for the creation of unique 3D volumetric models that can be used to preserve neurosurgical dissections. These specimens can then be used for reinforcing foundational knowledge of craniometric and soul cal points.

3D volumetric models created from these models are accurate, user-friendly, and easily accessible for resident surgical training and/or self-led neuroanatomical learning.

Photogrammetry is a low cost method to attain high quality models that can be accessed anywhere on a web-based application on phones/computers.