Autonomous Anatomical Recognition and Analysis for External Ventricular Drain Placement

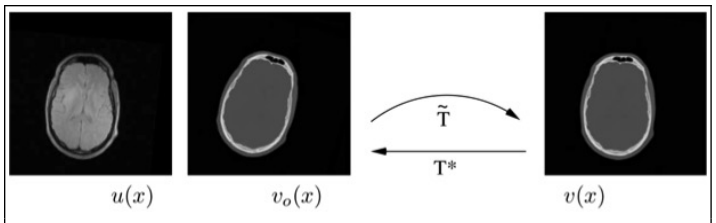
Joel Beckett; Bilwaj K Gaonkar PhD; Neil A. Martin MD; Luke Macyszyn MD, MA
University of California Los Angeles, USA

Introduction

Placement of the Kocher's point external ventricular drain is the most common neurosurgical procedure. Often performed in urgent conditions, the operating neurosurgeon makes adjustments based on patient specific radiographic findings; however, the default trajectory is typically 90° perpendicular and 6-7 cm deep from the calvarial vault (1). Machine learning and automation is one of the most exciting developments in the 21st century. Herein we develop and trial a novel computer-automated imaging recognition algorithm to determine an ideal trajectory of EVD placement from Kocher's point.

Methods

On a publicly available 3T Brain MRI from NITRC (https://www.nitrc.org/frs/?group_id=899) (n=36, mean age = 20.12, SD = 1.73; 18 females), Kocher's point, the ipsilateral foramen of Monroe and guide placement points were identified by an automated pipeline utilizing a modified Demons Image Registration Algorithm (DIRA) (2).

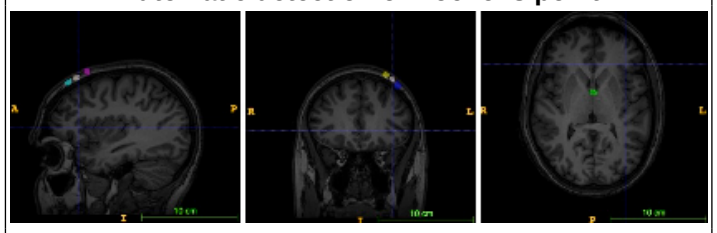


DIRA Image Registration and Correction Schematic

Results

Automated placement of points was accurate in 34/36 cases. A sample point placement is visualized in the figure using software provided by authors of [3]. The two failed cases had slit ventricles. The mean distance between Kocher's point and the ipsilateral foramen of Monroe is 6.9 +/- 0.1 cm (95% CI) Ideal trajectory was, in repsect to the calvarial surface, sagittal 82 +/- 1 degrees, coronal 85 +/- 2 degrees (acute angles anterior and lateral).

Automatic detection of Kocher's point

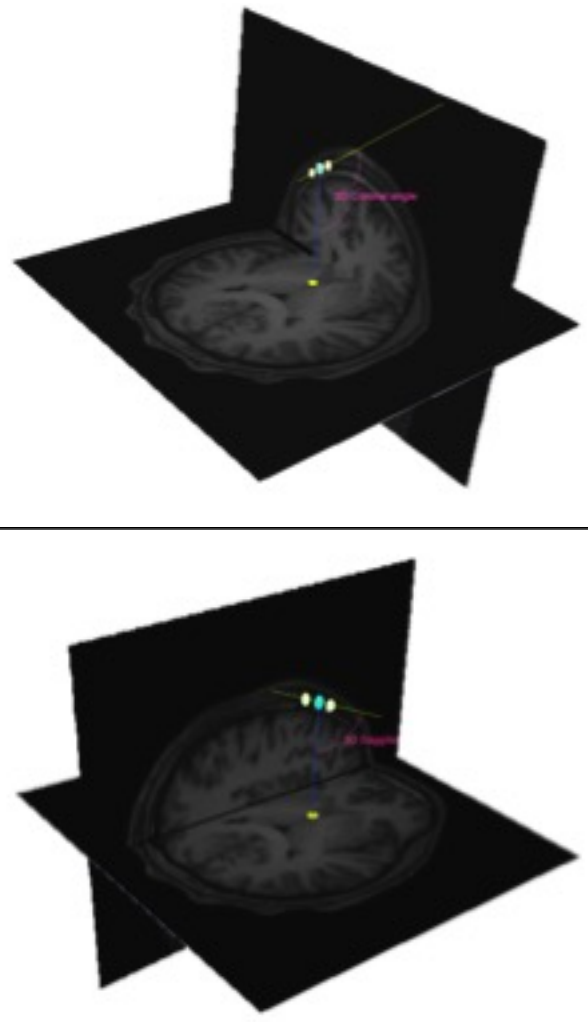


Computerized planning of EVD trajectory is based on automated placement Koche's point as well as ancillary guidepoints as shown in the figure

Conclusions

The DIRA can automatically and accurately select entry points and plan trajectories for EVD placement. Our study demonstrates that EVD placement is not perfectly perpendicular to Kocher's point; hence, using a data driven approach will improve the safety and accuracy of this procedure. Ultimately, this automation could be fed into custom 3D guide printing.

DIRA Automated Planned EVD Trajectory



EVD trajectory from Kocher's point to ipsilateral Foramen of Monroe (A) in sagittal plane and (B) in coronal plane.

References

[1] Rehman, T. et al. A radiographic analysis of ventricular trajectories. World Neurosurg. 80, 173–178 (2013).

[2] Vercauteren T, et al. Diffeomorphic demons: Efficient non-parametric image registration. NeuroImage. 31;45(1):S61-72 (2009)

[3] Yushkevich, P.A., et al.User-guided 3D active contour segmentation of anatomical structures: significantly improved efficiency and reliability. Neuroimage, 31(3), pp.1116-1128 (2006)