Investigation of Cerebral Vessel Geometric Morphometrics for Prediction of Mechanical Thrombectomy First Pass Outcome

JSS Mostafa Mousavi, BA Santo, AA Baig, AH Monteiro, M Waqas, AH Siddiqui, VM Tutino

Intro: Vessel tortuosity is a major factor in successful first pass outcomes for mechanical thrombectomy (MT), but previous methods to quantify tortuosity are not accurate enough to predict outcome. We investigated a new method for vessel characterization and outcome prediction based on geometric morphometrics (GMM).

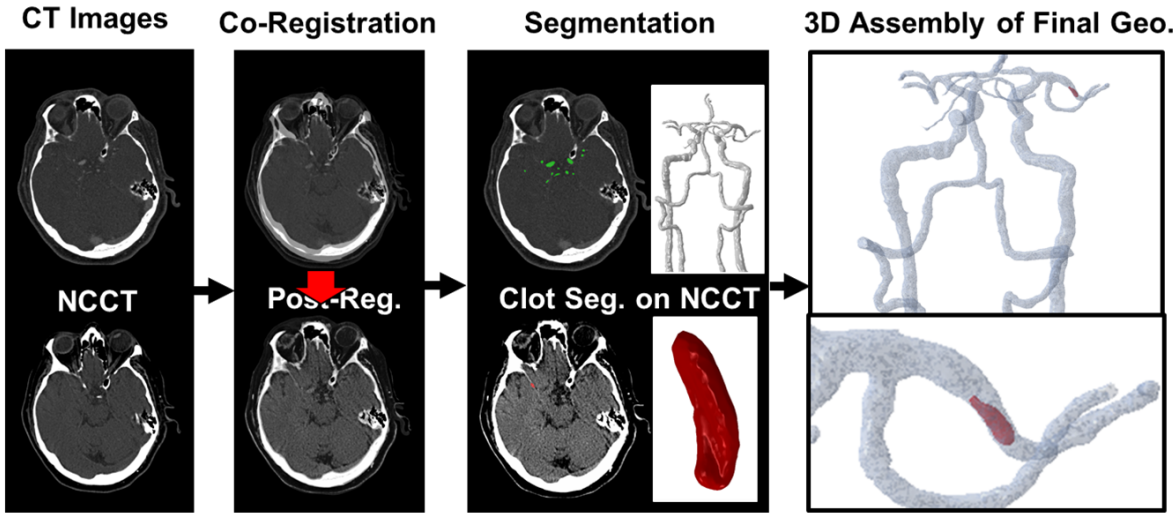
Hypothesis: Our hypothesis was that morphometric analysis of engineered centerline landmarks would identify vessel characteristics that can better predict first pass MT outcome.

Methods: Vessels and clots were manually segmented and reconstructed from pre-treatment CTA and nCCT images (*n*=5 cases) (Fig. 1A). The vasculature corresponding to the ICA and MCA from the affected hemisphere was isolated, and centerlines were engineered as curved landmarks. MorphoJ, a GMM software, was used to complete generalized Procrustes and principal component (PC) Analysis that included registration of patient geometries, calculation of average morphology and landmark variation, and identification of anatomical landmarks differentiating MT outcomes (Fig. 1B). Morphometrics were compared against local and overall tortuosity by measuring the separability of and cohesion within outcome classes.

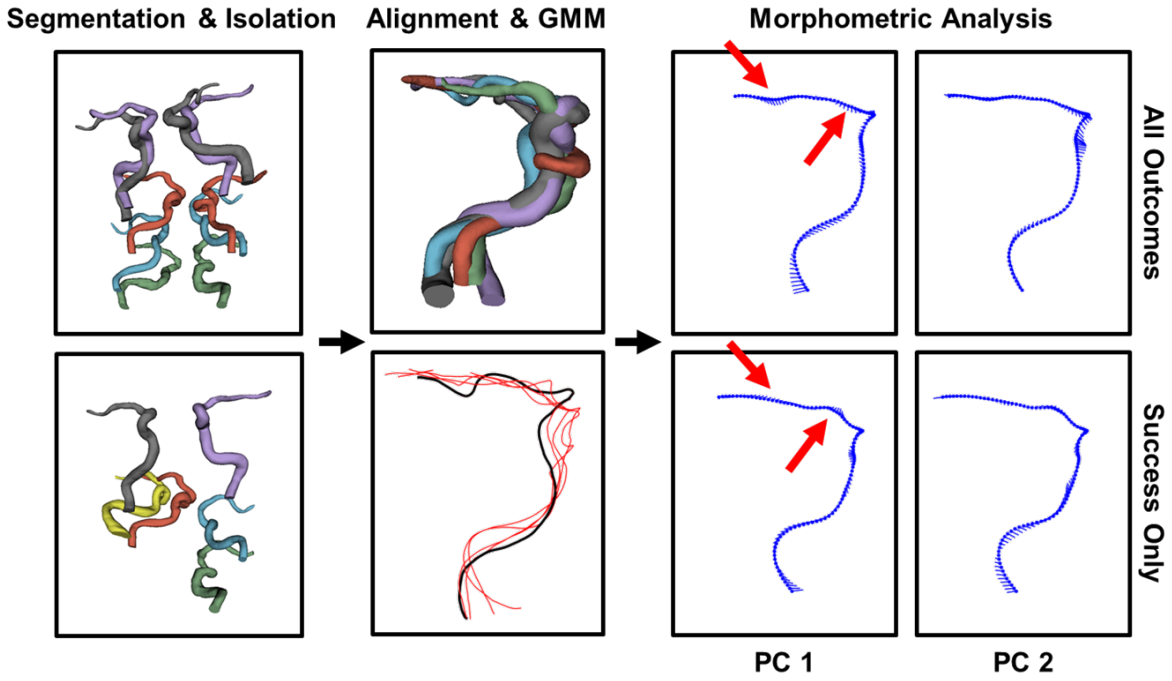
Results: GMM produced two PCs, which described local variation in M1 (PC1) and the ICA (PC2) (Fig. 1B). When compared against vessel tortuosity features, GMM PCs increased the distance between outcome classes (first pass effect vs. no first pass effect), improving separability by 23.6%. Further, GMM PCs increased the compactness/cohesion of outcome classes, reducing cumulative distance between failures by 50% and successes by 9.4% (Fig. 1C).

Conclusion: GMM analysis of pre-treatment vessel characteristic highlights regional variation in M1 as a strong indicator of MT failure, and suggests that GMM has the potential to better predict MT outcome than ICA tortuosity alone. Investigation of more complex vessel morphometry through feature engineering is needed.

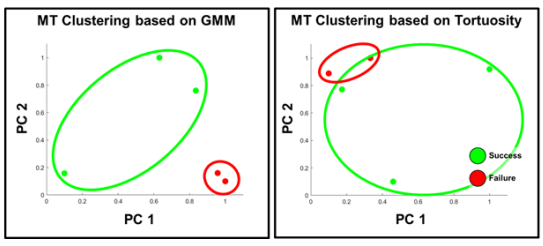
A. Vessels and clots were reconstructed from pre-treatment imaging.



B. Morphometric analysis was completed for isolated vessels.



C. Local MCA variation indicated MT outcome better than tortuosity.



	Method	
	GMM	Tortuosity
Compactness* (Successful - FPE/ Failure – no FPE)	0.664/0.733	0.002/0.004
Separability	0.986	0.753

*Lower values indicate better resolution of outcome classes