Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2026, Vol. 8, No 1, Suppl. 1, Article ID 2729, 1 Page

Abstract

Arterial deformation evaluation during endovascular procedures using 3D-printed aortic aneurysm models: a pilot study

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During endovascular procedures, arteries undergo deformations induced by the insertion of devices. In tortuous anatomies, the iliac arteries are straightened by stiff guidewires and sheaths which can influence endograft positioning and adequate sizing. This work presents preliminary results from a pilot study, using flexible 3D-printed aortic aneurysm models to characterize these deformations.

Three infra-renal aortic aneurysm models, including aneurysmal and non-aneurysmal iliac arteries, were 3D-printed in silicone using Dynamic Moulding technology. The vascular geometries were derived from patient CT scans and subsequently modified to fit the experimental setup. Using a test bench including a pulsatile pump, the models were integrated into a flow loop with controlled flow rate, pressure and temperature. Endovascular devices, namely a stiff guidewire, a 16Fr sheath and an 18Fr sheath, were inserted through dedicated puncture points within the test bench. At each step, 2D fluoroscopy and 3D CT scans were acquired using a GE hybrid-room scanner. DICOM data were processed using 3D slicer. Each anatomy was segmented, and centreline models were generated using the Vascular Modelling Toolkit. Extracted coordinates were processed in MATLAB.

For the least aneurysmal common iliac artery, the iliac tortuosity index [1] (ITI) was calculated at each step. Change in ITI, along with maximal and mean Hausdorff distance [2] between steps were quantified. Initial ITI ranged between 1.02 and 1.45 (1.22 ± 0.22, N=3). In the anatomy with the lowest initial ITI, no change in ITI was detected, despite visually observable deformation, suggesting ITI change alone does not fully capture geometric changes. Across all models, increases in device size produced larger changes in both maximal and mean Hausdorff distances. These early results demonstrate the feasibility of the proposed experimental and computational workflow. Further experiments are required to verify the statistical robustness of the findings. Future work will quantify post-endograft deployment deformation and compare model behavior to clinical endovascular aneurysm repair procedure data to evaluate the realism of the 3D-printed models.

Author's statement

Conflict of interest: S.H. is a consultant for GE Healthcare and Cook Medical. M.J., A.O., L.D., and A.B. have no conflict of interest to disclose. Informed consent: Informed consent has been obtained from all individuals included in this study. Research funding: This project benefits from a public grant managed by the French National Research Agency, under the 3rd PIA, and integrated into the France 2030 plan, with the following reference: ANR-21-RHUS-0011.

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DOI: 10.18416/AMMM.2026.26062729