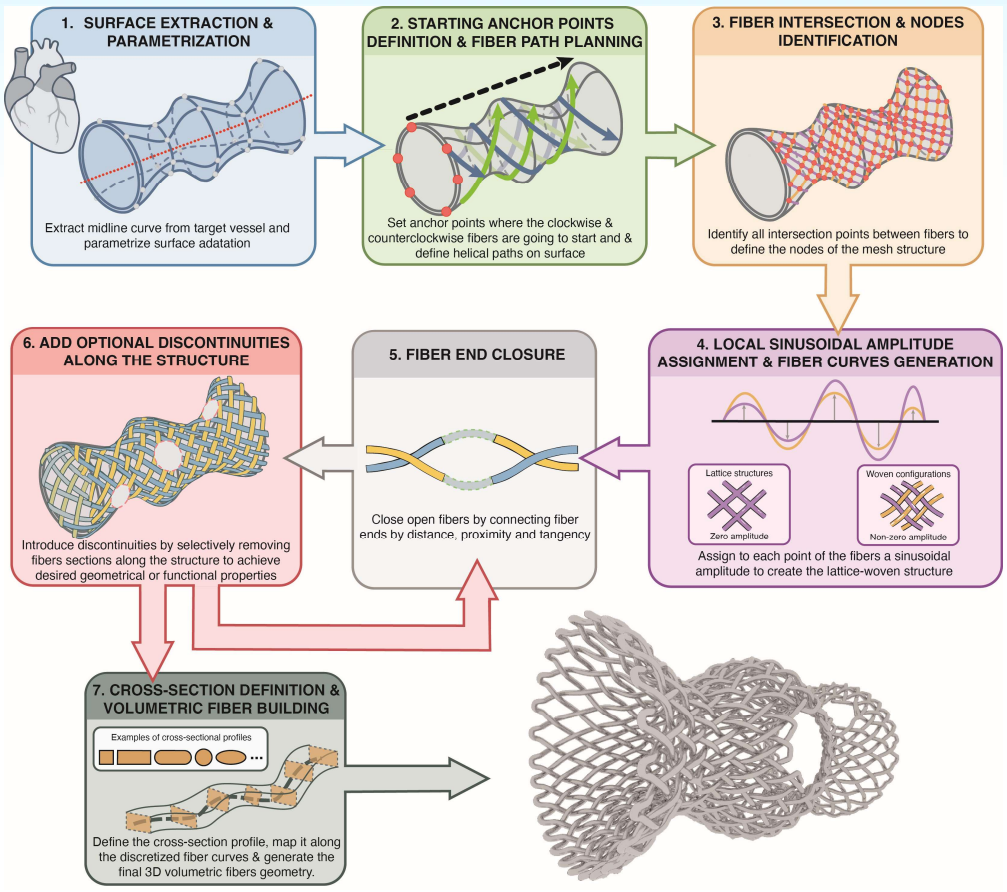
Algorithmic design and laser powder bed fusion of woven NiTi bio-metamaterials for cardiovascular repair

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Computational design for 4D-printed NiTi braided medical devices

The workflow begins with geometric extraction and parametrization of the target surface, where the central guide curve is obtained and discretized, tangent vectors are calculated, and sectional curves are fitted to define the adjustment surface. Topological fiber fitting information extraction establishes fiber winding patterns, generates surface-fiber intersections, and creates helical path references. Amplitude extraction of sinusoidal fibers constructs reference curves and parameterizes amplitudes based on fiber intersections and local spacing requirements. Generation of surface-fitted woven fibers utilizes geometric parameters to create sinusoidal fiber curves conforming to the target surface. Fiber end closure enables optional sewing of upper and/or lower ends through distance-based pairing and edge curve generation. The addition of discontinuities (optional) allows controlled gaps through volumetric body removal and subsequent fiber reconnection via iterative edge curve closure. The final step involves constructing the complete 3D geometry with locally varying radii and cross-section ready for additive manufacturing.

Workflow for patient-specific braided aortic valve frame design (structure without leaflets) using CT-derived anatomical data

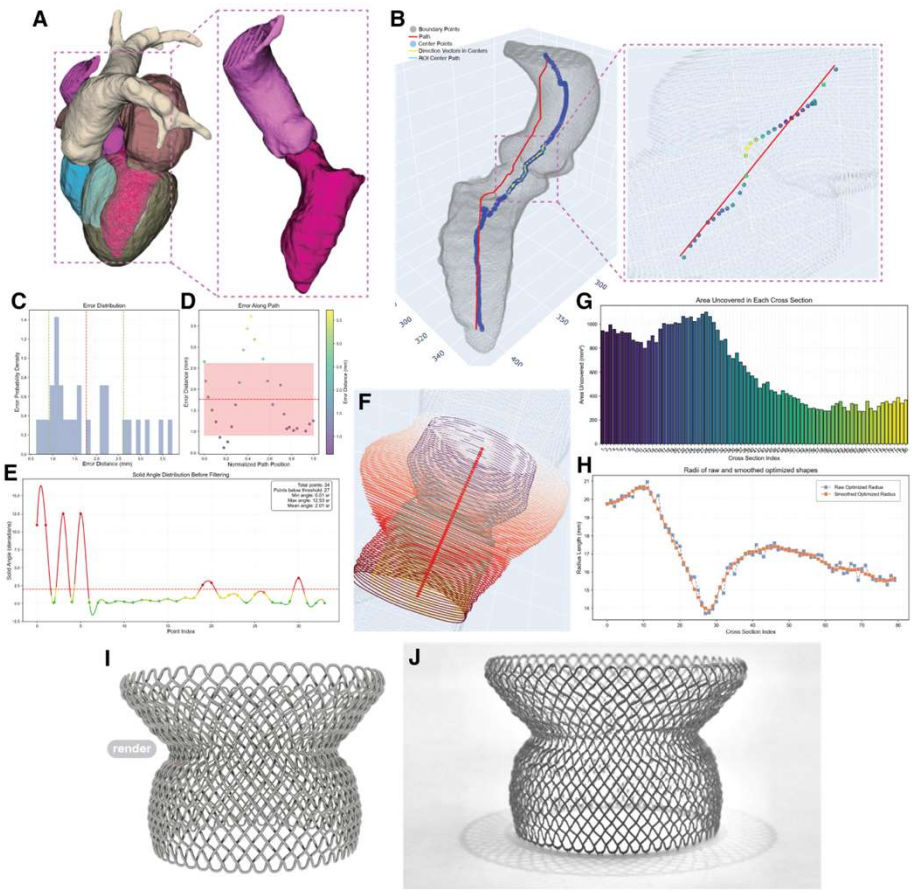
(A) Segmented mask of the aorta and left ventricle obtained from CT imaging.

(B-E) 3D midline trajectory is extracted via a modified BFS algorithm, centroids and anatomical directions are computed, and the region of interest (ROI) centered at the aortic annulus is selected; polynomial regression refines the guide path.

(F) Cross-sectional boundaries are generated by projecting mask voxels onto local planes, then optimized as parametric curves (circular, elliptical, or spline) to minimize area mismatch with the ROI contour.

(G-H) Quantitative metrics assessing the accuracy and continuity of the shape optimization.

(I-J) Anatomical data is used as input for creating a 3D-printed NiTi braided frame, ensuring precise conformability to the patient's vascular anatomy and structural integrity of the TAVR implant.



Design (I) and prototype (J).

Collection of cardiovascular devices obtained by laser powder bed fusion of woven NiTi bio-metamaterials with superelastic properties



