ON-LINE APPENDIX

CFD Meshing Strategy

The CFD meshes in the current study were created following a previously described meshing strategy, which was developed to address difficulties when meshing endovascular devices.[1] It is difficult to create volume meshes for IAs with deployed FDs because FDs are geometrically complex and their braided wires are much smaller than the IA. Therefore, additional surface meshing operations on the deployed FDs were required before volume meshes could be generated.

Following deployment of FDs by using HiFiVS,[2] surface meshing operations were performed on the FDs to prepare them for volume meshing. FD wire-to-wire surface contacts and intersections (especially those between overlapped FDs) were removed by surface wrapping FDs in Star CCM+ v.10 (CD-adapco). The surfaces of the wrapped FDs were then remeshed with triangles that had nominal edge sizes of approximately 5–10 μm. An example of FD wires that were wrapped and remeshed is shown in On-line Fig 1. After we surface-remeshed the FDs, surface Boolean operations were performed to remove any sections of the FDs that were protruding outside of the IA or parent vessel because the surface of each flow domain (ie, IA and parent vessel) had to be closed and continuous before volume meshing.

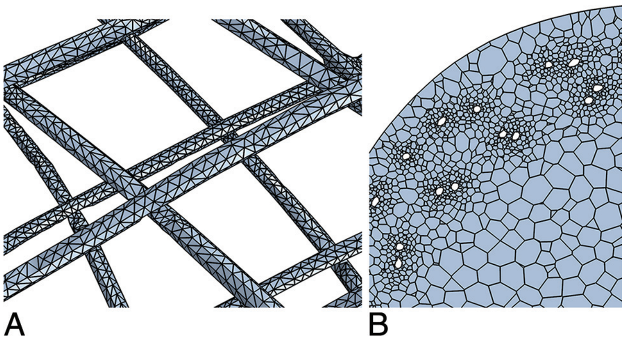
After surface preparation, flow domains were discretized with surface-conforming polyhedral cells to create unstructured volumetric meshes. Volumetric mesh controls (polyhedral cell size expansion rate, mesh density, and growth factor) were used to ensure sufficient mesh resolution around the FD wires while limiting the number of cells in the flow domain. An example of the effect of mesh-density controls on the overall CFD mesh is shown in On-line Fig 2.

Mesh-Independence Study

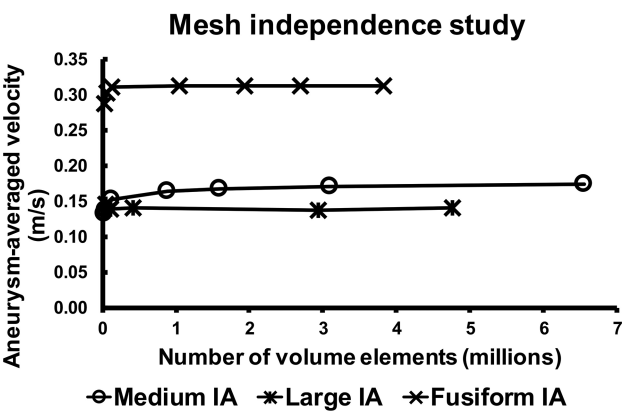
The reductions in all 5 hemodynamic indicators following each FD deployment strategy were reported as percentages of those in the untreated IAs (Fig 5 in the text). Therefore, we performed a mesh-independence study to assess the degree to which the volumetric discretization of the flow domain affected the solution of the flow fields in each untreated (fusiform, large, and medium) IA. A series of volumetric meshes with decreasing nominal volume cell edge sizes was generated in each untreated IA. After we performed each CFD simulation, the value of aneurysm-averaged velocity in each IA sac was plotted against the corresponding number of volumetric cells in the flow domain, shown in On-line Fig 2. The simulated flow fields were assumed to be independent of the spatial mesh discretization if the value of aneurysm-averaged velocity varied no more than 2% among 3 consecutively refined meshes. On the basis of the results, the fusiform, large, and medium IAs were meshed with nominal volume cell edge sizes of 200, 200, and 100 μm, respectively. Volume meshes for the noncompacted, overlapped, and compacted FD scenarios in each IA were meshed by using these same nominal volume cell edge sizes.

REFERENCES

1. Damiano RJ, Ma D, Xiang J, et al. **Finite element modeling of endovascular coiling and flow diversion enables hemodynamic prediction of complex treatment strategies for intracranial aneurysm.** *J Biomech* 2015;48:3332–40 CrossRef Medline
2. Ma D, Dumont TM, Kosukegawa H, et al. **High fidelity virtual stent placement (HiFiVS) for intracranial aneurysm flow diversion: in vitro and in silico.** *Ann Biomed Eng* 2013;41:214–56 CrossRef Medline



ON-LINE FIG 1. Surface-meshed FDs and CFD volume mesh. *A*, Example of overlapped FD wires after surface wrapping and remeshing. Surface remeshing created a triangulated mesh of the FD wires to approximate their tubular shape. *B*, A section plane through the parent vessel with overlapped FDs. The mesh density controls produced a volume mesh that contained a higher resolution of cells around the wires of the overlapped FDs than in the parent vessel.



ON-LINE FIG 2. Mesh-independence study. Aneurysm-averaged velocity in the fusiform, large, and medium IAs plotted against the number of volume cells in the flow domain.