Aortic-Common Iliac Bifurcation Aneurysm Model

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Model Geometry

Vessel geometry was researched and characterized to produce a realistic model with average dimensions to represent a large patient population. Figure 1 shows parameters for target dimensions listed in table 1.

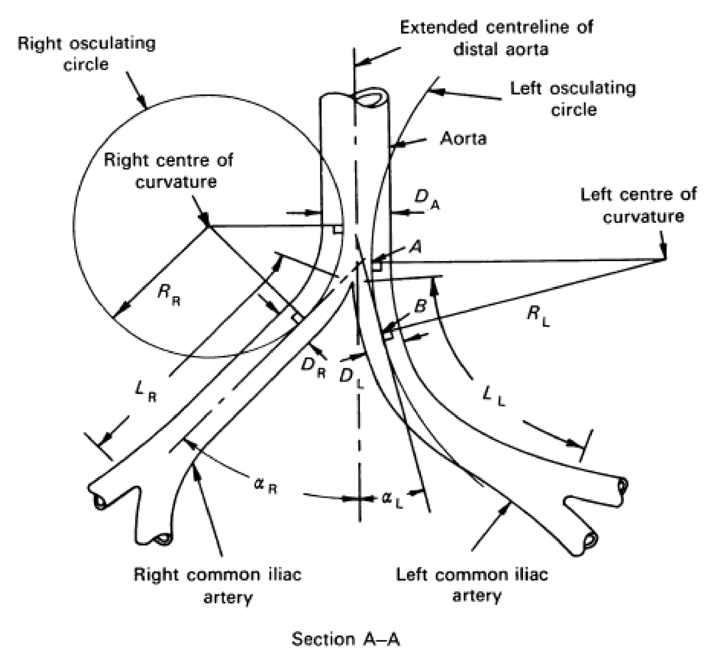

Figure 1: Bifurcation geometry [1]

Table 1: Average Geometry Target Values

Aortic-Common Iliac Average Geometry Values		
Length of Right Common Iliac	L_R	6.086 cm
Length of Left Common Iliac	L_L	5.814 cm
Diameter of Right Iliac at Bifurcation	D_R	1.271 cm
Diameter of Left Iliac at Bifurcation	D_L	1.236 cm
Radius of Curvature at Right Junction	R_R	3.457 cm
Radius of Curvature at Left Junction	R_L	5.05 cm
Take Off Angle of Right common iliac	α_R	29 degrees
Take Off Angle of Left common iliac	α_L	14 degrees
Diameter of Distal Aorta	D_A	2.186 cm
Angle W.R.T. Aoritic Centerline	θ	15 degrees

Prototype Model

An original CAD model prototype was developed based on average vessel geometry (figure 2). From this model, prototype patterns were printed for mold construction. The first successful prototype utilized this design (figure 3).

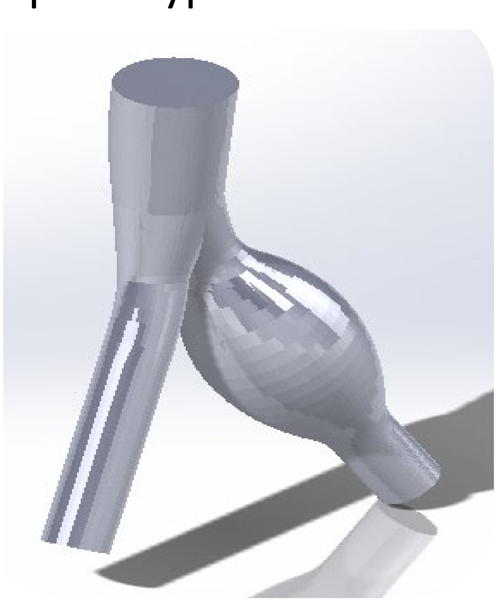
Figure 2: Prototype CAD Model


Figure 3: Finished Prototype

Clay was used to define the parting surface of prototype molds (figure 4). This technique was effective but time consuming. Clay was replaced by a 3D printed surface for the final models.

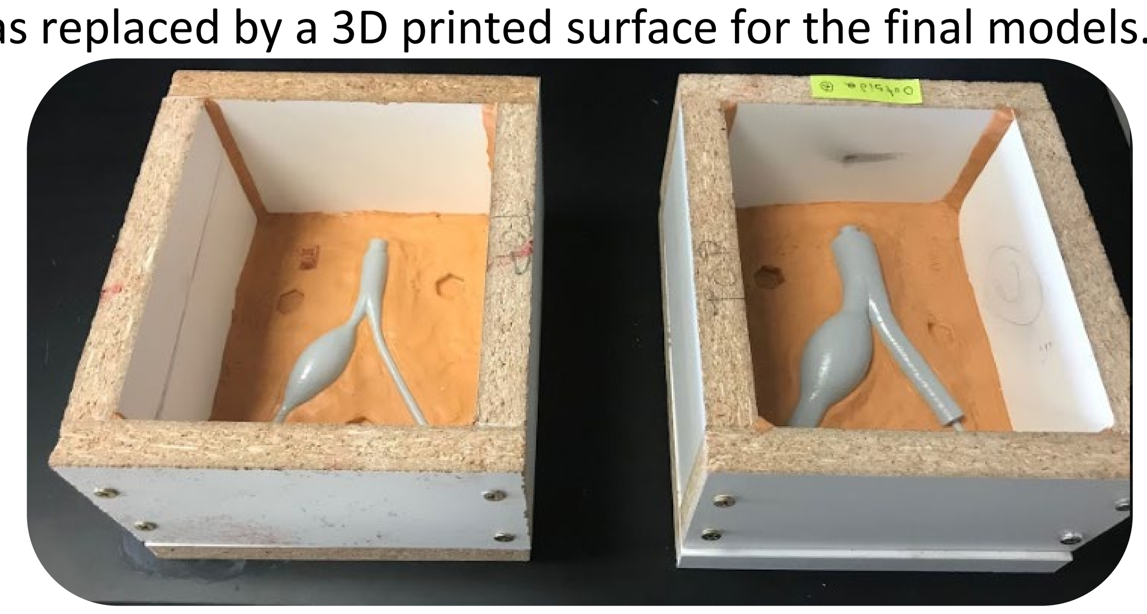
Figure 4: Prototype Patterns in Mold Boxes

Chemical Vapor Treatment

ABS prints were used for mold patterns (figure 5). Surface texture from printing translated to the molds and model during prototyping. Prints were treated in an acetone vapor bath to smooth and seal patterns.

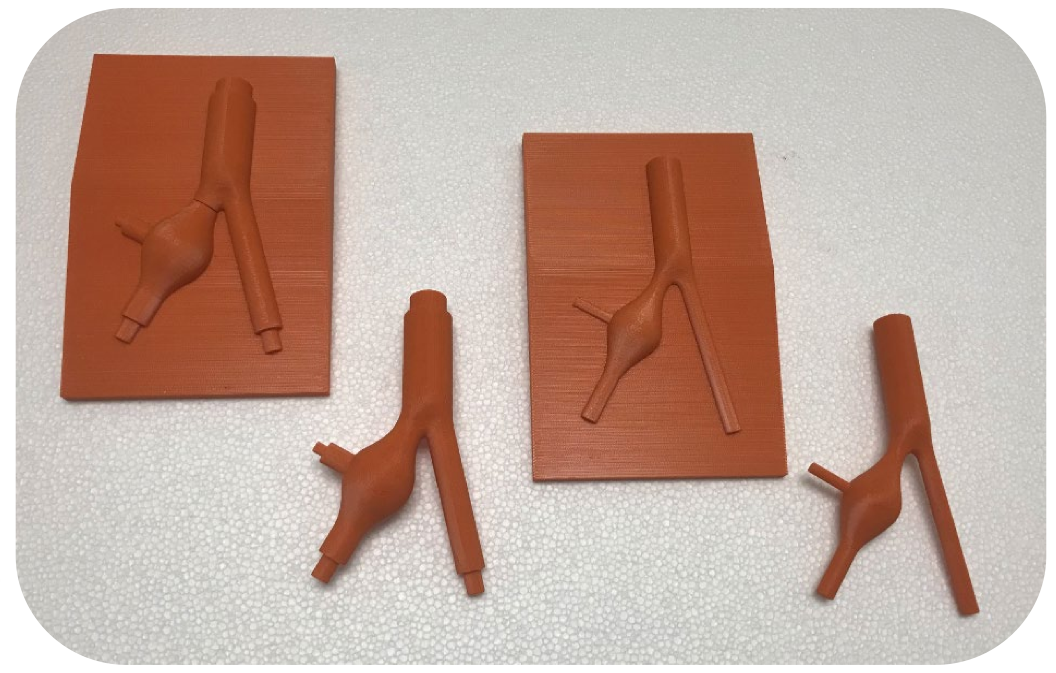
Figure 5: ABS Patterns

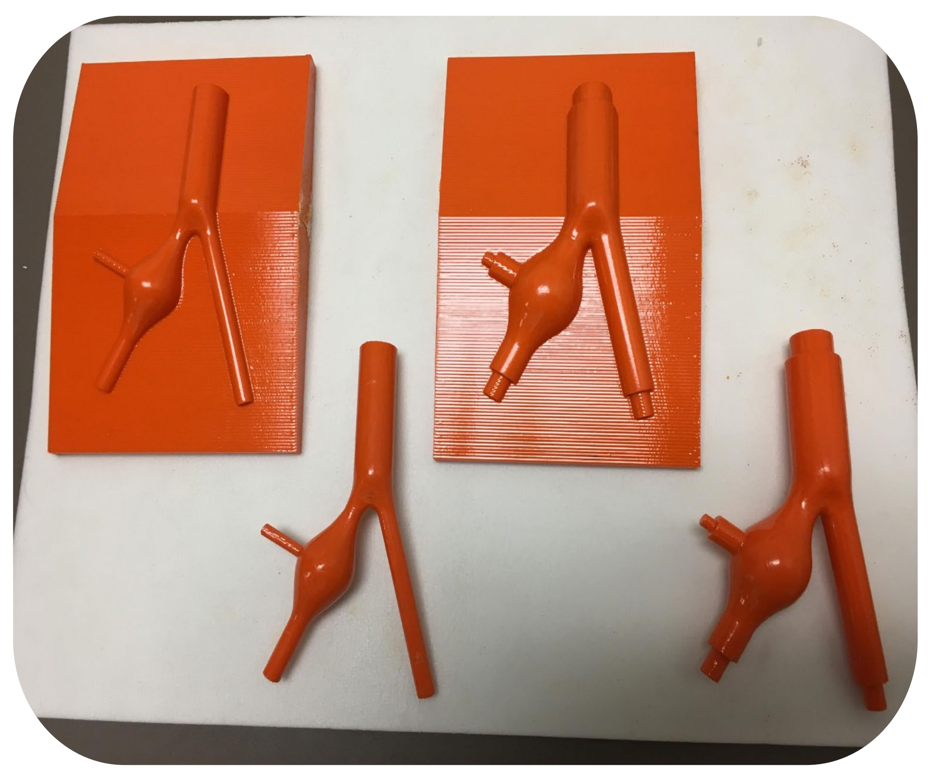
Figure 6: Patterns After Chemical Treatment

Each pattern was treated twice in the chemical vapor bath for 40 seconds and sanded with 150 grit sand paper between treatments. The chemical treatment produced a smooth, high-gloss surface on the patterns to improve clarity in the final models (figure 6).

Manufacturing

Platinum based silicone was selected for use as a mold material. Models were cast from room temperature curing polyurethane in these molds (figure7). A systematic casting process was developed. Materials were degassed in a vacuum chamber before pouring (figure 8). Mix ratios were documented for each model.

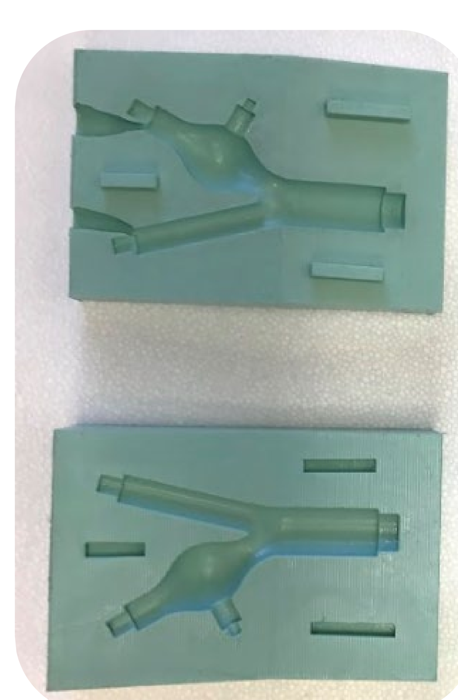
Figure 7: Silicone Molds

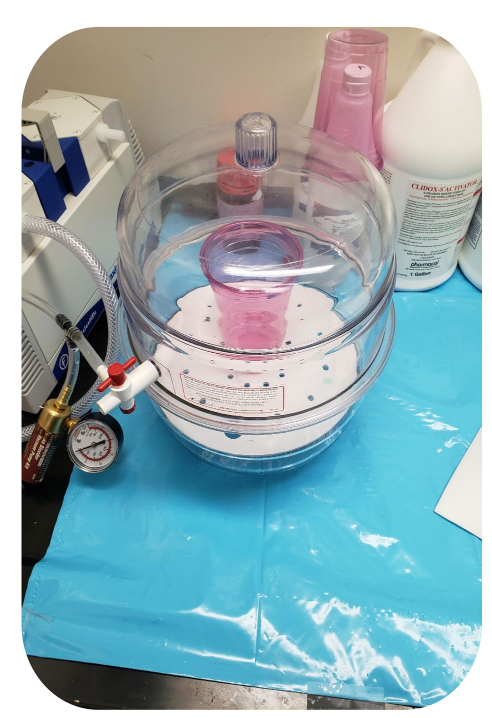
Figure 8: Vacuum Degassing

Figure 9: Filling Mold

Material Composition

Water-clear, flexible polyurethane was selected for the models (figure 10). Polyurethane showed several advantages over silicone:

- Lower Friction for Catheter Insertion [2]
- Longer Fatigue Life [2]
- Viscoelastic properties [2]
- Higher Translucence to Improve Visibility [3]
- Low (900 cps) viscosity for easier pouring [3]

Figure 10: Two-Part Liquid Polyurethane

Figure 11: Softening Agent

A softening agent (figure 11) was used to adjust mechanical properties of the material for the final models. Four different ratios of polyurethane to softener were selected for testing. A 3:4 (75%) softener to polyurethane ratio was selected based on test results.

Conclusions

Silicone molds developed from vapor treated patterns reduced surface texture, improving clarity of the final models (figure 12). Polyurethane with added softening agent produced flexible models with Young's modulus and shore A hardness of 467.7 ±19 kPa, and 15 ±1, respectively. Model geometry was tested to using a sample size of 6 to validate the manufacturing process.


Figure 12: Final Model

References

[1] P. Shah, H. Scarton, And M. Tsapogas, "Geometric anatomy of the aortic-common iliac bifurcation," *Journal of Anatomy*, vol. 26, no.3, pp. 451-458, Aug 1978.
[2] BJB Enterprises (2019) bjbenterprises.com [Online]. Available:https://bjbenterprises.com [Accessed Mar. 3,2019]
[3] V. Kanyanta and A. Ivankovic, "Mechanical characterisation of polyurethane elastomer for biomedical applications," Journal of the Mechanical Behavior of Biomedical Materials, vol. 3, no. 1, Jan., pp. 51-62, 2010.