Mobile In-Vitro Neurovascular Cast System

Operation/Assembly Manual

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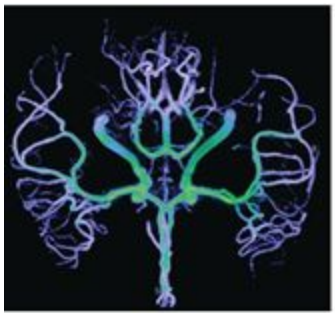

Mobile In-Vitro Neurovascular Cast System

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1.0 Introduction

The model of the Circle of Willis (CoW) is created using 3D printing. The material used is a digital photopolymer. The process is done by ProtoLabs, where the digital photopolymer is a proprietary material.This document outlines the details of manufacturing and maintenance on the printed CoW model. An image of the CAD file for the CoW can be seen in figure 1.

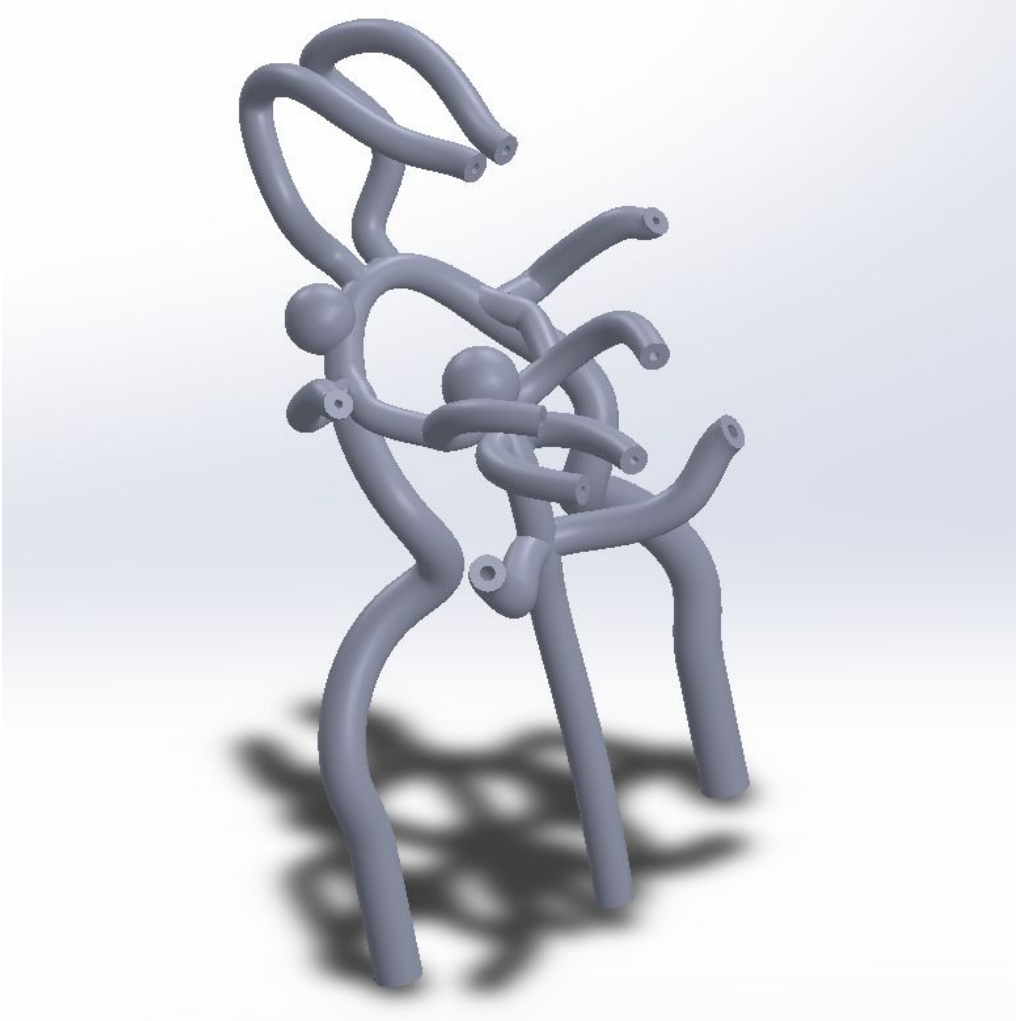

Figure 1: SOLIDWORKS Model of modified Circle of Willis

2.0 Manufacturing

The material used is a digital photopolymer which is printed using a PolyJet process. This process involves liquid droplets of the material being sprayed and then instantly cured by UV light. Different materials can be used in different compositions to create a variety of material properties. Figure 2 shows a picture of one of the PolyJet printers.

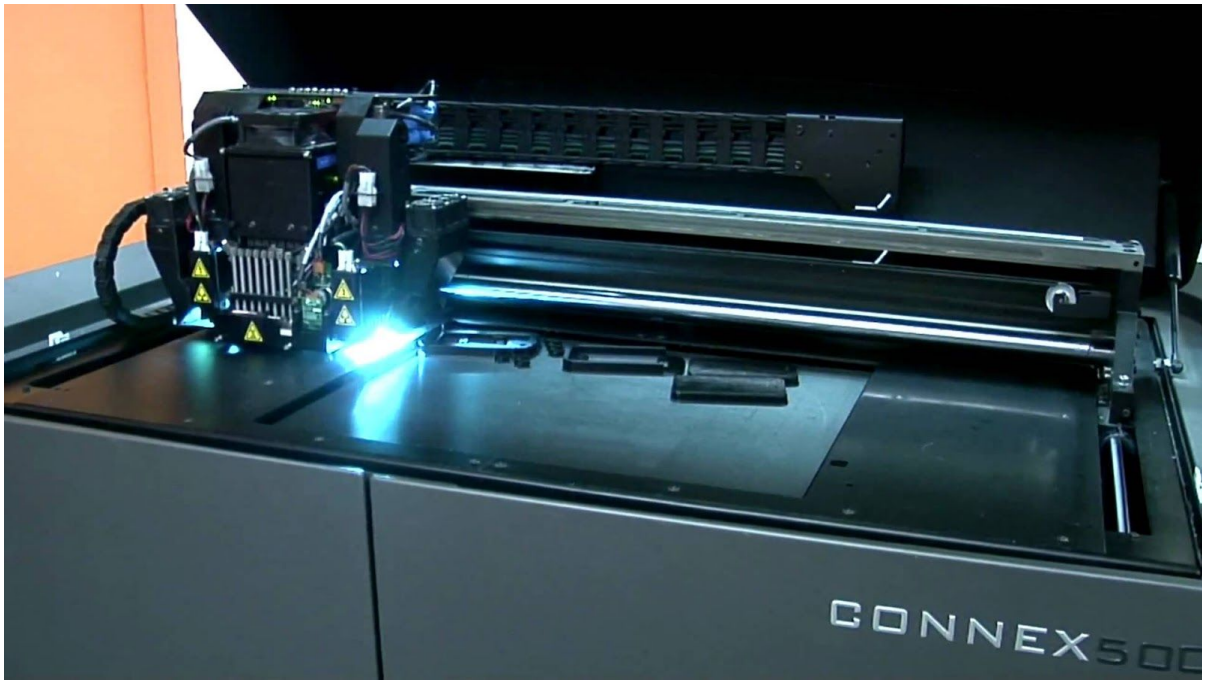

Figure 2: PolyJet 3D printer

For the CoW model, the digital clear/translucent variant of the material is used. In addition, a Shore hardness of 30a is selected. The resulting material properties are shown in table 1.

The 3D prints should always be ordered from ProtoLabs, as the digital photopolymer and manufacturing process is proprietary. If the material changes or is no longer available, further research will need to be done in order to select a suitable replacement.

Table 1: Material Specifications from ProtoLabs

PROPERTIES:			Shore A							
Digital Material Properties	ASTM Standard	Unit of Measure	30	40	50	60	70	85	95	Rigid
Tensile Tear Strength	D-624	Kg/cm	5.0-7.0	6.0-8.0	7.0-9.0	7.0-10.0	12.0-14.0	22.0-26.0	26.0-30.0	-
Elongation at Break	D-412	%	220-270	190-210	170-210	150-170	120-140	70-90	50-70	10.0-25.0
Shore Hardness	D-2240	Scale A	30-35	40-50	50-55	55-60	60-70	80-85	85-90	83-86 (D)
Tensile Strengnth	D-412	MPa	2.4-3.1	3.0-4.0	3.0-4.0	3.5-4.5	4.0-6.0	6.0-10.0	10.0-14.0	50-65

1. Receive measurements of lengths and diameters of blood vessels located in the Circle of Willis (CoW) using medical Literature [1].
2. Design the model of the core using SolidWorks™ that resembles a realistic view of the CoW including Aneurysms.
3. Design another model without aneurysms using SolidWorks™ which is used to test the connectivity of flow system.

Figure 3 - Circle of Willis without Aneurysms

4. Both cores are then sent to ProtoLabs™ in order for it to be 3D printed and then shipped back to the user.
5. An Acrylic box adapter is built using six sheets of UV resistant Acrylic [2] and then they are bonded together using an adhesive [3].
6. The final print of the core, including aneurysms is connected to the flow system

3.0 Maintenance

The printed CoW model has a limited number of uses. This is partially due to the limited number of aneurysms in the model (4). If material is injected and hardens in all 4 aneurysms, the model would need to be dissected in order to recover the material. Regardless, the model will be replaceable.

4.0 Operation

The neurovascular cast consist of three major systems which include the flow system, the Circle of Willis, and the case it is housed in.

4.1 Case

The acrylic case is built with magnets inserted on the top lid for ease of access in the system. The lid once aligned easily connects together for the system.

4.2 Circle of Willis

The Circle of Willis model is a highly elastic material which the vessel ends can be attach to the inlet and exit ports of the system with plastic barbed tubes as connectors to prevent any leaks. The luer locks are attached to the inlet and outlet adapters which the connectors can be securely connected.

4.3 Flow System

The flow system consist of a pump, an inlet and exit port for the system. The case houses both a 3D printed inlet and outlet adapter that support the luer locks so that the tubing can be connected appropriately and securely. Once the pumps are active, inspect all ports for possible leakage. The flow of fluid enters through the inlet port and out through the outlet manifold.

4.3.1 Inlet Port

The inlet adapter is attached to the case and has three ports which the pump and the tubings will attach. Ensure the connector attachments are appropriately and securely attached to prevent leakage or damage.

4.3.2 Outlet Port

The outlet adapter has the exit ports which the Circle of Willis vessels attach to for the fluid to exit the system to the pump system. There is one hose at the bottom right side of the case which the user will attach the exit tubing securely.

4.4 Head Gel

The head gel comes as a 2 liquid parts that are mixed in a 1:1 combination and solidifies. The liquids must be poured carefully into the container to avoid creating bubbles. The two gel is stable at room temperature but should not be overly exposed to air. The gel was developed by neurosurgeons to mimic pushback from brain tissue.

4.5 Operational Steps

1. Turn on hot plate to activate the warming of the “blood.”
2. Connect circle of Willis to the Case starting with the large arteries into the inlet adapter and then connect the smaller vessels to the outlet manifold. (note each vessel should lie close to the connector they connect to, they should never change the geometry to connect)
3. Mix head gel in a separate container, equal parts of both bottles.
4. Pour the head gel into the case, place lid on case, and allow to solidify for at least 30 minutes before use.
5. Connect the flow system to the inlet adapter and outlet manifold.
    a. It is up to the user's discretion as to which vessel they would like to access with the microcatheter. To change the accessed vessel simply change which port has the introducers leading to it.
6. Turn on the pump by flipping the switch located on the rear of the pump.
7. If DAQ monitoring is desired, turn on computer and start the labview program. Ensure that all DAQ equipment is powered on.
8. Insert microcatheters through the two introducers and begin administering the treatment.
9. Once treatment has concluded, drain all fluid from the circle and remove head gel
    a. Store head gel in an airtight container, in a cool dry location.
10. Remove circle from case and perform any studies on the treatment area.

5.0 References

[1] S. Kamath, "Observations on the length and diameter of vessels forming the circle of Willis", Department of Anatomy, St John's Medical College, vol. 133, no. 3, pp. 419-423, 1880.

[2] "McMaster-Carr", Mcmaster.com, 2018. [Online]. Available: https://www.mcmaster.com/. [Accessed: 06- Apr- 2018].

[3] "Amazon.com: Online Shopping for Electronics, Apparel, Computers, Books, DVDs & more", Amazon.com, 2018. [Online]. Available: https://www.amazon.com/. [Accessed: 06- Apr- 2018].