Alternative Design 1

The first design will incorporate a transparent integumentary system, with the ability to see the movement of lymph fluid within the arm after removal of the compression sleeve. The outer structural support will consist of a three-ringed metal system with supports at the wrist, elbow and shoulder. The rings will have a miniature removable spoke system supporting the outer structure to the inner bone layer as seen in Figure 1. The pins, or “spokes” can be locked into place to allow structural support, or be removed when removal of the inner bone and muscle system is needed (to view the lymphatic layer).

![Figure 1: (i) An outside view of Alternative Design 1 showing the spokes attaching at wrist, elbow, and shoulder. (ii) A Visio drawing of Alternative Design 1 displaying the transparency of the arm with (a) representing muscle, (b) the lymphatic and interstitial layer, (c) the skin layer, and (d) the cross-section of the elbow that is displayed in (iii). (iii) Cross-section of elbow where (a) is the bone structure, (b) is the lymphatic system and interstitial space, (c) is the skin, (d) is the sleeve, (e) is the spokes, and (f) is the wires from the air muscle arms.](image-url)

The transparent polymer skin layer will fit tightly under the ringed structure to keep the arm model to scale with the average arm dimensions of a mid thirty year old woman. The lymphatic/subcutaneous layer will be modeled by hydrogel with a specified porosity that will be placed between the skin/support layer and the muscle layer in a thinly sealed, plastic container.

The muscle layer will be modeled by a series of pneumatic artificial muscles, or “air muscles”. It will be attached to an inner hollow cylinder that will represent the bone. The muscle system will be an inflatable air muscle system will contain two air muscles representing the muscles of the lower arm and two to three air muscles representing the upper arm. The air muscles will be hooked up to a compressor via wiring through a microcontroller. The wiring will travel through the hollow bone cylinder where they will attach to a microcontroller. The microcontroller will be hooked up to a compressor. The microcontroller will help to send signals from a user interface that will allow the user to choose a certain state of muscle activity. As the user chooses a state, the air muscles within the muscle system will inflate or remain at a constant pressure depending on the chosen state.

To test the compression sleeve, dye will be injected at multiple openings throughout the wrist with a syringe. The compression sleeve will apply pressure to the arm model while the muscle pump system will be regulated via the user interface. When the testing period is
complete, the sleeve will be removed by following a protocol typically used to remove compression sleeves so the arm is not afflicted in any way. The transparent skin layer will then allow analysis of lymphatic flow by providing a visual of dye through the gel layer.

When the lymphatic/subcutaneous layer must be removed for replacement, the muscle system will be deflated, spokes of the support will be removed, and the skin layer will be able to be removed to replace the lymphatic layer underneath. The inner bone cylinder will be attached at the ends to a stand that will distance the arm from any kind of external surface interaction and will allow for different layers to be removed one at a time.

Some of the pros of this design is the ability to have a transparent skin layer for ideal viewing of the lymphatic system. Furthermore, the outside solid support is stabilized and does not need to be adjusted to allow viewing into the lymphatic layer.

Some of the things that negatively impact this design include the strength of the support structure. Because the structural support is held together only at the wrist, elbow, and shoulder by spokes, the arm may not be supported enough possibly resulting in a sagging of fluids in some layers. The outer structural support may also reduce the amount of force produced by the compression sleeve on the skin layer (and eventually the lymphatic and interstitial layer) in the important areas of the wrist, elbow and arm. This would be problematic since in lymphedema, edemas can form in areas specific to the elbows and wrist. Even though the skin layer is transparent, this may not be the most ideal viewing for the lymphatic fluid flow. This design requires viewing through 2 layers—the skin and the hydrogel—to visualize the effect of compression on the lymphatic layer.