

# ***Hip Aspirate Model to Teach Physicians***

*BME Design Excellence Award - My An-adirekkun, Jessica Brand, Stephen Schwartz*

Septic arthritis is an inflammation of the joints caused by a bacterial or fungal infection that spreads through blood. Although this rare orthopedic disease can be seen at any age, it is most common in infants under two, the elderly, and those with weakened immune systems. If this disease is not treated properly, it can lead to tissue necrosis causing lifelong pain and discomfort. Septic arthritis is most effectively diagnosed by aspirating (drawing out) synovial (joint) fluid. When synovial fluid builds up too quickly, the fluid must be aspirated quickly.

Although the hip is one of the most commonly affected joints, there is no product on the market specially designed for residents to practice X-ray and ultrasound-guided hip aspiration in infants. Most hip models on the market, such as those from Sawbones Company, are adult orthopedic models which only show bone and muscle anatomy or are designed for other purposes. These models do not allow for synovial fluid aspiration, and therefore are not suitable for our purposes.

As our team has only three members, we each must perform multiple roles to complete the design process. Fortunately, the design team that worked on this project in the fall of 2014 already made significant progress selecting materials that satisfy the client's objectives, such as mimicking the mechanical and optical properties of biological tissues. Thus, our team has picked up where they left off and started immediately with designing a cohesive, working model.

After brainstorming and evaluating various ideas, we settled on a final design. However, before we could justify its fabrication, we needed to test the central mechanism which governs the entire design: the ability for a water balloon to hold fluid around the femoral head and burst in a containable way upon being punctured. After successfully demonstrating this mechanism, our team moved forward with ordering the rest of the materials and beginning fabrication.

The final design involves using a tube channeled through a cavity in the femur to pump fluid into a balloon that is secured around the femoral head. This entire assembly fits into a cavity that has been carved out of an infant-sized mannequin's hip/thigh. A flap of artificial tissue layers--including silicone-based skin, fat, and a urethane joint capsule--will be secured around the radiopaque femur and balloon. Once all of the components are correctly set in place, the balloon will be filled with fluid and a hip aspiration procedure can be conducted.

We have found a balloon that works well with our model, ensuring that our design concept is feasible. When testing the resealing properties of our tissue layers, all materials, especially the urethane, offered resistance to a needle even after multiple punctures. Additional tensile testing as well as x-ray and ultrasound compatibility tests will be performed. Once fabrication has been completed, we will test the whole model to ensure proper functionality.

Our overall design will accurately replicate an infant hip joint by providing appropriate fluid distribution and proper overlaying tissue layers that effectively mimic fat, skin, and a joint capsule membrane. It will be a long-lasting, reusable device requiring only one inexpensive portion to be replaced between uses. By allowing the user to repeatedly practice an essential, time-sensitive procedure in a risk-free setting, our device will ultimately save lives.