Biomaterial Implant Design Competition for High School Students

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Statement of Purpose: To provide educational outreach to local high school students, a biomaterial design competition was developed. The goal of the competition was to teach high school students about bone anatomy and physiology, implant design, and biomaterial selection by requiring them to design a biomaterial implant for filling and stabilizing a bone void. The competition needed to be relatively easy to understand, simple and easy to conduct in any setting.

Methods: High school students (grades 9-12) were provided instructions for the competition prior to the day of the competition. Students formed teams of five or fewer members and were required to design and construct a prototype implant to fill and stabilize a partial bone defect (2 inches long, ½ inch wide, and ¾ inch deep) in a sawbone (Sawbones Worldwide, Vashon, WA) femur. Partial bone defects were measured and cut using a Dremel® tool, and the canal was plugged with approximately ¼ inch of calcium sulfate. Teams were provided the femurs on the day of competition and were given ten minutes to apply their implant materials/devices to fix and stabilize the damaged sawbone on site (Figure 1).

Figure 1. A student team setting up their implant

Students were required to design an implant that filled the entire space of the defect and the total cost of materials could not exceed $15. No power tools were allowed during the competition, but hand tools were allowed. Teams were also required to present a poster on their implant design. The posters included a description of basic bone anatomy, physiology, and/or bone healing, identification and description of materials, a design and materials rationale, and a budget breakdown of materials. The students' posters and designs were judged by biomedical engineering undergraduate and graduate students. The scores for the team included scores for design, presentation, poster and the amount of weight held. Once the implants were set up in the bone defect, the stabilization of the sawbone was tested using three point bending (Figure 2). The weight of failure of the sawbones with defects but no implants was found to be approximately 28-30 kg.

Figure 2. Competition set-up

In order to speed up testing, the bones tested in the competition were all first loaded with 22.68 kg. After the initial weight was added, weights were added every 20 seconds to the testing apparatus until the sawbone failed. The weight at failure was recorded for every implant.

Results: Eight high school teams participated in the competition; 3 private schools and 5 public schools. The overall team scores (Figure 3) were quite close. One student team went over their ten minute set up time limit and one team went over their budget restrictions, but the remaining teams followed the guidelines. Commonly used materials included duct tape, wooden blocks and rods, and dry wall tape. Only one student team designed an implant that stabilized the bone enough to prevent fracture; however, their design of two metal rods and metal clasps surrounding the bone was one of the more impractical designs. All of the student teams provided background information about bone anatomy and the healing process, and most students could answer questions in a logical manner. Many of the students were enthusiastic about their implants and what they had learned.

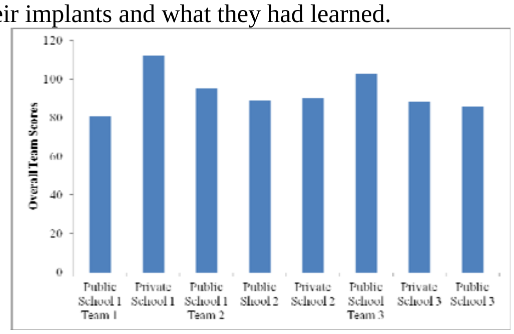

Figure 3. Overall team scores for design competition

Conclusions: The biomaterial bone filler design competition was determined to be an easy and simple outreach activity to implement in any setting. Students could design simple or complicated implants, with whatever materials to which they had access. Students seemed to easily understand the concepts and realized very quickly how they could improve upon their implants. The students competing in the teams, as well as student observers, seemed to enjoy the three point bending test and watching the bones break. Future competitions will include changes to the scoring system, including adding design feasibility. The score system that was used in this study placed too much emphasis on the weight until fracture. Smaller sawbones could also be used in future competitions for reduced loads to failure. Instead of three point bending, a more functional four point bending test could also be utilized. Additionally, implant cost will also be factored into the score, because balancing cost and function is an important consideration in implant design.

Acknowledgements: The Biomaterials Applications of Memphis (BAM) Laboratories, the UM Biomedical Engineering Department, and the UM Herff College of Engineering for their support