Executive Summary: Tong BME Design Award, BME 402

Development of an Upper Extremity Fracture Model

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Improper bone alignment during bone fracture reduction by poorly trained physicians can lead to severe and costly complications for the patient, especially in children. A recent study in the Journal of the Academy of Orthopedic Surgeons shows that casting was the number one cause of litigation in a group of 400 physicians, and 35 percent of casting complications paid an average of $120,000 each. In addition, fracture of the distal radius and ulna near the wrist, a common pediatric ailment, can lead to years of complications if improperly aligned. A pediatric fracture simulator that provides immediate feedback, in the form of pressure, alignment, and temperature data, will provide an improved and cost effective training for the physicians.

The final design consists of the following three layers: an artificial bone structure, a middle soft tissue layer, and an outer protective layer. The artificial bone structure has rounded mating surfaces at the fracture site and is held out of alignment by latex tubing under tension. This forces the user to maintain proper alignment throughout the cast application. Sensors at the fracture site also give immediate feedback on the degree of alignment. The bone structure is encased by a custom molded gel layer that mimics the properties of muscle. On the dorsal and ventral sides of this gel layer there are pressure mapping sensors. These sensors collect data throughout the procedure and can be used to determine when a user is applying the proper pressure to reduce the fracture. Temperature sensors are located on the lateral sides of the gel. Temperature data is used to determine if the cast application would result in burns to the patient. The final layer consists of a protective mesh strip over the sensors to prevent possible damage during the removal of the cast. Data is collected on a computer from each of these sensors to allow real time or retrospective evaluation of casting procedures. Each of the layers is fabricated in a way that they can be easily removed in order to access the innermost components if any mechanical adjustments need to be made. The device closely mimics the feel of a real fractured wrist according to our client, a practicing Orthopedic Surgeon.

Currently, there are no competing commercially available devices that allow physicians to train on proper fracture reduction. New physicians learn proper casting procedures through supervised trial and error on patients which can result in poor outcomes. With about 17,000 med students graduating every year and over 400 teaching hospitals in this country there is a real need for a device that can safely teach proper casting procedures. The fracture simulator gives physicians the opportunity to gain more hands-on experience in properly reducing fractures before ever having to practice on a live patient and without the risk of possible litigation.