Product Design Specification

Sensorized Broken Wrist Model for Teaching Casting via Simulated Fluoroscopy

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Function:

No teaching tool exists for surgeons to learn the process of casting a broken wrist with objective, real-time feedback. Modifying an existing Colles' fracture simulator with a force-sensing linear potentiometer (FSLP) and inertial measurement units (IMUs) allows for an effective way to communicate reduction quality to the user in the form of a graphical user interface (GUI). IMU angle and position measurements allow for synchronization of wrist motion to simulated fluoroscopy while an FSLP displays the target force range and location to achieve proper reduction. Future use of this simulator includes teaching casting and the ability to declare objective competency of the procedure.

Client Requirements:

- Design a network of integrated sensors into a Sawbones® arm model to detect force location and fracture angle during casting of a distal radius fracture
- Create a graphical user interface to display force and angle readings
- Make multiple iterations to present and collect data at the *Top Gun* resident training competition at the 2018 International Pediatric Orthopaedic Symposium (IPOS)

Design Requirements:

1. **Physical and Operational Characteristics**

    a. Performance Requirements: System must be able to perform consistently and reliably. Inconsistent measurements will discredit data collection and therefore affect learning outcomes.

    b. Safety: The product must not harm the user or the Sawbones® arm model.

    c. Accuracy and Reliability: Sensors must produce readings that are consistent with the amount of force applied. The FSLP needs to detect a range of 1-70 N. The angular sensor needs to be accurate to ± 2°.

    d. Life in Service: Entire system must be able to endure numerous casting procedures without damage from water or casting material. If damaged, system should be designed to be easily repaired.

    e. Shelf Life: Two years.

    f. Operating Environment: Our product should be operable anywhere. Water exposure will also occur during every casting.

    g. Size: Thickness of implanted technology must must not interfere with user palpitations and should be secured so they are not damaged during palpitations.

    h. Weight: Weight will be minimal, and a lighter model will be advantageous as it will be less cumbersome for the participant casting the model.

    i. Materials: Includes Sawbones® distal radius fracture model, microcontroller (Teensy 3.2), wire, FSLP, IMUs (BNO055), Bluetooth module, lithium battery, and computer.

    j. Aesthetics, Appearance, and Finish: Device should have a smooth feel and appearance with limited protrusions. Virtual modeling of feedback should be visually informative and displayed on a laptop.

2. Production Characteristics

a. Quantity: Six working prototypes are desired.

b. Target Product Cost: Allocated $5,000 but should be conscientious of budget considering that the product is to be applied as a low-cost training aid.

3. Miscellaneous

a. Customer: Device will be used as a tool in resident education to teach proper three-point molding and assess casting competencies.

b. Patient-Related Concerns: Product will be fabricated for Sawbones® model, not a human being, but should function as if the participant was reducing and casting a real fracture.

c. Competition: No reduction sensing devices are currently on the market for assisting in the teaching of cast application. Traditionally, medical students learn how to reduce distal radius fractures by observing and then practicing (i.e., an approach that lacks immediate feedback).