Executive Summary: Design Excellence Award, BME 402

Prosthetic Thumb

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Client: Shirley Katz, OT

A low income, uninsured individual suffered from a severe infection in their dominant hand, which resulted in the amputation of the thumb, index finger, middle finger, and the medial side of the palm. The ring finger lost all function, the pinky finger had only 10 degrees of flexion, and the wrist had only 20 to 30 degrees of flexion. The individual can not complete simple tasks such as picking up and holding everyday items. The individual lacks dexterity and strength in their dominant hand, which has caused difficulty in finding a job. Prosthetic devices that are currently on the market are too expensive for this individual to buy.

The current devices on the market are too expensive and many are ineffective for the individual due to his remaining anatomy. He is unable to afford more technologically advanced solutions that are customizable to his unique amputation. One affordable option for the patient would be a prosthetic from the company, e-NABLE. This prosthetic is impractical because it is intended for users who have lost all digits on their hand, and it would be difficult for the patient to operate. Due to the patient's remaining two fingers, the prosthetic would not fit well. The operation of the e-NABLE design relies on strong, full flexion of the wrist in order to pull cords that flex the fingers.The individual's wrist would not be strong enough or flex far enough to operate the prosthetic successfully. Other low cost prosthetics, similar to e-NABLE, require patients to have a specific site of amputation in order to fit the device.

In response to this problem, a low-cost, operational prosthetic controlled electronically by wrist flexion was designed, developed, and tested. It works to oppose the currently functioning pinky finger to increase hand function for this individual. The design consists of a forearm cuff, a mechanical thumb, a linear actuator, cuff sleeve, motor driver, arduino microcontroller, two 9V batteries and a button. The linear actuator is attached to a cord that runs through the 3D printed thumb, acting as a tendon. When the linear actuator is commanded to extend through the circuitry, the cord is pulled, resulting in the flexion of the thumb, allowing the user to grasp. When the linear actuator is commanded to retract, the thumb will extend, allowing the user to release their grip.

The device was evaluated with a series of tests, each of which analyzed various aspects of the prototype. Initially, a general test of motion was performed (n=10) to determine if prototype motion was replicable. After it was determined the device could successfully replicate motion, follow up testing included testing range of motion, force exerted, and reaction time. Testing with the patient was successful. The patient quickly learned how to use the prosthetic device and successfully picked up objects of varying shapes and weights ranging from a set of keys to a bottle of lotion.

A functioning bionic thumb was successfully created with the ability to pick up and hold objects of about 0.5kg. The overall price point of the thumb remains under $200 which is significantly reduced from the thousands of dollars a customized bionic upper limb prosthesis costs on the market. The thumb reacts in under .5 seconds and has a range of motion of 8 cm linearly. The skills that the device will provide for the user will greatly enhance his ability to complete tasks in daily life. In addition, he will be able to pursue more employment opportunities with a greater range of function in his hand.