Dynamic Sling to Support Upper Extremity Post Brachial Plexus Injury

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ABSTRACT

The brachial plexus is a network of nerves in the shoulder that can lead to varying levels of sensation and motor loss if damaged [1, 2]. Karen Blaschke is an occupational therapist with UW Hospitals and Clinics, and she works with patients that have experienced brachial plexus injury including our client, Margaret "Meg" Overstake. Our design team was asked to create a dynamic sling that would allow someone with a brachial plexus injury to return to an active lifestyle. Usability and force distribution testing demonstrated that the design supports properties specified by the client and design requirements.

INTRODUCTION

- The brachial plexus is a network of nerves leading to the arm and shoulder (Figure 1)
- Injury can be due to detachment of the nerves or laceration which can lead to loss of sensory perception and motor control [1, 2].
- The most common cause of the injury is road traffic accidents where the shoulder is jarred, causing strain or laceration of the nerves [3].
- Recovery time is typically one to five years.
- Often occupational or physical therapy is prescribed to regain arm function.
- Our client asked us to design and fabricate a dynamic sling that will support the injured arm while running, allowing patients that have suffered a brachial plexus injury to return to an active lifestyle.

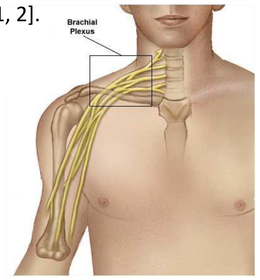

Figure 1: A diagram showing the network of nerves known as the brachial plexus [4].

DESIGN REQUIREMENTS

- Easy for a patient to put on with one arm
- Allows normal range of motion in the shoulder
- Maximum force on shoulder less than 10% of user's body weight
- Adjustable in size for users with chest circumference of 80 to 90 cm
- Adjustable in resistance and elbow angle according to patient strength
- Comfortable for at least three hours of continued use
- Constructed from lightweight and washable fabric that will not irritate skin
- Last throughout patient recovery or minimum of four years

FINAL DESIGN

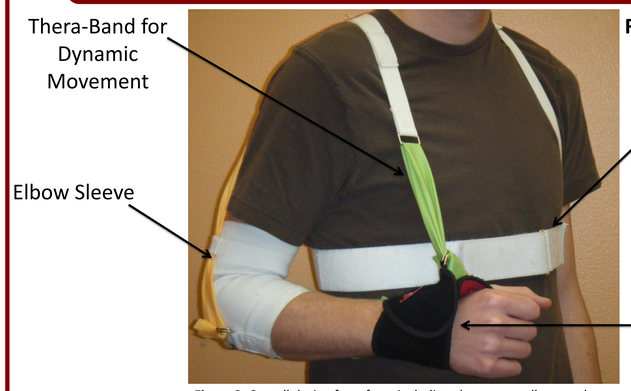

Figure 3: Overall design from front including chest strap, elbow, and wrist components.

Figure 4: Overall design from back including chest strap, ring on back, and connection points on straps.

Wrist Brace

Figure 5: Wrist component showing dual ring connection for Thera-Band.

Elbow Sleeve

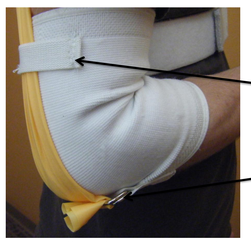

Figure 6: Elbow sleeve component showing dual ring connection for Thera-Band.

TESTING & RESULTS

Usability Testing:

- Each subject was given the instruction manual and asked to put on the sling using only one arm.
- Test subjects evaluated comfort, usability, and overall feel of the sling on a scale from 1 to 5 (Table 1).
- Each subject used the sling for about 5 min.
- The time taken to put on the sling was recorded for two separate trials (Table 2).
- 30 subjects were tested.
- Age range: 18 to 23 years
- Height range: 5'3" to 6'3"

Results:

- Paired Sample T-test yielded a p-value of 1.65×10^{-5} when comparing trials 1 and 2.

Ratings	Mean	Std. Dev.
Overall	4.37	0.615
Comfort	4.50	0.630
Usability	4.07	0.868

Table 1: Mean and standard deviation based on ratings on scale from 1 to 5 for the 30 subjects.

Time to Put On Sling (sec)	Mean	Std. Dev.
Trial 1	112.33	62.53
Trial 2	60.33	27.34

Table 2: Mean time to put on the sling in seconds for the 30 subject in two separate trials.

Force Testing:

- Force applied to shoulder was measured using a dynamometer.
- Measurements were taken at five different elbow angles.
- A team member wore the sling while jogging in place and sensor was held on shoulder.
- Future tests would collect data while using a treadmill.

Results:

- Figure 7 shows force as a percentage of the user's body weight.

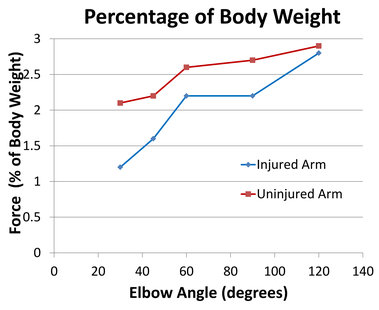

Figure 7: Graph displaying force on the injured and uninjured shoulders as a percentage of body weight at different elbow angles with respect to shoulder (n = 3 trials).

DISCUSSION

Testing:

- The lowest scoring evaluation category was usability.
- Based on comments, the lower score was likely attributed to the subjects' first time exposure to the sling.
- The highest scoring evaluation category was comfort which was supported by numerous positive comments about the sling's supportive design.
- Positive feedback was received in all three categories.
- There was a significant improvement between time trials, indicated by the low p-value.
- Results of the force test show that the applied force on the uninjured shoulder is greater than the applied force on the injured shoulder.
- The force on each shoulder was found to be less than 3% of the user's body weight.
- Limitations existed in the accuracy of the dynamometer and measured elbow angles.

Budget:

- There was no set budget for the project.
- About $25 was spent out of pocket and the rest of materials were obtained through donations from our client and the UW Health Orthotics Clinic.

FUTURE WORK

- Design sling with an athletic fabric that is more washable and breathable
- Perform additional testing to see how fabric deforms after extended duration of running and after multiple uses
- Perform additional testing of the sling on a patient with a brachial plexus injury
- Modify design to be worn by patients with injury to either arm
- Create additional or modified components allowing adaptability for other forms of shoulder and arm injury
- Change Thera-Band and chest strap connection points for easier attachment with one hand
- Create larger and smaller designs for varying body sizes and builds
- Develop instructional video to aid user's in putting on the sling

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- UW Orthotics Clinic

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[4] Brachial Nerve Plexus. *MedicaLook.* (2012). <http://www.medicalook.com/human_anatomy /organs/Brachial_nerve_plexus.html>