

Abstract

Casts are most commonly used to treat pediatric distal radius fractures, but improper application may result in loss of reduction and pressure sores due to a poor fit. Furthermore, cast-saw burns may harm the child during removal of the cast. Splints are an alternative to casts. Splints are cheaper, easier to implement, and more convenient, since it can be taken off when desired. However, current splints do not apply three-point pressure loading to maintain reduction.

The goal of this design project is to design a splint with a lining that allows dynamic and controllable pressure loading. This semester we collected data required for the pressure application as there are no literature values available. The final design includes a splint with individual pads that can be inflated and deflated to the desired pressure. Future testing will determine the accuracy and precision. This will allow for a safer and more convenient treatment of pediatric distal radius fractures. In the future, the design will be translated to a pediatric splint and further testing will be performed.

Introduction

Background

- 3.5 million children sustain a pediatric distal radius fracture yearly¹
- Casts are commonly used to reduce, or realign, the fracture
- Casting requires a large learning curve for doctors
- Improper techniques may result in pressure sores or improper healing²

Recent studies have shown that splints are just as effective as casts in treating non-displaced distal radius fractures that crack but maintain alignment³. However, the current splints do not provide 3-point bending, like casts, which help to maintain reduction in displaced fractures as shown in Figure 1.

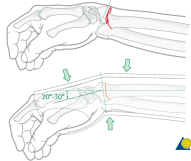


Figure 1: Illustration of the fracture (top) & reduced fracture with application of the 3 loads⁴.

Motivation

Compared to casts, a splint is a cheaper alternative that is easier to apply in the hospital and more versatile for children in daily activities⁵. Table 1 compares and contrasts splints and casts.

Casts	vs	Splints
No difference in healing and pain		
Relies on technique of doctor		Reduces the need for follow up visits
Risk of loss of reduction if poor fit		Less inhibiting on lifestyle
~\$300-400		~\$30
Cast saw can frighten and burn children		Current Splints don't offer 3 point stabilization

Table 1: A Comparison of Casts and Splints^{2,6}

Pressure Testing

Pressure During Casting

The dynamic splint will replicate the values of pressure applied during casting. Since no literature values of the pressure during casting exist, the pressures during casting were experimentally obtained with the aid of our client.

Method

Three individuals of our group were casted by Dr. Halanski. Piezoelectric sensors (Tekscan A401-25 FlexiForce®) were placed over a single layer of pre-wrap in the positions as shown in Figure 2. During casting, the resistance was measured using a multimeter. Three measurements were obtained during each test including the pressure when the fiberglass was set, five minutes after application when the cast was partially dry, and 10 minutes after application when the cast was completely dry. Application of the cast was performed to allow exposure of the 2-pin male square lead the cast for the measurements.



Figure 2: Location of the sensors during casting, anterior (left), posterior (middle), and final casting⁷.

Results

After collecting the data, the resistance was converted into conductance and the average and standard deviation was calculated. By calibrating the sensors, a calibration curve was obtained with a linear line of force as a function of conductance for each sensor. The force from each sensor was calculated from the calibration curve. Pressure was determined as the force divided by the area of the sensor. Table 2 shows the results of each sensor and the average pressure at the location, shown in Figure 3 of the sensor during application of the cast.

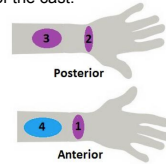


Figure 3: Areas of pressure corresponding to Table 2. A 1-3 utilize three-point bending⁷.

Area	Pressure (psi)	SI Pressure (kPa)
1	4.71	32.44
2	0.56	3.87
3	4.50	31.00
4	3.64	25.10

Table 2: Pressure locations (1-4) and the average pressure on the area during application of the cast.

Design Criteria

By utilizing the pressure values obtained in the experiment, a dynamic splint for pediatric distal radius fractures will be created with the following features/requirements:

- Easy application and removal for doctors and patients
- Dynamic and controllable pressure lining for pressure adjustment
- Comfortable fit for a pediatric wrist
- Non-irritating, hypoallergenic materials to eliminate allergic reactions and pressure sores
- Radiolucent materials so the device can be used in x-rays

Final Design

•The final design will utilize the football helmet pads as seen in Figure 4

- Three small pad (labeled #1) provides the three-point pressure loading and can be inflated or deflated as desired for healing
- A doctor can easily inflate/deflate these pads with a hand pump
- Long, larger pads (labeled #2) provide stability and do not inflate
- A hard protective cover protects the splint from daily activities
- A liner between the skin and the pads avoids irritation for the skin
- A guard on the posterior side of the forearm extending to the palm prevents full flexion and extension of the wrist to avoid setbacks to the fracture healing process.
- The current prototype costs \$238.06

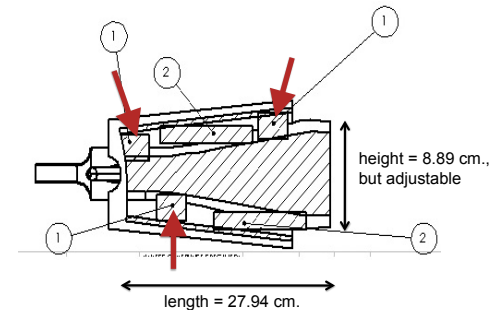


Figure 4: A side view of the final design. #1 indicates an inflatable air bladder, #2 indicates a stability pad. The red arrows indicate the three-point loading⁸.

Future Work

- Test the dynamic air bladders to determine the accuracy and reliability
- After constructing an accurate and comfortable dynamic splint, translate the design to a pediatric splint
- Test the pediatric dynamic splint on pediatric distal radius sawbones to ensure it exerts the correct pressure as shown in Table 2
- After extensive testing of the pediatric dynamic splint, test the accuracy and reliability in clinical trials

Acknowledgments

- Dr. Matthew Halanski, Client
- Sarah Sund
- Professor Paul Thompson, Advisor

References

¹ Bount, W.P. Fractures of children. Baltimore: Wilkins and Wilkins, 1995.
² Halanski, Matthew, M.D. "Pediatric Wrist Fractures Indicators for Pinning."
³ Pitt, A.C., Perry, J.J., Correll, R., Gabouvy, I., & Lawton, L. "A randomized, controlled trial of removable splinting versus casting for wrist buckle fractures in children." *Pediatrics*, 2008; 117(3):691-697.
⁴ Summit Medical Group: Wrist Casts - Summit Medical Group, 23 October 2012.
⁵ www.summitmedicalgroup.com
⁶ Forearm Fractures in Children, 2010. American Academy of Orthopedic Surgeons, 15 October 2012. orthoinfo.aaos.org
⁷ Pitt, A.C., Perry, J.J., Correll, R., Gabouvy, I., & Lawton, L. "A randomized, controlled trial of removable splinting versus casting for wrist buckle fractures in children." *Pediatrics*, 2008; 117(3):691-697.
⁸ Photo credit: Kate Howell
⁹ Design made in SolidWorks by Sean Heyrman