SpiCast - Safe Transportation for Pediatric Patients with Femur Fractures

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Introduction

Problem

Pediatric femur fractures are the second most common long bone fractures in kids. Nineteen out of every hundred-thousand children in the United States experience femur fractures every year.[1] Within the past year, an estimated 14,600 children between the ages of 0 to 11 had a femur fracture.[2,3] The most common form of treatment for children under the age of five is immediate spica casting.

Spica casts immobilize the child at the hips as its bound to maintain a sixty degree hip abduction, thirty degree hip flexion, and forty-five degree bend at the knees. Due to these set angles, patients' legs are positioned in such a way that the knees are pointed to each side of the body. This positioning causes the legs to be farther apart than in the normal seated position. Everyday car seats do not provide the space, comfort or ease for spica cast patients. This project focuses on finding a solution to facilitate transportation for spica cast patients.

Existing Intervention

The Hippo car seat is the only car seat that complies with Federal Motor Vehicle Safety Standards and is also approved for patients with spica casts. As of 2015, the Hippo car seat is no longer being manufactured.[4,5] Furthermore, older models that were produced range in price from $500-$900. The Hippo car seat is bulkier than a normal car seat and it is harder to install. Since recovery time for a pediatric patient with femur fractures is no longer than 12 weeks, buying an entirely new car seat is not practical.

Proposed Intervention

Our solution for this problem is to create an attachment that can be inserted into the regular car seat of the patient. This attachment, the SpiCast, will be inexpensive, feasible to reproduce, and comfortable for the patient.

Specifications

Child	Spica Cast
❖ Age: 1-3 year old ❖ Weight: 11.25 kg ❖ Waist Circumference: 21" ❖ Waist to Knee Length: 11"	❖ 60 ° hip abduction ❖ 30° hip flex ❖ 45° bend at the knees ❖ Made with fiberglass
Car seat	**Forces**
❖ Top is 1" above child's head ❖ Hip room: 14" interior ❖ Seat pan: 12.5" deep ❖ 5 Point Strap System Placement	❖ Force in car accident - 668 N with stopping distance of 2 meters ❖ Force sitting in cast - 120 N ❖ G forces: 20-30 G's

Methods

1. Place 15 lbs of lentils into a vacuum sealable bag.	**2.** Fit patient within bag and vacuum air out.	**3.** Lay overlapped fiberglass on mold. Set for 20 minutes.
4. Spray expandable foam within parchment-lined 1' by 1' box, with smooth 2" layer.	**5.** Set fiberglass mold and wait 8 hours for curing.	**6.** Size foam insert to patient car seat and install.

Figure 1. Fiberglass laid out on lentil mold.

Figure 2. Expandable foam with fiberglass.

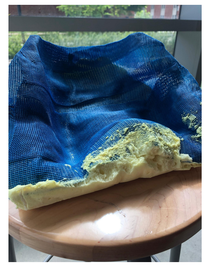
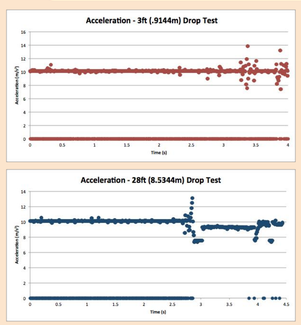


Figure 3. Finished expandable foam mold.

Results



Figures 4 and 5. Acceleration data was plotted in Excel after logging with Arduino IDE/Serial. Data was taken at a 3ft and 28ft drop. Minimum values are 7.37 and 7.34 m/s^2 for 3ft and 28ft respectively.

Figure 6. *(top-left, clockwise)* Parametric scan of car seat with model insert; electronics circuit with Adafruit ADXL345, OpenSourceRF Wireless Shields, Arduino Unos, in unpacked and packed setup; drop test physical setup; sensor on car seat with model baby.

Conclusions

In the process of making the SpiCast, we have developed a prototype that will allow patients in spica casts to use regular car seats. This prototype is both tailored to the individual patient and their car seat, it is 1/27th the cost of the Hippo car seat, and is easier to install. While creating this product, the team was able to identify a clinical problem, brainstorm different approaches, and work towards a single solution after several rounds of prototyping. During this process, we learned the significance of trial and error, and realized how crucial it is to obtain the actual measurements of the patient and car seat in order to finetune our design. We see promise in the vacuum bag mold design for a final model. After the design was finalized, a drop test was performed to evaluate the impact forces on the child. The results showed that the acceleration on the baby was reduced by 2 m/s^2 with the carseat, whereas the acceleration drop on the baby is consistent between a 3 ft and 28 ft drop with our setup. Further tests from this pilot can verify efficacy and lead to eventual approval with Federal Motor Vehicle Safety Standards. Utilizing the SpiCast shows promise as a safer alternative to currently used methods.

Ethical Implications

- ❖ Reduces parental strain
- ❖ Reduces financial burden - $500/900 → $33.23
- ❖ Improves safety and allows for proper healing
- ❖ Easier installation and provides comfort for injured children
- ❖ Tailored attachment fit to needs of each patient
- ❖ Reduces waste

Future Work

- ❖ Material Exploration for vacuum-sealed bag, lentils, and expandable foam
- ❖ 3D printed mold for car seat insert made from polypropylene
- ❖ Further acceleration testing with developed electronics setup
- ❖ Crash Testing with SpiCast to conform to Federal Motor Vehicle Safety Standards
- ❖ IRB Testing with SpiCast inserts

References and Acknowledgement

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