

3-42

The Shower Sleeve

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Problem identification

Fractures are becoming increasingly common among the elderly. 1 in 2 women and 1 in 5 men will experience a fracture in their lifetime. Fractures typically occur in old age due to osteoporosis and, in the case of women, decreases in estrogen levels due to menopause. Osteoporosis is, in fact, becoming so common that it causes a fracture every two minutes in people over the age of 50¹.

Additionally, more elderly are having to tend to their injuries alone. In 2011, 9% above the age of 65 lived alone. In the last 15 years, the number of women living alone has increased by nearly 40%.² The impact of the pandemic has also resulted in the elderly becoming increasingly isolated, with more having to fend for themselves.

Showering while having a limb immobilised in a cast is a herculean task. Many people who have experienced fractures can relate to the difficulty of trying to keep the plaster cast dry in the shower. This problem is made worse in the elderly who have limited dexterity³ and so cannot adequately water-proof their casts. This leads to chronic infection in the cast, affecting healing.

Needs Survey

We out carried out a survey on 37 Singaporeans across age groups (Appendix I). 64.9% of respondents stated that they, or a family member, have experienced a fracture. 76.9% indicated that it was difficult to shower while immobilised by a cast. Some common issues faced included the difficulty of covering the cast and the limited mobility due to the immobilisation of the limb.

Most respondents who tried covering the casts expressed difficulty doing so. 80% said they did not try to seek specialised cast sleeves and resorted to plastic bags and tape to cover the casts. Such temporary measures are ineffective in keeping casts dry.

Defining the Overarching Problem

There needs to be an effective waterproofing solution for plaster casts, particularly one that is easy to apply and remove by elderly patients, without need for additional help. This should also be versatile enough to accommodate a large variety of fracture injuries.

Current Products

There are several products and devices in the market (Table1) , but these come with several drawbacks. For example, one cast cover by DryPro, is made of flexible latex that stretches easily. However, several reviews mentioned that the vacuum seal on the cover was too tight

¹ *Over-50s' osteoporosis "causes fracture every two minutes."* (2013, October 13). BBC News. Retrieved July 11, 2021 from <https://www.bbc.com/news/health-24517402>

² *Linton, Gubhaju, Chan, E. B. A. (n.d.). Home Alone: Older Adults in Singapore. Duke-NUS Medical School. Retrieved July 11, 2021, from <https://tinyurl.com/e4ym22w3>*

³ Carment, L., Abdellatif, A., Lafuente-Lafuente, C., Pariel, S., Maier, M. A., Belmin, J., & Lindberg, P. G. (2018). Manual Dexterity and Aging: A Pilot Study Disentangling Sensorimotor From Cognitive Decline. *Frontiers in neurology*, 9, 910. <https://doi.org/10.3389/fneur.2018.00910>

and removing the cover hurts the already-injured arm more. Even the more positive reviews on the product admitted that the seal gave way after only a week and that the cost of S\$49.99 was too high⁴.

Existing Product	Cost	Durability	Ease of use
DryPro Waterproof Vacuum Sealed Full Arm Cast Cover	\$49.99	Durable rubber	Material can stretch, supposedly easy to put on and remove without assistance. Very precise measuring is required.
Water Proof Leg Cast Cover for Shower by TKWC Inc - #5738 - Watertight Foot Protector	\$18.99	6-8 weeks	Free size, within a range. Claims to be easy to put on and remove without assistance
Waterproof Cast Cover Arm - 100% Reusable - Watertight Seal	\$11.95	Reusable over and over again.	Easy to use, lightweight,

Table 1: Comparing current products and identifying their drawbacks

Drawing lessons from these, the factors to consider when designing our product are cost, durability (strength) and ease of use.

Our Idea

Our original design featured a drawstring membrane with sodium polyacrylate powder inserted into slots at the end to absorb water (Fig. 1). The latter idea was dropped as sodium polyacrylate gets heavier as it absorbs more water, making it uncomfortable. Instead, we focussed our efforts on selecting more suitable plastic materials to use for the sleeve (see Table 2).

⁴ *DryPro Waterproof Vacuum Sealed Full Arm Cast Cover, Small.* (n.d.). Amazon. Retrieved July 20, 2021, from <https://www.amazon.com/DryPro-Waterproof-Vacuum-Sealed-Cover/dp/B003DZCJM6>

100% Waterproof Cast Cover Arm - Reusable Adult Half Arm Cast Covers for Shower Elbow, Hand & Wrist - 3 Pack from Amazon <https://www.amazon.com/Adult-Arm-Cast-Covers-Shower/dp/B078Q7WJSG?th=1>

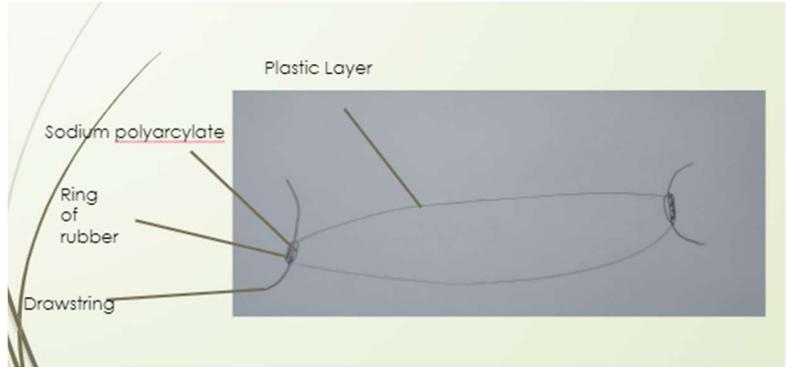


Fig. 1: Our original product design

Plastic Material	Transparency	Flexibility	Cost	Strength	Total Score
Acrylic ⁵	4	1	2	3	10
LDPE ⁶	2	4	4	1	11
HDPE ⁷	3	3	1	2	9
Polycarbonate ⁸	1	2	3	4	10

Table 2: Our decision matrix for the plastic material to use for the prototype.

Our Processes

Our first prototype was a simple plastic cylinder made of Low-density polyethene (LDPE) in the lab. The dimensions of the plastic are 16 inches by 13 inches.

To close of the end of the cylinder easily, we focused on a drawstring design, using either plastic raffia or cotton twine. A quick experiment (Appendix II) determined that plastic raffia was more effective in keeping the cast dry (Fig. IIa, Fig. IIb). The drawstring was also more difficult to pull when made of cotton twine.

Our second prototype featured raffia string at both ends (Fig. 2). In addition, we also experimented with adding a layer of transparent rubber at the ends of the product (Appendix III)

⁵ Curbell Plastics.(n.d). Curbell plastics. Retrieved July 20,2021 from [Acrylic Plastic Material | Clear Plastic Uses & Properties of Acrylic | Curbell](https://www.curbellplastics.com/clear-plastic-uses-properties)

⁶ Polyethylene (Low Density) LDPE, LLDPE. (n.d.). British Plastics Federation. Retrieved July 20, 2021, from <https://www.bpf.co.uk/plastipedia/polymers/LDPE.aspx>

⁷ Polyethylene Sheets. (n.d.). Lundell Plastics Cooperation. Retrieved July 20, 2021, from <https://www.lundellplastics.com/specialty-custom-plastics/polyethylene-sheets.asp>

⁸ Greenhouse Coverings. (n.d.). U.S. Global Resources. Retrieved July 20, 2021, from <https://www.usgr.com/greenhouse-coverings/greenhouse-coverings/>

(Fig. IIIa). It was noted during the manufacturing that the layer of rubber made the drawstring harder to pull; elderly users of our product might have difficulty doing so on their own.

The additional layer of rubber does nothing to keep water out. Instead, it acts as a funnel and allows water to drip in (Fig. IIIb). We hence removed this rubber layer from our design considerations.



Fig. 2: Prototype 2, which features raffia string at both ends.

We used this prototype to interview potential users (Appendix IV). We asked elderly aged 65 and above who have suffered fractures before to test this product for us. Some of the survey questions included how easy it was to put the product on, what was good about the product, and how we could improve. Unfortunately, PH2HA meant we were only able to interview 5 persons. Overall, we received positive feedback for the prototype. 80% of respondents agreed that the product was easy to put on, but one person said that the plastic was not flexible enough and the length of the product should be adjustable. Another also remarked that the string was difficult to pull and the ends were stiff. However, all agreed that the sleeve was comfortable and lightweight. Most of them indicated they were “highly likely” to use our product should they suffer from a fracture again.

We used this feedback to construct our final prototype. The final prototype (Fig. 3), is a result of all the improvements we have made due to the experimentation and feedback. The material of the sleeve is lightweight, comfortable, and affordable low-density polyethylene, which has remained the material of choice throughout the modelling process. The choice of elastic bands and the buckle drew inspiration from a waterproof bag for water sports, and was a response to users’ hope for an adjustable length. It can be rolled up or down to alter the length of the sleeve to suit users’ needs.

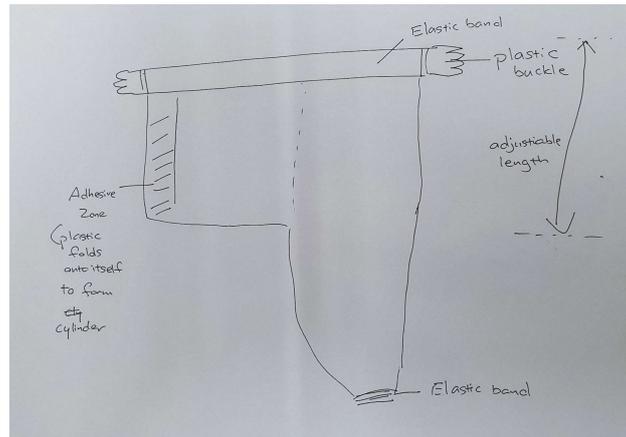


Fig 3a: A sketch of our final prototype design.



Fig 3b: The final prototype of our product featured elastic bands at the ends and a buckle to secure the end. The band is rolled up or down to adjust the length of the sleeve.

We calculated the cost of the final prototype:

- Buckle \$6
- Elastic: \$10 for 5m (\$2 per metre, approx. \$0.40 for 1 sleeve)
- Plastic: \$0.20 per square foot (\$0.28 for 1 sleeve)
- Tape: \$0.05 per metre (\$0.01 for 1 sleeve)
- Labour cost: \$2
- Total: \$8.69

The cost of our prototype is around 70% that of our cheapest competitor. We envision that, with mass production, the unit cost of this will decrease even further.

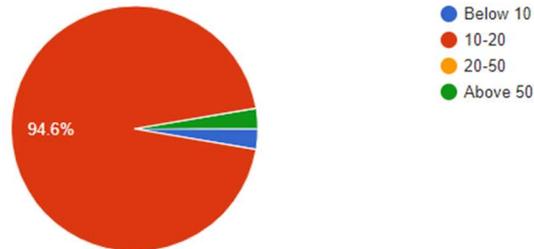
Conclusion

The product that we created is adjustable, lightweight, and affordable, suiting the needs of the elderly. This gives users a cheap and high-quality product compared to others that we have right now.

Appendix I - Results of needs survey

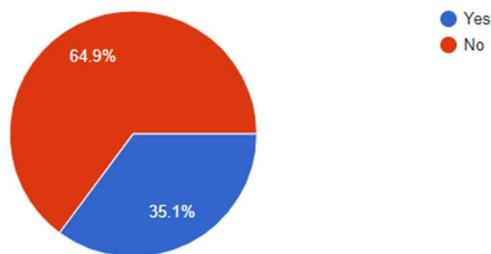
Please specify your age group

37 responses



Have you or your family members had a fracture?

37 responses



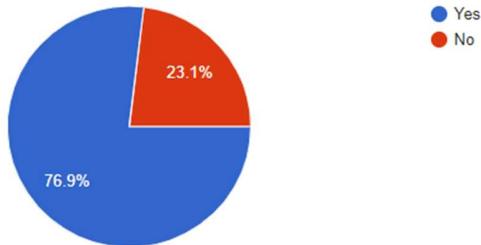
Specify the type of fractures that you have encountered.

13 responses

- Leg bone fracture
- Hairline fracture
- Left humerus fracture, right ulna fracture
- Arm fracture
- Ankle sprain, wrist fracture
- My grandmother fractured her hip and waist
- Ankle and wrist
- sprain
- Collar bone? I forgot

Did you or your family find it difficult to shower while you/they were in a cast?

13 responses



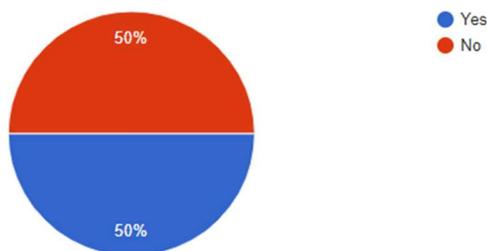
What was difficult about the process?

10 responses

- They can't shower by themselves
- The temporary cast wasn't waterproof
- I had to cover the cast with plastic bags and water always seeped in.
- That particular part of the body could not move
- Cold showers were painful.
- It was hard to get out the soaps
- They had to cover the area with a plastic bag
- Not being able to do certain things
- Afraid wound would get wet

Did you try to cover up the cast?

8 responses



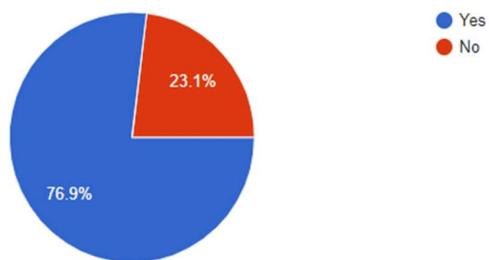
What did you use to cover up the cast. If you bought a cast sleeve from online, what brand is it?

5 responses

- na
 - Um plastic bag??
 - We used a plastic bag (those for containing food) and taped it tightly around the cast
 - Plastic bag
 - Plastic bags and tape
-

Do you think a product designed to protect casts from water is useful?

13 responses



Appendix II - Experimentation Processes to determine drawstring material

Aim: To find out if drawstring made of raffia or cotton twine is more effective in keeping water from seeping in.

1. Put 2 pieces of tissue at each end of the sleeve, which are fitted with cotton twine and raffia string respectively.
2. Run each end of the sleeve under the tap for 60 seconds
3. Compare the moisture of the two pieces of tissue



Fig. IIa: Soaking the prototype under the tap in the lab



Fig. IIb: The results for the first testing.

Appendix III - Experimental Processes to determine if a layer of rubber helps to keep water out

Aim: To find out if a layer of rubber absorbs water and prevents it from seeping into the sleeve

1. Put one piece of tissue paper at the end of the sleeve with the rubber film
2. Run the end of the prototype under running water for 60 seconds
3. Repeat with the other end



Fig IIIa: A layer of transparent rubber at the ends of the prototype to absorb more water.



Fig IIIb: The results of the second testing. The additional layer of rubber drew more water in.

Appendix IV - Results of User Experience Survey

Describe your experience using our prototype

5 responses

Putting the product onto the arm was easy but it was difficult to put it onto the leg as the foot got in the way.

The string was difficult to pull and the ends were stiff. It would be best to replace the raffia string with elastic bands to make the end more stretchy.

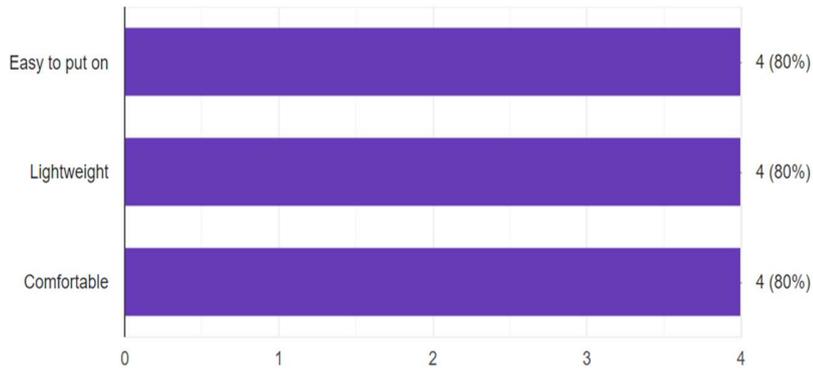
Easy to use

Easy

Keeps dry very well

What was good about our prototype? If you do not have any positive feedback for us (!?) please tell us what can be improved by answering the next question.

5 responses



If our prototype has failed to impress you, please tell us how we can do better

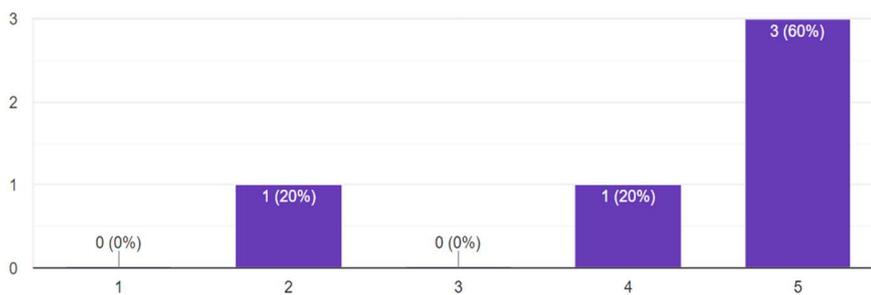
5 responses

- Nil
- Difficult to put onto the leg as the foot got in the way, plastic not stretchy and flexible enough.
- Make the length of the plastic adjustable. Preferable for the sleeve to come in custom sizes.
- Can think of a way to dry it faster after use

On the scale of 1 to 5, how likely are you to use our product should you suffer from a fracture?



5 responses



On the scale of 1 to 5, how likely are you to recommend our product to a friend who is suffering from a fracture



5 responses

