Final Presentation

Hand Burn Rehabilitation Device

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Outline

- Overview of Project Scope and current Design Specifications
- Parts List and associated mechanical diagrams
- Device assembly
- Display of working prototype
- Did it meet the design specifications?
- Validation and Verification
- DesignSafe
- Conclusions
- Questions

Project Scope

1. Develop a device that provides rehabilitation for hand burn patients after they receive initial treatment from medical professionals.
2. Help restore the pre-burn range of hand motion for second and third-degree hand burn victims.
3. Device is easily accessible to rural population of Nepal.
4. Patient compliance of at least 90%.
5. 90% of users have their normal hand movement reestablished at the end of their recovery period.

Design Specs

Table 1. Design Specifications (*citations for* desired *in progress report*)

Specification	Desired	Actual
Length of hand + wrist	19.57 cm - 27.1 cm	25 cm
Width of hand	7.0 cm - 10.0 cm	10.0 cm
Circumference of hand	16.5 cm - 23.75cm	Adjustable straps
Profile (length above and below wrist)	+/- 2 cm	-0.6 cm +2 cm
Stability	Static Progressive	Static Progressive
Weight	<= 0.45 kg	102.20 g
Pressure applied to wrist and hand	20 mmHg – 30 mmHg	Acceptable based on user feedback
Patient Compliance	High (90% of population)	N/A
Lifespan	12 Months	N/A
Waterproofness	Yes (1 m)	Yes
Breathability	Ret 6 to 13	Acceptable based on user feedback
Functional Temperature range	5 deg C to 45 deg C	0 deg C and 45 deg C
Resistance to Shock/Drops	2 m	2 m
Post Supervision	Minimal	N/A

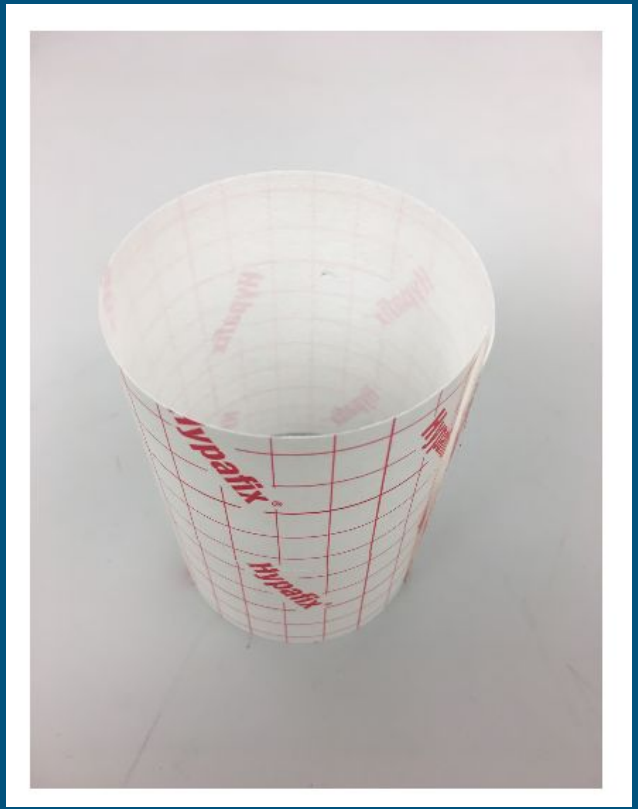
Parts List

Table 2: Parts List

Part	Source	Price	Lead time
Exoskeletal Splint			
Hatchbox ABS, 1.75mm, 1 kg Spool	ABS bought on Amazon, Splint 3D Printed	$21.99 ($0.022/g)	10 hours
Monoprice Hook & Loop Fastening Tape 4.57 meters/roll (3 rolls)	Bought on Amazon	$5.83/roll ($1.28/meter)	2 days
Guitar tension adjustment knob	Bought at Local Music Store	$6.99	1 day
Ernie Bell Nickel Guitar String 0.025 mm (diameter) 6 string pack (3 packs)	Bought on Amazon	$6.99/pack ($1.17/string)	2 days
Compressive Glove			
4-Way Stretch Nylon Spandex Matte Tricot, 1 sheet: 0.91 m length, 1.52 m width	Spandex bought on Amazon, Glove sewn by hand	$9.95	2 hours
Hypafix			
Hypafix dressing retention sheet roll 0.10 m width, 9.14 m length (2 pack)	Bought on Amazon	$23.53	2 days
Total cost of R&D		**$100.92**	
Cost of 1 full splint (based on amount of materials used)		**$17.26**	

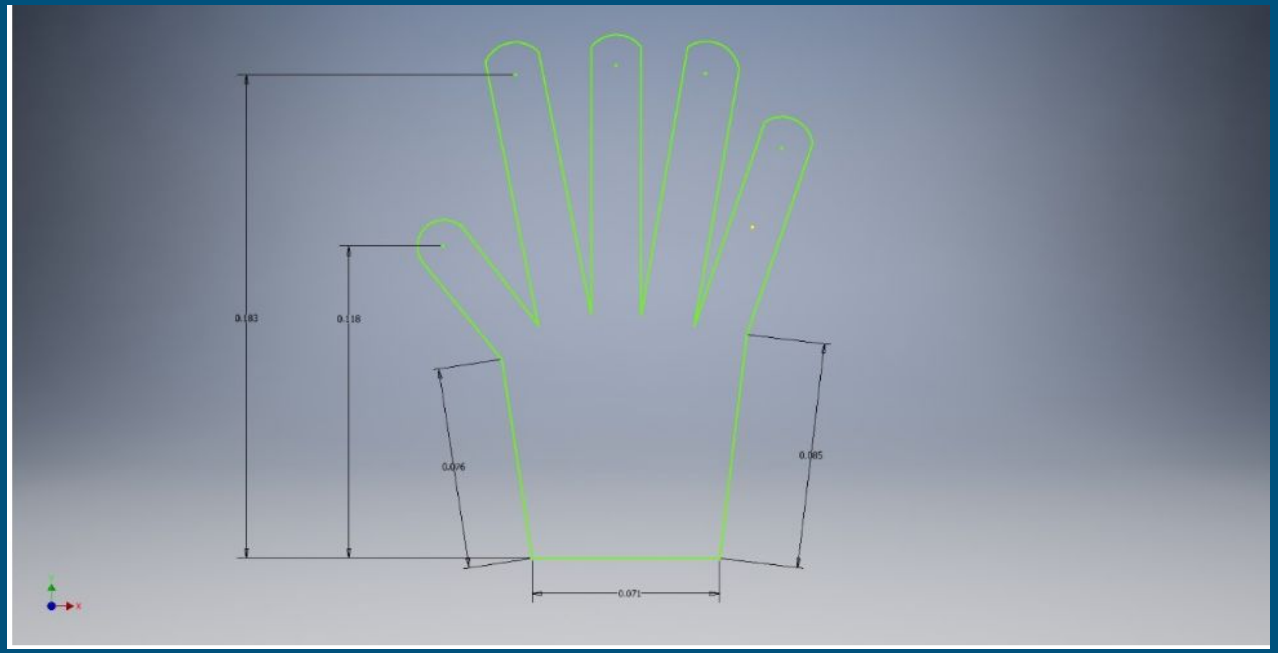
Hypafix

- 1 layer of hypafix applied before wearing compressive glove
- Used to promote healing of the wounds and prevent contact of spandex and ABS with the wound



Compressive glove

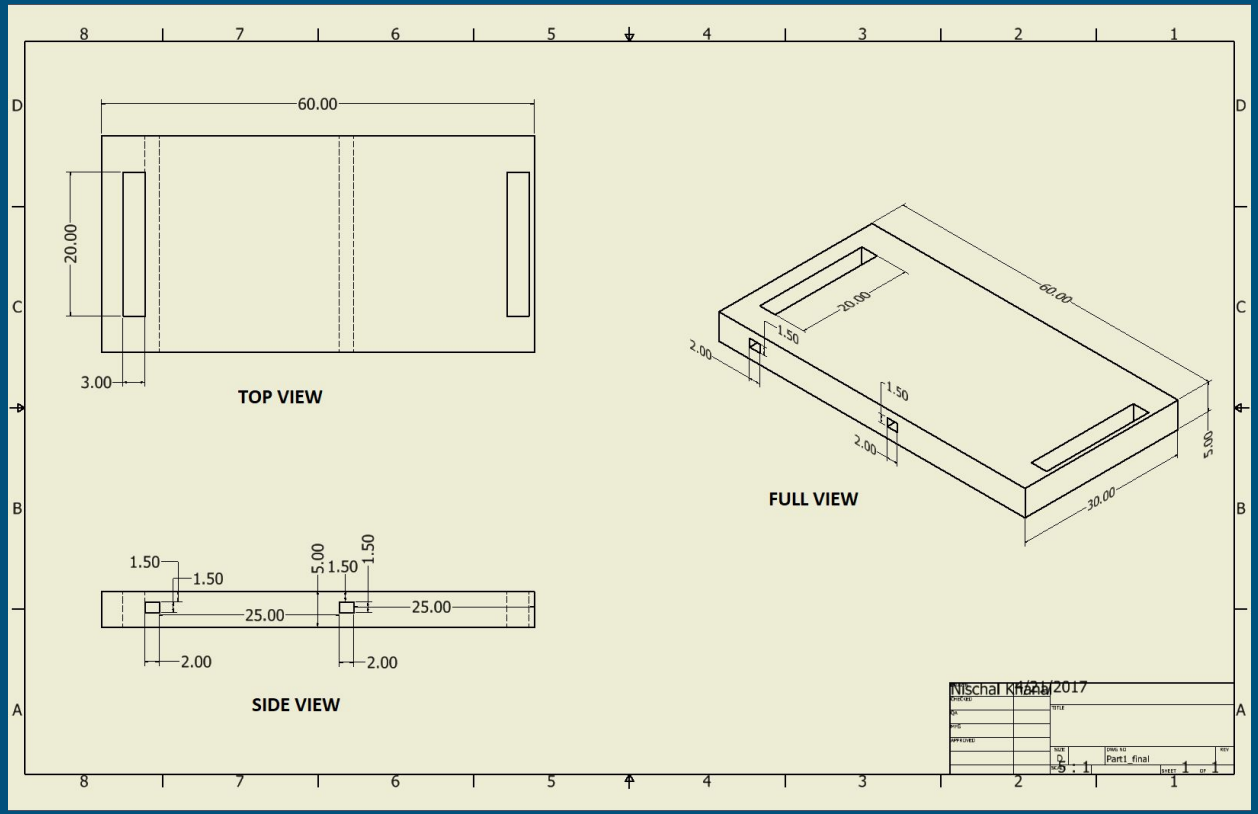
- Sewn from two sheets of spandex using trace of hand



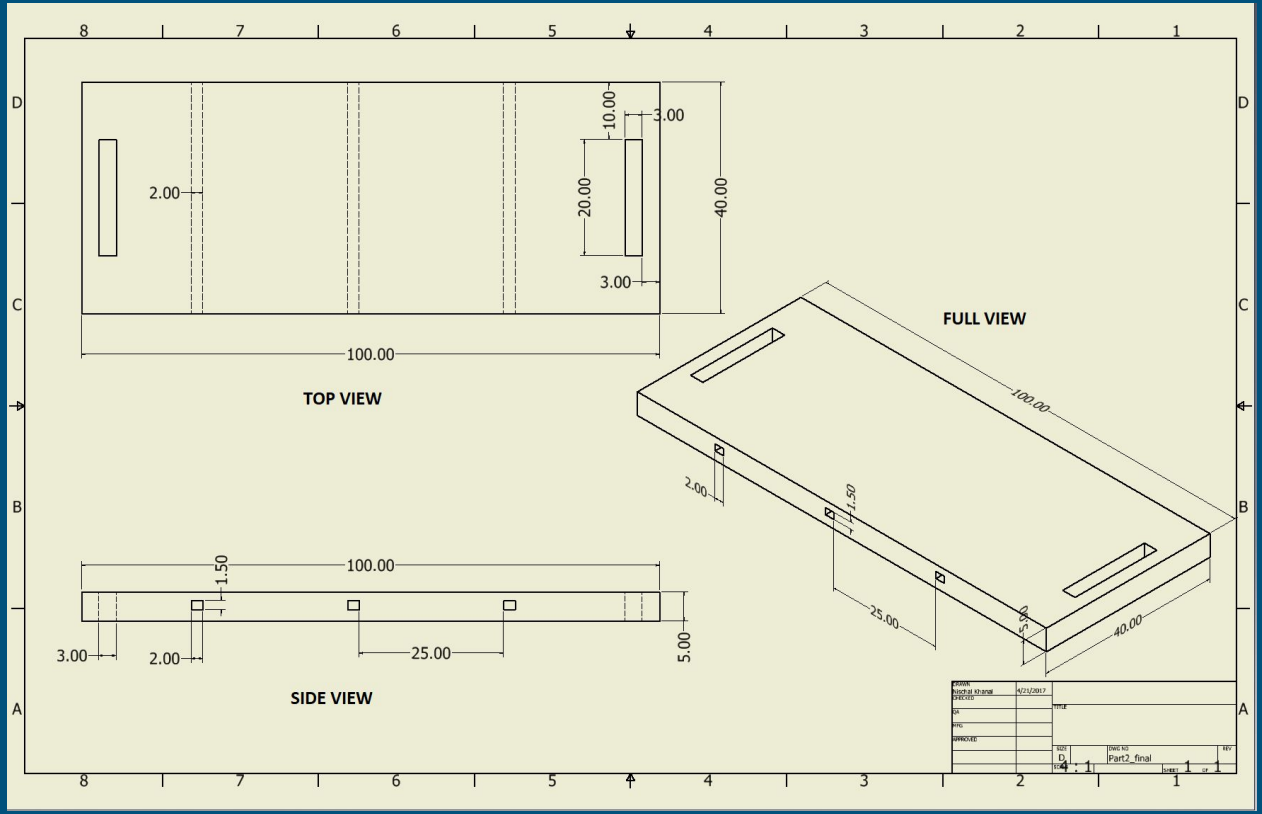
Exoskeletal Splint

- 3D printed using ABS
- CAD models developed on Autodesk Inventor

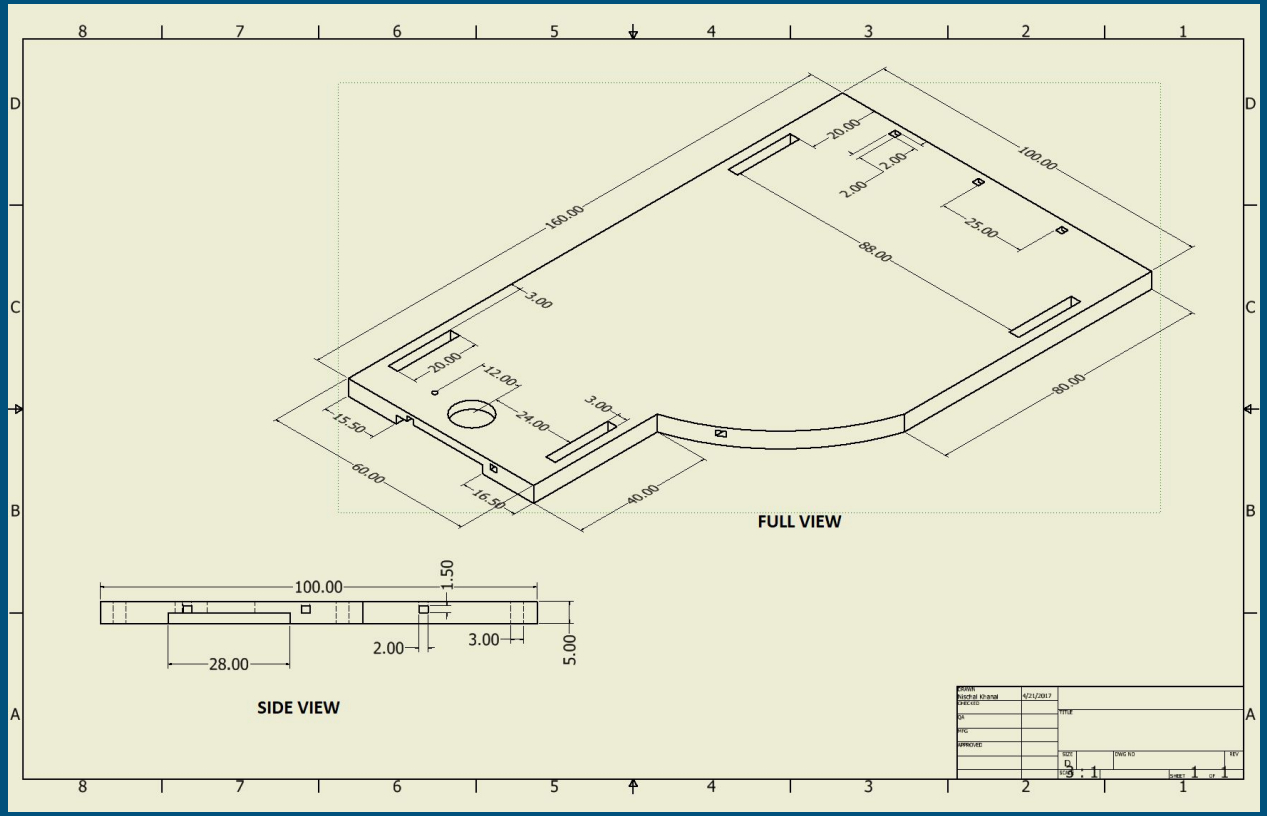
Exoskeletal Splint



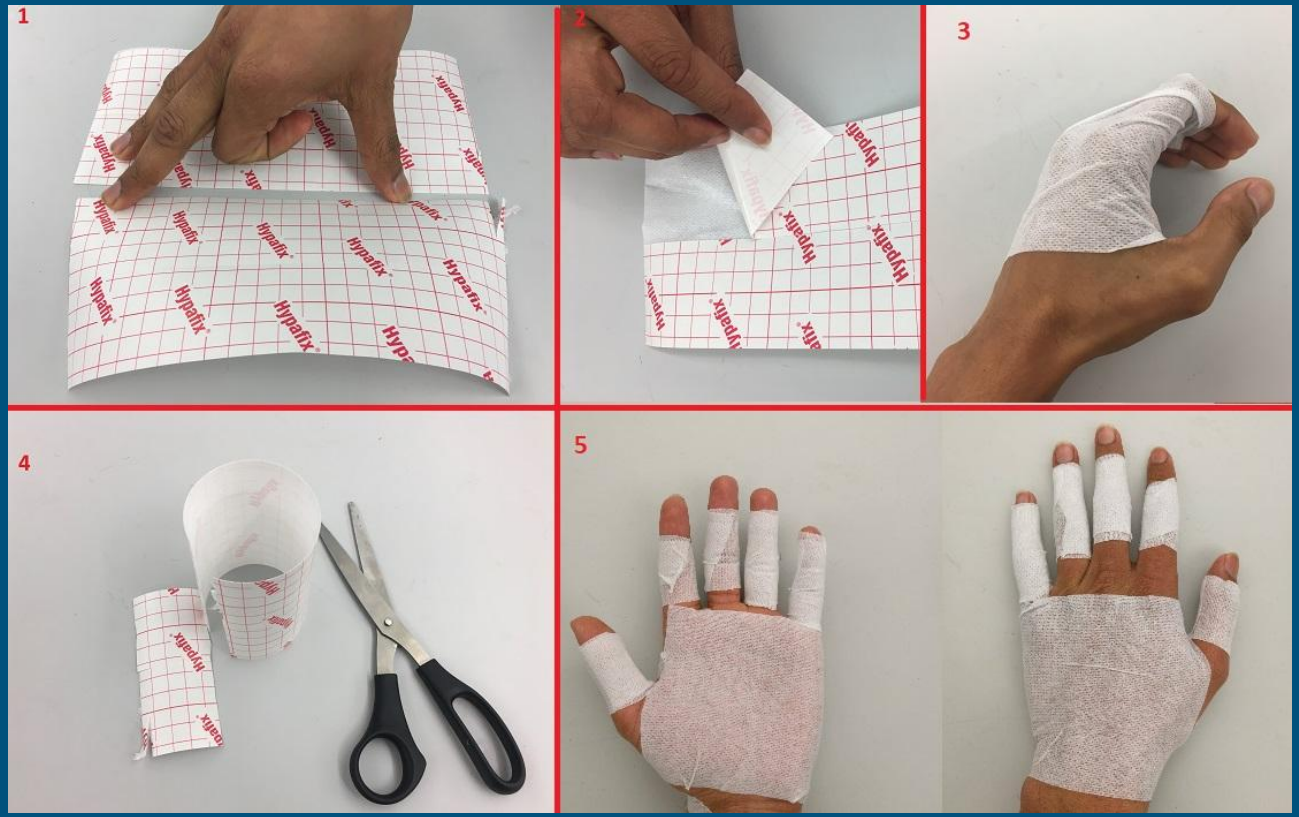
Exoskeletal Splint



Exoskeletal Splint



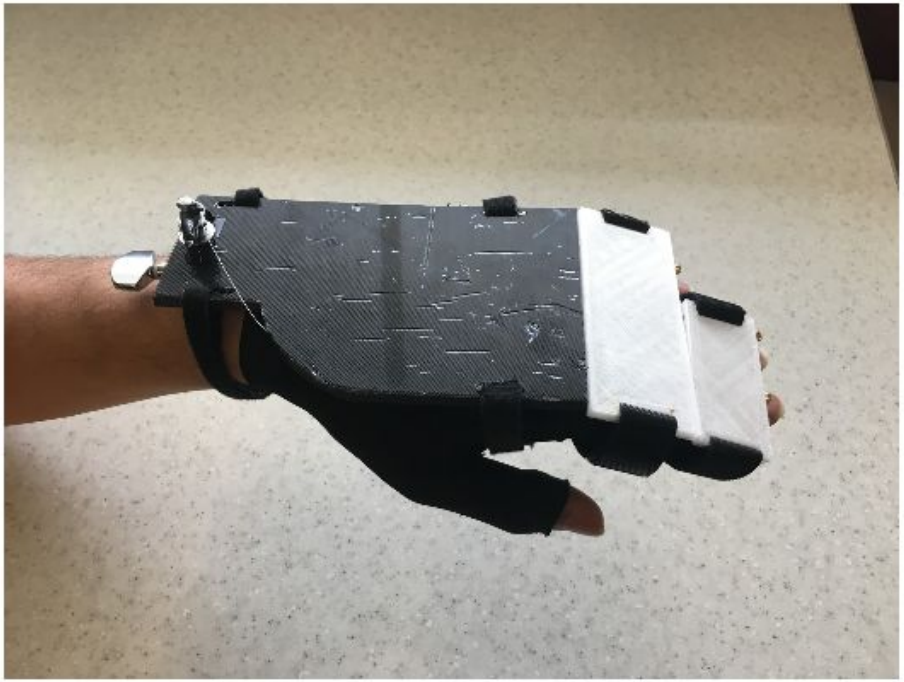
Assembly - Step 1) Hypafix



Assembly - Step 2) Elastic Glove

Assembly - Step 3) Exoskeleton

Assembly - Step 3) Exoskeleton



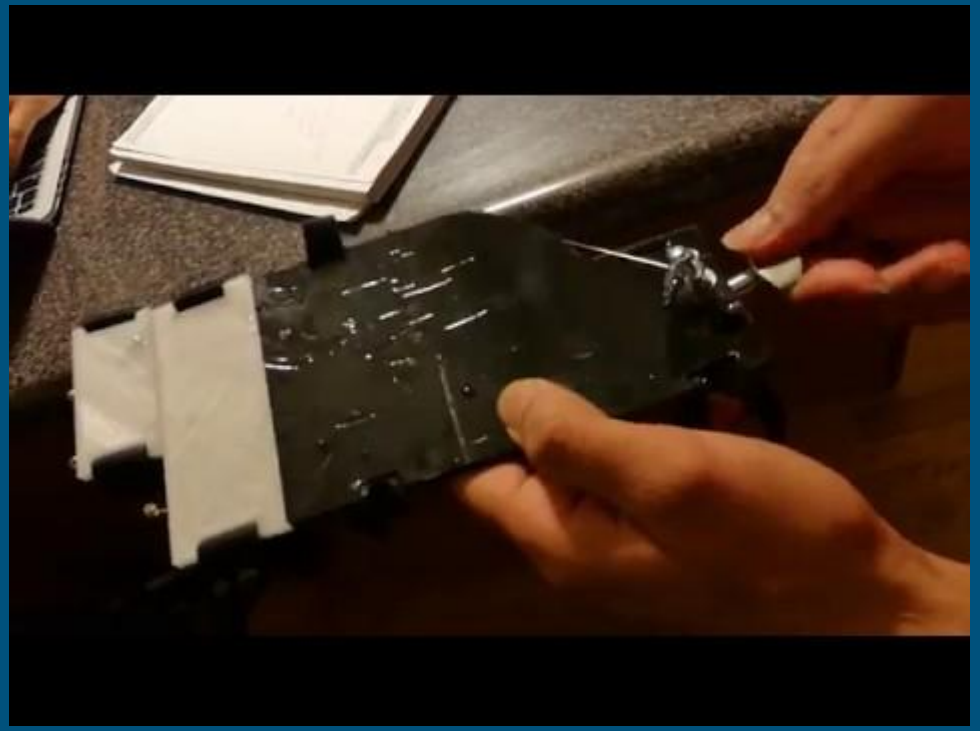
Working Prototype

Verification Test Summary

Table 3: Verification Tests Result Summary

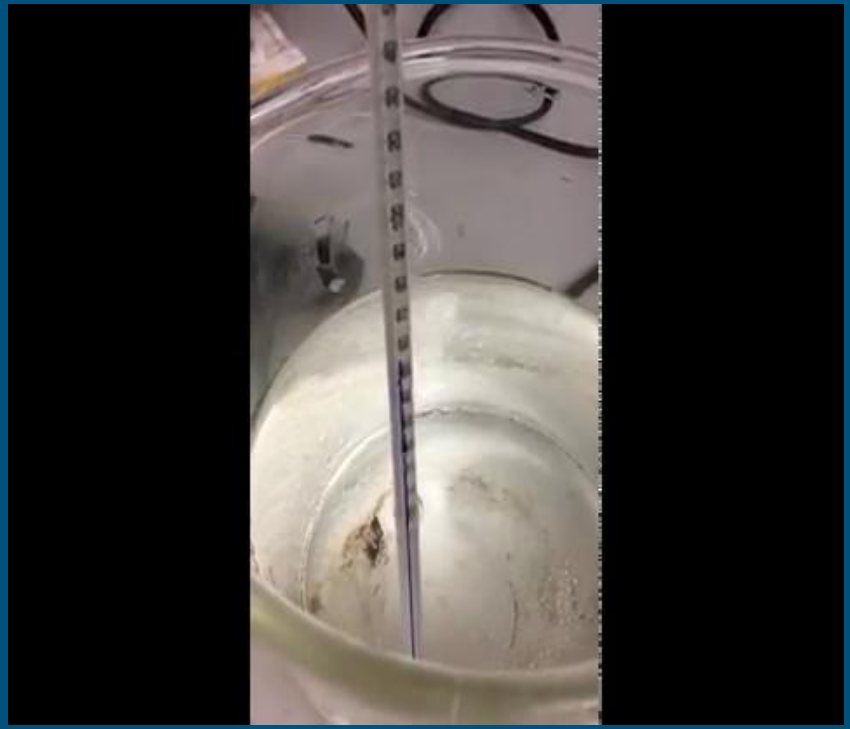
Test	Relation to Design Specs	Short Description	Passed?
Water Exposure Assay	Waterproofness	Submerged in 1m of water for 1 hour	Yes
Extreme Temperature Assay	Functional Temperature Range	Tested in 0^0 C and 45^0C water bath	Yes
Drop Test	Durability	Dropped from vertical distance of 2m	Yes
Breathability	Breathability	Testing in temperature higher than 21^0C	Yes (though our subject noted that the Hypafix layer built up sweat after several hours)
Installation Time	Ease of Use	Less than 5 mins	Yes
Weight Test	Mass range	Less than 0.45 kg	Yes
Pressure Test	Desired Pressure for compression	Estimated via response from subject	Yes*

Verification Report: Water Exposure Test



Testing functionality after exposure

Verification Report: Extreme Temperature Assay I

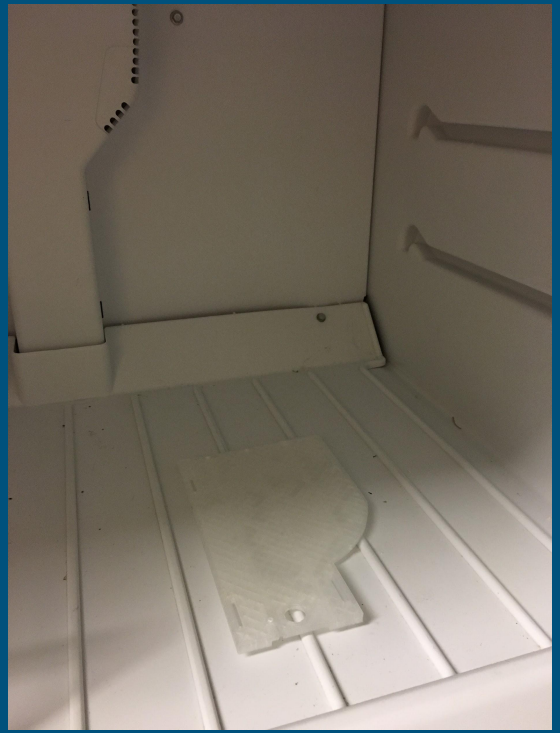


Before

After

Verification Test: Extreme Temperature Assay II

- An ABS portion of the splint was placed in a freezer set to 0 degrees C for a period of 30 minutes
- The structural integrity of the ABS was determined to be the same before and after the test
    - This is determined by applying a compressive force onto the ABS

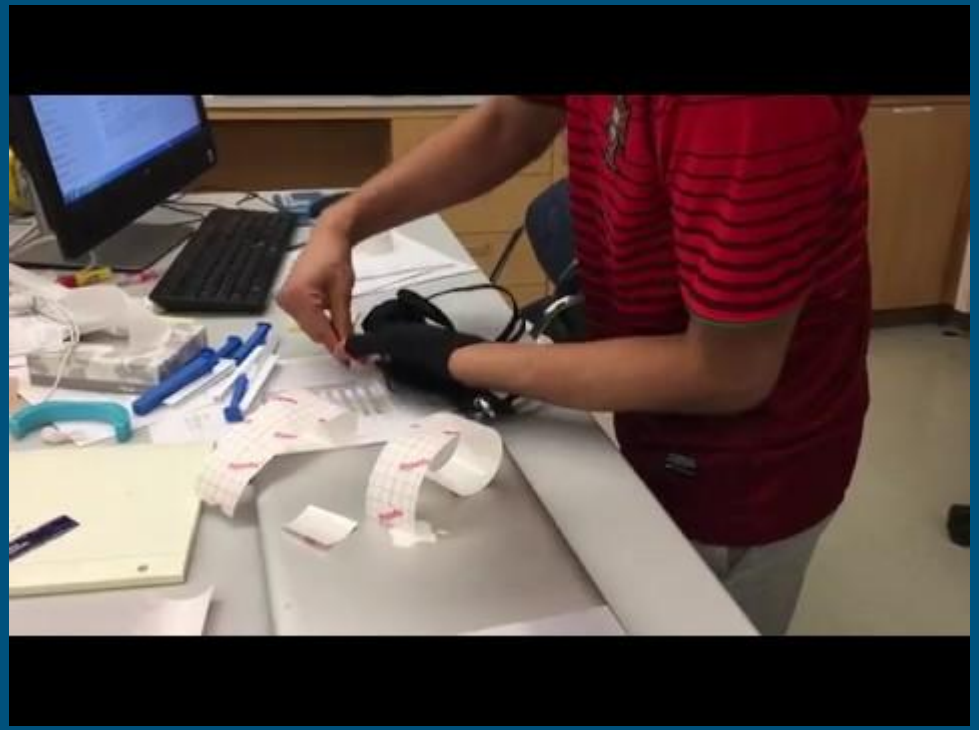


Verification Report : Drop Test

V&V Report : Breathability

- Breathability was determined subjectively
- User wore splint while performing tasks over a period of four hours
- Comfort level of hand was determined via user feedback and sweatiness level
- User confirmed that breathability was acceptable, though the hypafix layer was getting somewhat sweaty

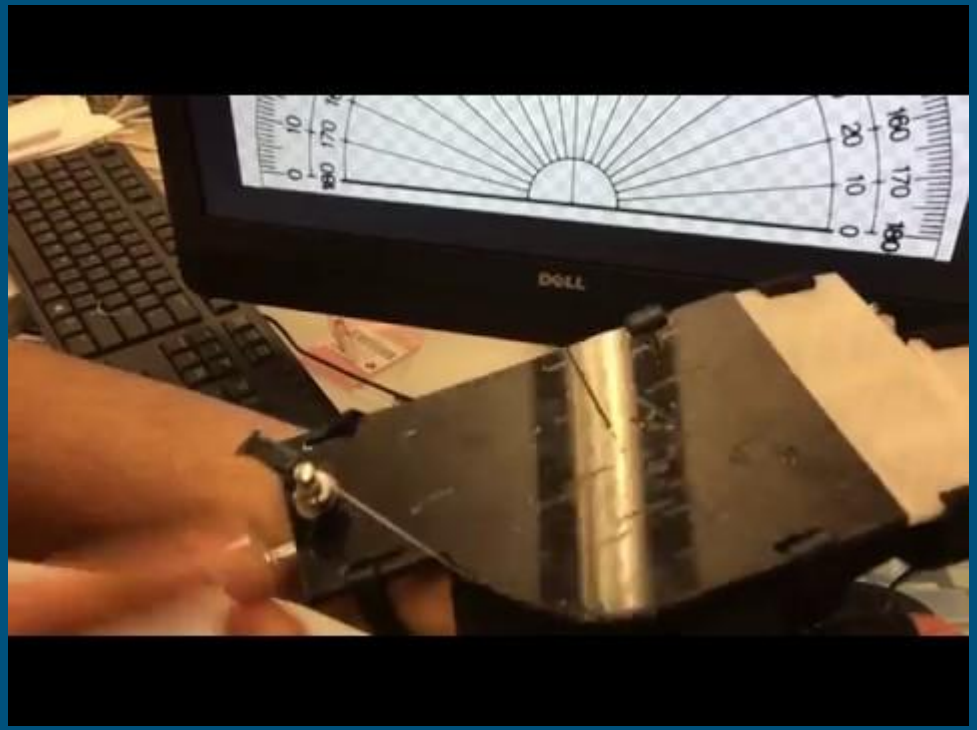
Verification Report : Installation Time



Installation Time:
2:29

Verification Report: Weight Test

Progressive Static Test



Validation Summary

Table 4: Validation Test Results Summary

	Level 1	Level 2	Level 3
Product Satisfaction	6	N/A	7
Progressive Static Functionality	6	N/A	5
Ease of Use	7	N/A	6
Compression Feature	8	N/A	9
Breathability	7	N/A	7

Design Safe Before

User	Task	Hazard Category	Hazard	Cause/Failure Mode	Severity	Exposure	Probability	Risk Level
Doctor	Patient Instruction/ Implementation	Material Handling	Detaching the exoskeleton and elastic glove	Unravelling of the sewing thread	Slight	Remote	Possible	Low
Patient	Readjusting the Device	Mechanical	Overstretching the scar tissue	Overturning the adjustable knob/extra tightening of the strings	Serious	Occasional	Possible	Medium
Patient	Physical Therapy	Heat/ Temperature	Overheating of the glove	Wearing for long hours a day	Serious	Frequent	Probable	High
Patient	Physical Therapy	Ventilation/ Confined Space	Low Ventilation	Low breathability of the material	Serious	Frequent	Probable	High
Patient	Physical Therapy	Mechanical	Over Compression	High elastic compressibility	Serious	Occasional	Probable	High
Patient	Physical Therapy	Material Handling	Wound infection	Contaminated contact media	Serious	Occasional	Possible	Medium
Patient	Readjusting the Device	Biological/Health	Choking Hazard	Swallowing of the knob	Serious	Remote	Unlikely	Medium
Patient	Physical Therapy	Chemicals/Gases	ABS produces toxic smoke upon combustion	Exposure to high temperature/fire source.	Serious	Occasional	Possible	Medium

Design Safe After Risk Mitigation

Method of Risk Reduction/Mitigation	Severity	Exposure	Probability	Risk Level
Proper handling and use	Slight	Remote	Negligible	Low
Standard calibration of the adjustable knob	Slight	Remote	Unlikely	Medium
Frequently taking off the device and allowing some time for airing	Slight	Occasional	Possible	Medium
Using spandex of high quality with high breathability	Slight	Occasional	Possible	Medium
Precise sewing of the elastic glove and periodic compression testing	Slight	Occasional	Possible	Medium
Regular dressing/changing hypafix	Slight	Occasional	Possible	Medium
Proper latching of the knob	Slight	Occasional	Possible	Medium
Not exposing the device to high temperatures	Slight	Occasional	Possible	Medium
Keeping the device away from fire source	Slight	Occasional	Possible	Medium

Conclusions

- We were able to make a compressive and static progressive splint
- We met most of our design specifications
- Cost, and important design requirement, could have been reduced by creating our own tension knob design
- The tension adjustment could be more precise and should include markings for different pressures applied
- We also were not able to include the thumb due to our current design restrictions

Future Considerations

- Would spend more time on increasing the comfort level of the device
- We would also want to increase the usability of the device by incorporating a more effective tension adjusting and locking mechanism
- We would look to field test the device with multiple patients across a period of time for a more accurate validation and verification
    - A key design requirement was patient compliance, which could not be tested during this prototype development

Acknowledgements

- Dr. Klaesner and Darshit
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Questions?