Bone Fracture Fixation

ENGINEERING DESIGN CHALLENGE

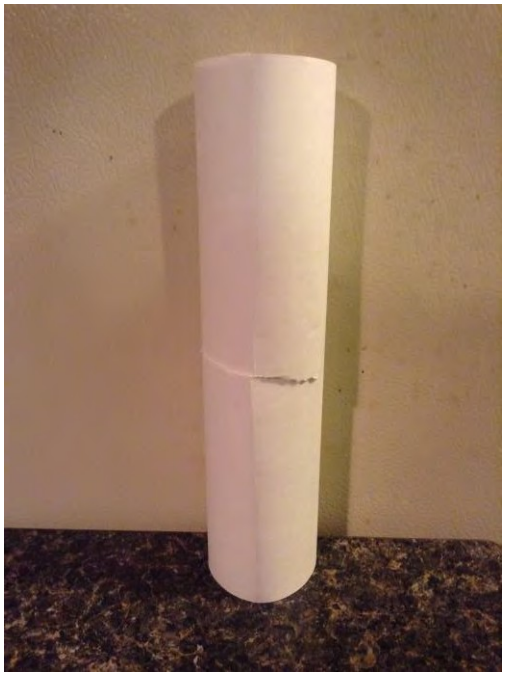
The Story

The bones are particularly strong in the longitudinal direction; that is why many bones are aligned vertically in your body. Since the bones are so strong, one of their tasks is to carry your body weight. Have you or one of your friends had a broken bone before? Doctors probably put a hard and thick cast around the broken bone, so it can heal without being disturbed. Although the current casts are successful at protecting the bones and making them as strong as before, the casts are often uncomfortable because they are bulky. Additionally, since the cast completely covers the skin around the broken bone for a long time, undesirable skin reactions such as itches and rashes are unavoidable.

Identify

Problem

- Current bone casts are heavy and cumbersome.
- The cast completely covers the skin for a long time, leading to uncomfortable skin reactions



Design Challenge Testing Station

- A paper roll with a tear — Fractured bone
- Weights — Load from the body weight

Primary Goal

- Build a fixation device to support the bone from collapsing under the weights.
- The structure must not completely cover the paper roll.

Secondary Goal

- Make the device as light as possible since the patient needs to wear it for a long time.

THE OHIO STATE UNIVERSITY

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TEK8
Translating Engineering Research to K-8

What will you engineer?

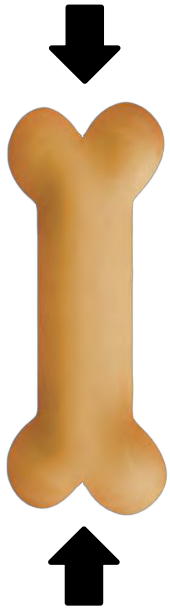
Design

Engineering Design Process

- Design a fixation that will support the teared paper roll, which is analogous to a fractured bone, under weights.
- Think before they act. Think about what your solution might be, and then draw it on a piece of paper to give you a better idea of how to build it. You can even do this after trying one design, to improve your solution.
- Remember that there is no “right” answer; there are many ways to make a fixation device that improves the strength of a broken bone to its original state.
- If you are working with a sibling or friend, work together to create a design with some components of both ideas. Engineers almost always work in teams to come up with the best solutions to difficult problems.

Helpful Concepts Overview

- Anisotropic behavior:
  - When a material is strong in one direction but weak in the other direction.
  - Examples: wood (which is easier to split along its grain than against it) or string cheese (same reason)
- Bones:
  - Are very strong in the longitudinal direction. This is why many bones are aligned vertically in your body.
  - In contrast, the bones are relatively weak in the transverse direction; as a result, a majority of bone fractures occurs when the force comes from the side of the bone.
  - Therefore, the bones are anisotropic: they are strong in the longitudinal direction but weak in the transverse direction.



Student Materials List

Structural Materials

- Paper Clips
- Q-tips
- Popsicle Sticks
- Plastic Straws
- Skewers/ Dowels

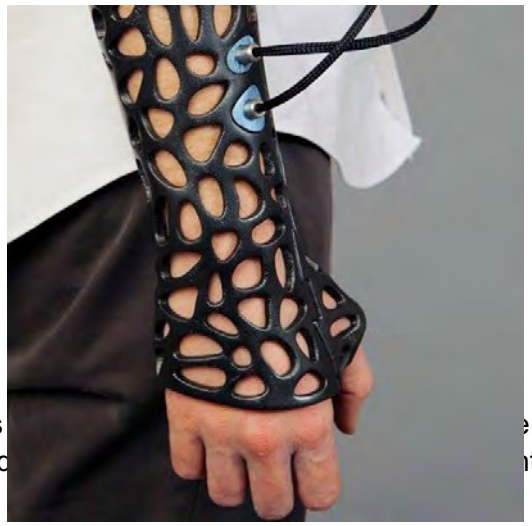
Adhesive Materials

- Scotch Tape
- Twist Ties
- Rubber Bands
- Glue
- String

Tools

- Pencils
- Scissors
- Rulers

Helpful Guiding Questions



- What are the anisotropic materials that you have? Can you use these materials to your advantage?
- What is the weakest part of your structure? How can you make a strong but lightweight structure?
    - Some areas of the fixation device can be weaker or be reduced in quantity, for example the connective materials (tapes, strings, staples, etc.)
    - Others should be rigid: supporting rods [illegible]. These keep the bone in a straight line and [illegible]t propagate the bone fracture.
- Think about the casts you have seen in the past.
    - How can they be improved? More lightweight? Better materials?

Build

Helpful Build Suggestions

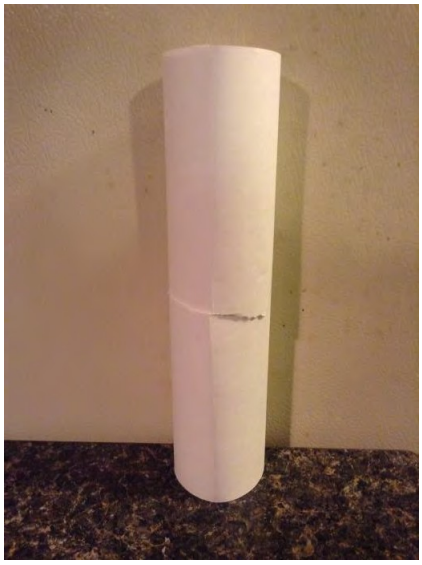
- Use your idea to construct a fixation device for your model of a fractured bone.
- After construction, evaluate your design. Do you think it will be able to support the same amount of weight that an unfractured bone (roll of paper) can support? If not, try to improve your design
- Once you are satisfied with your fixation device, test it! Load the bone with weight, cans, water bottles, anything you can find to test its abilities. Make sure you test an unfractured roll of paper with the same weight to determine if your design was successful

After testing:

- Did your design fail? If so, why?

- What could you change about your design to prevent this failure? Redesign and try again!

Test Setup Build Instructions



- Teared paper roll:
  - Regular printing papers were used.
  - If preferred, thicker paper materials, such as construction papers or cardstocks, can be used for a stiffer bone model.
  - Roll paper in the horizontal direction, so that the short edges of the paper will become the height of the roll.
  - The roll should have a diameter of around 2 inches.
  - Use tape or a stapler to fix the top, bottom, and middle of the roll.
  - Tear the roll halfway near the center.
- Weights:
  - Weights will be placed on top of the teared paper roll.
  - Virtually any regular objects can potentially be used as weights
  - Suggestions: books, canned goods, water bucket, etc.

After you finish

Return to the video and learn more about biomechanics and how you could use this new engineering knowledge as a biomedical engineer!