



The Scalpel Jockeys

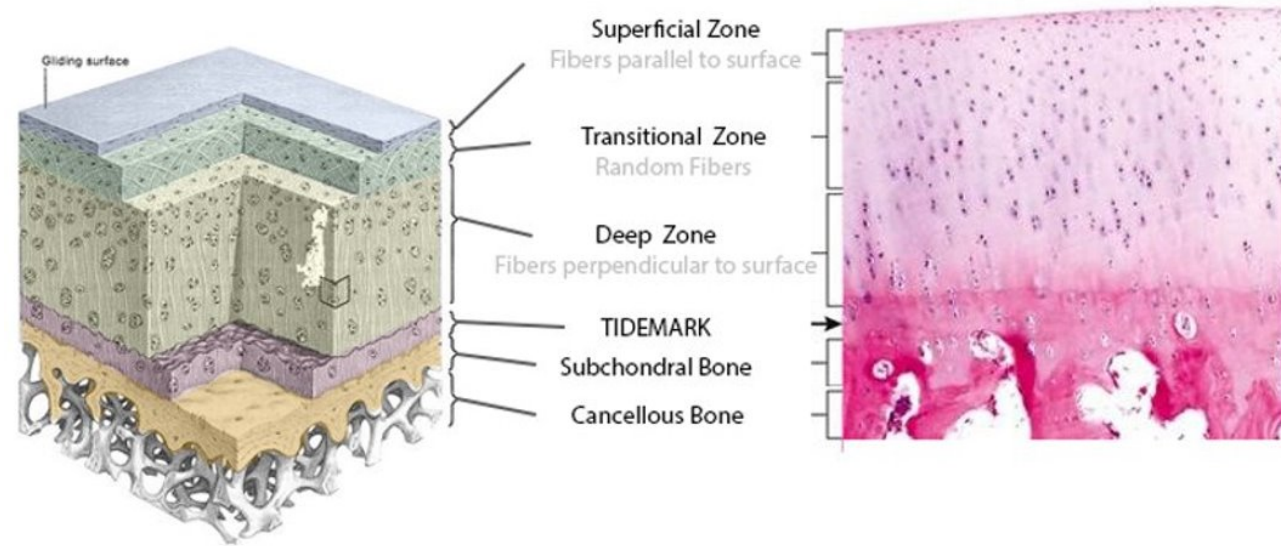
Engineering Release Review

Ethan Overfelt, Katie Farris, Suhaim Altaleb, Lissa Nickell, LeeAnn Hold, Qingyun Wang, Qian Xu

Sponsored by: Dr. WDB Hiller, MD

Background: Cartilage

- Decreases friction and distributes loads
- Stress shielding
- Contains 3 layers of collagen fibers with different orientations
- Has a poor healing capacity and after normal wear and degradation usually leads to surgical repair

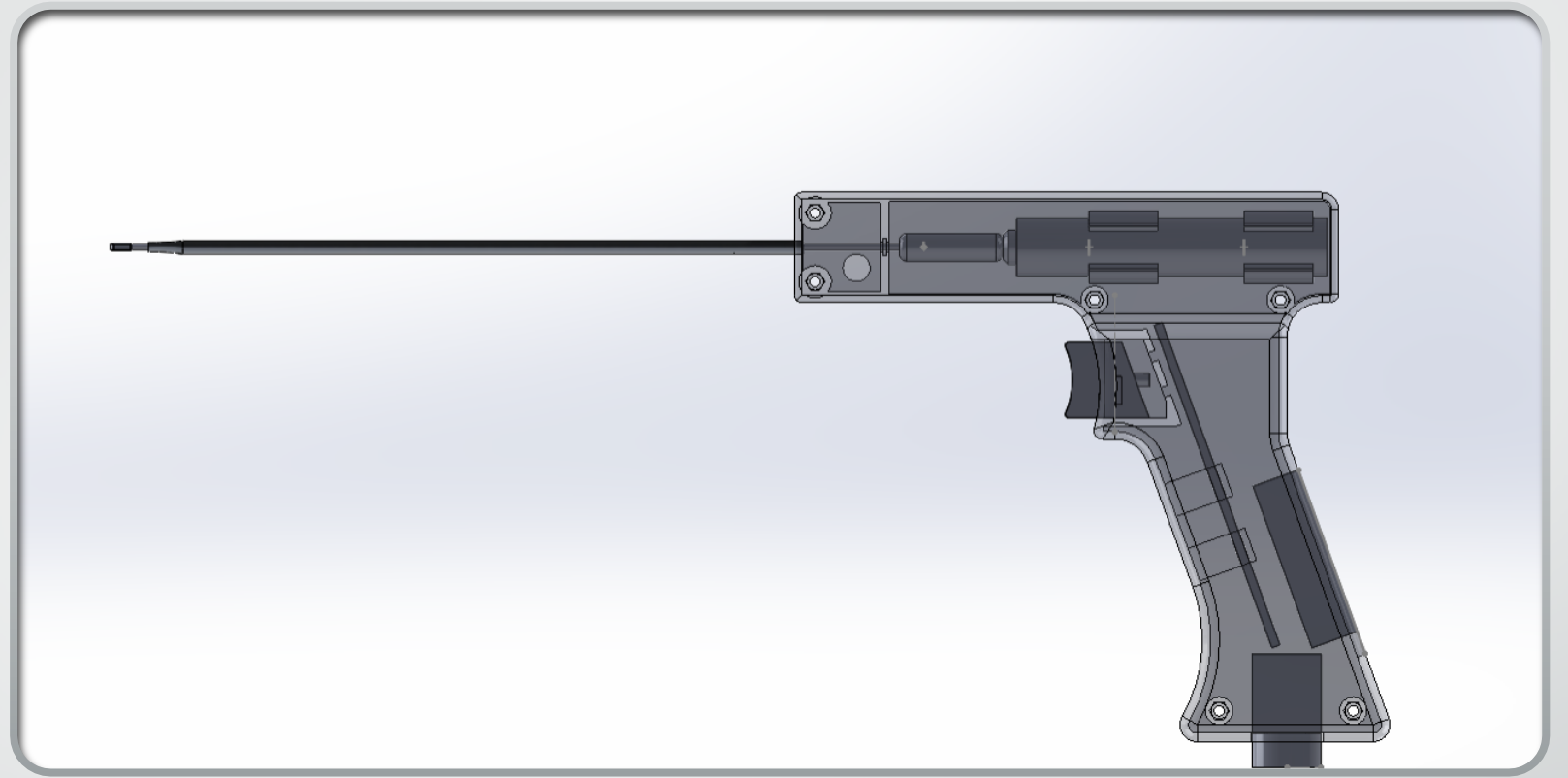


Project Objective

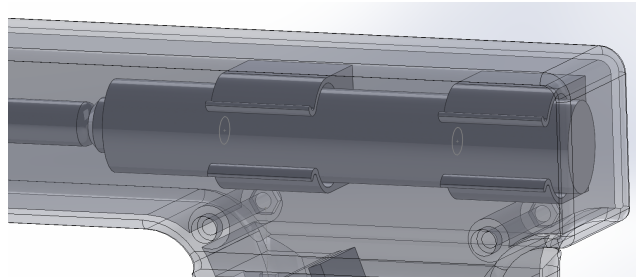
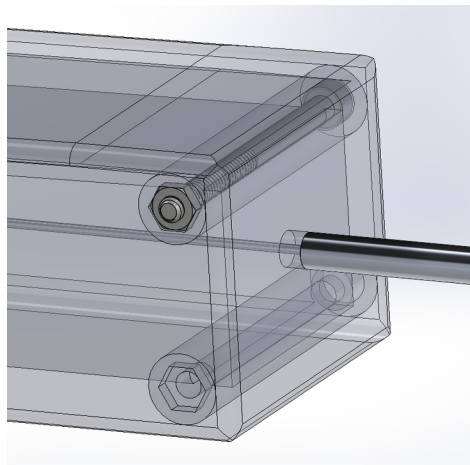
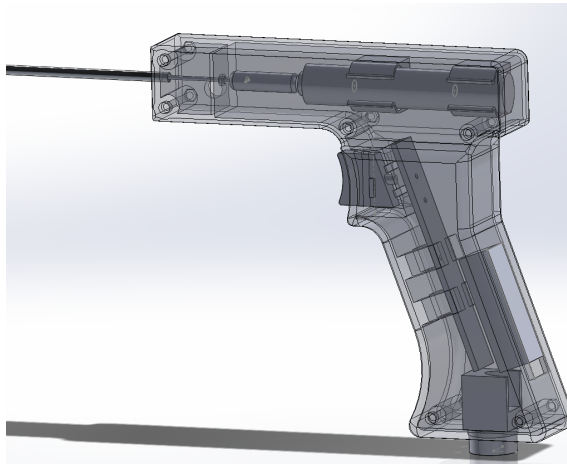
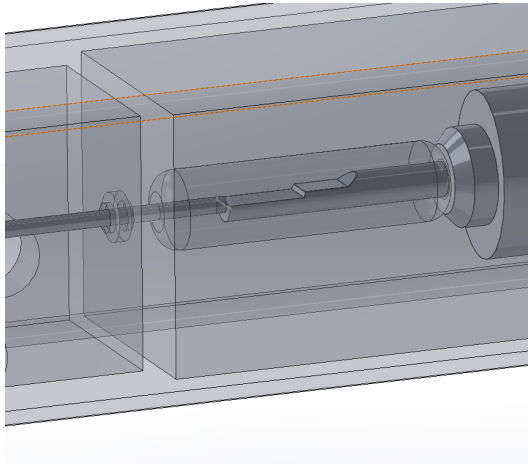
- Our team is driven to improve arthroscopic debridement by creating a novel arthroscopic shaver that can be used to create smoother articular surfaces. Currently our prototype includes a pistol-grip handle which will be more ergonomic and functional than current technologies, a motor and a shaft with a gritted head. Our device should result in a post-surgical joint that lasts longer and is more comfortable, improving the quality of life for patients.

Our Progress

- Since our design review we have:
 - Created a prototype of our arthroscopic shaver for testing which includes:
 - A 3D printed pistol grip handle.
 - Shaft with gritted head attachment (adapted from Dremel heads)
 - Motor (from toothbrush) & Control system via Arduino
 - Tested our prototype for shaving articular cartilage



Design (CAD modeling)



Design (CAD
modeling)

3D Printed Model

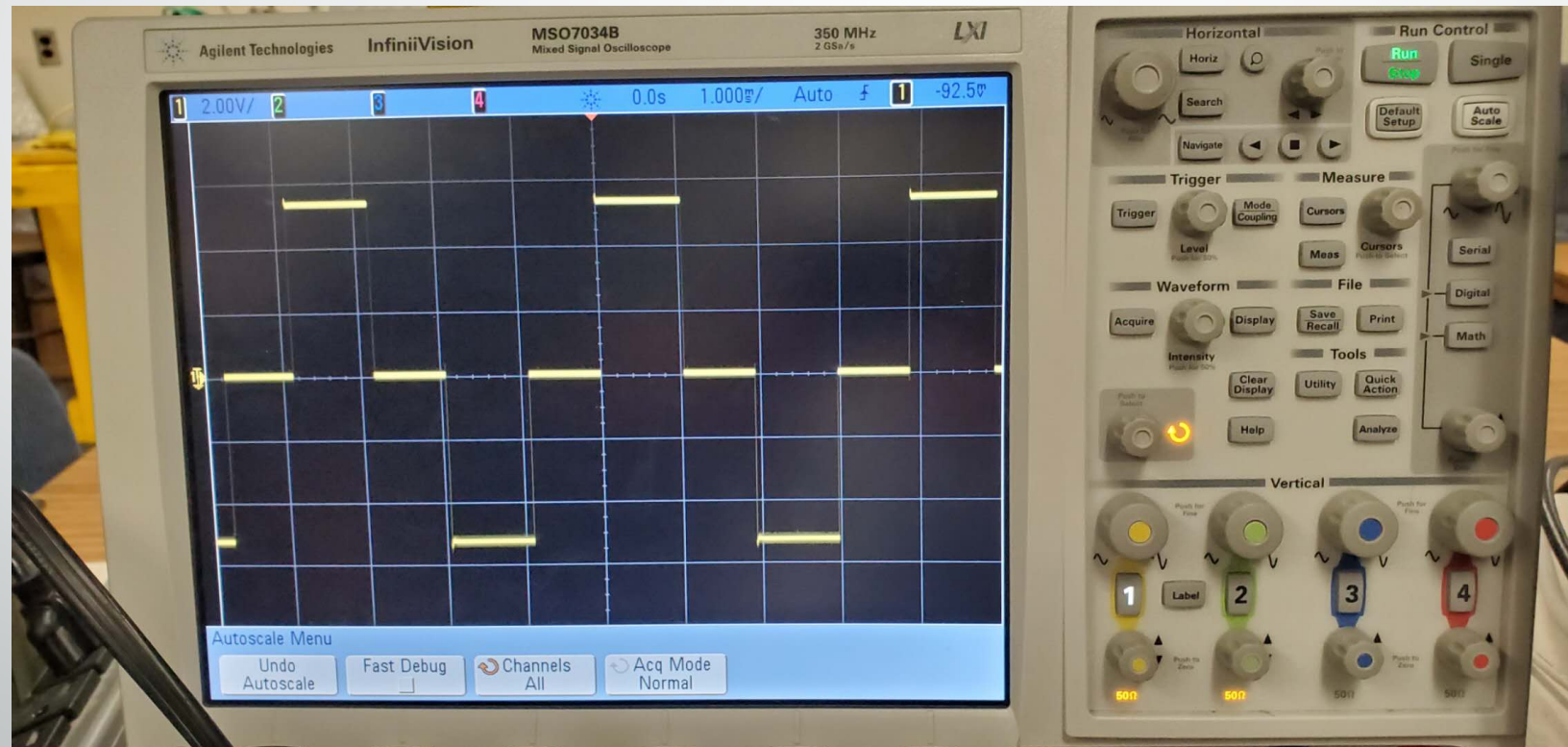


Shop Process



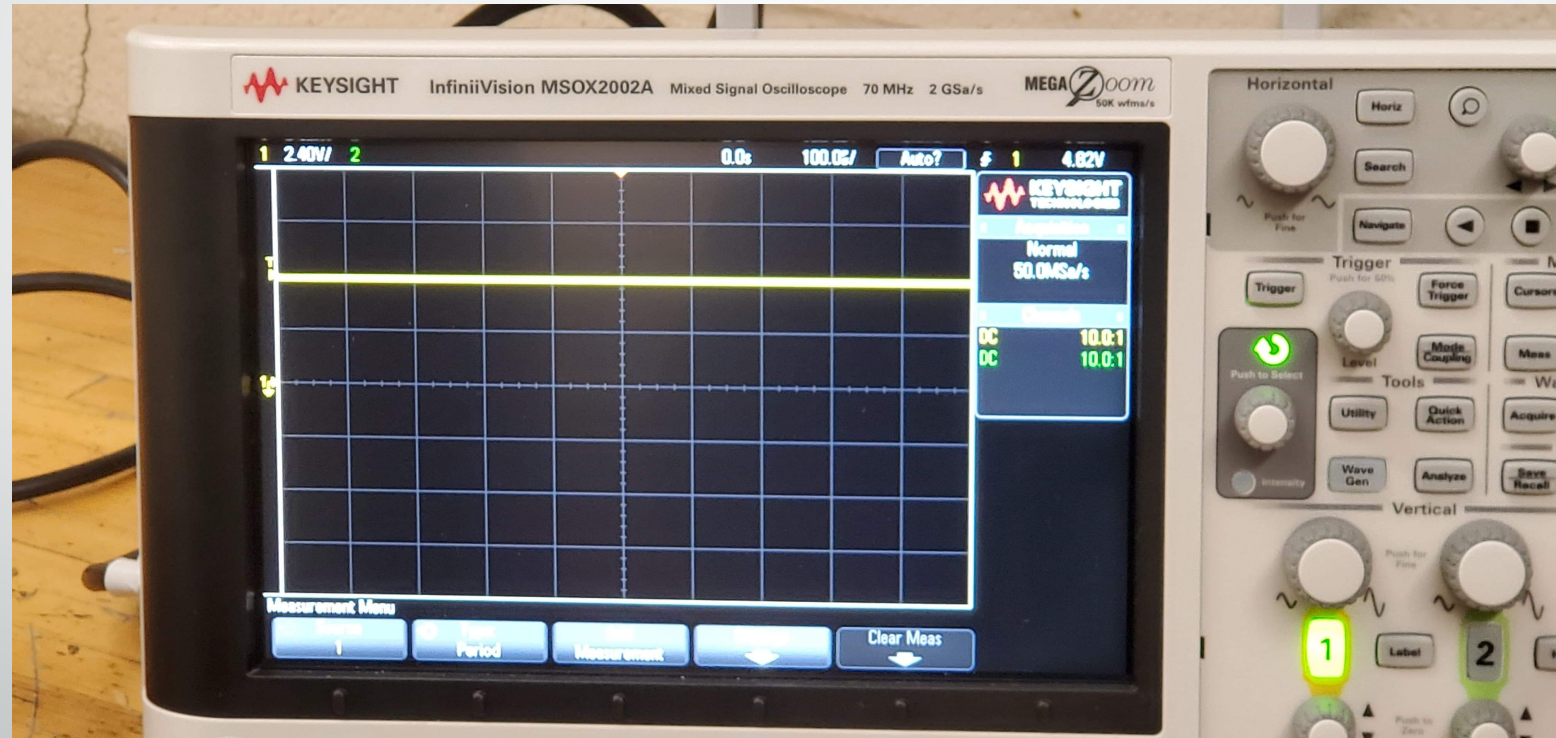
Design

The original motor's frequency is about 250Hz



Design

The motor needs 4.8V voltage.

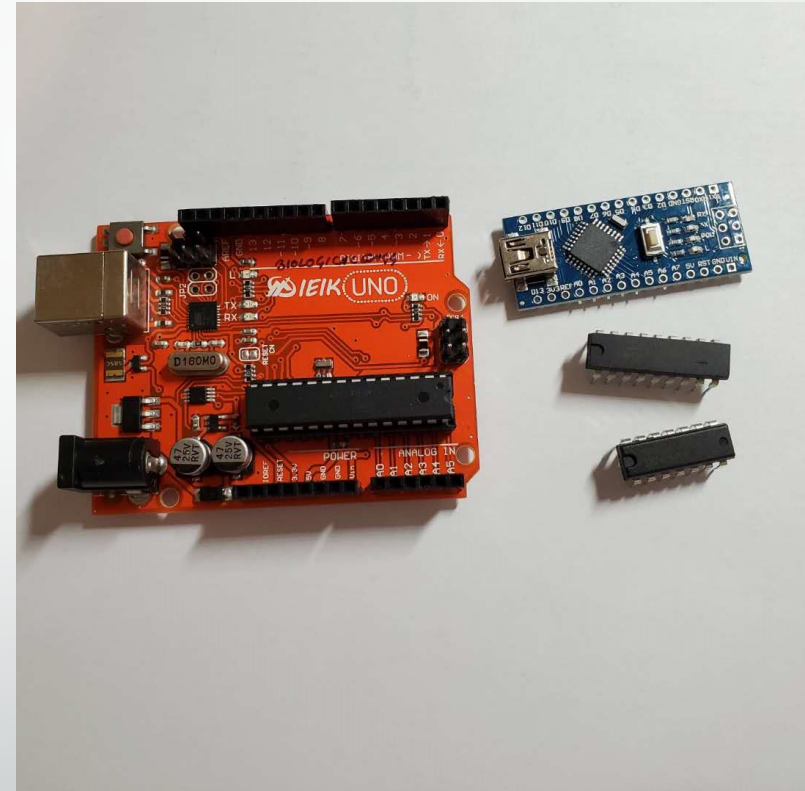


Design

```
vibrationmotor | Arduino 1.8.12
文件 编辑 项目 工具 帮助

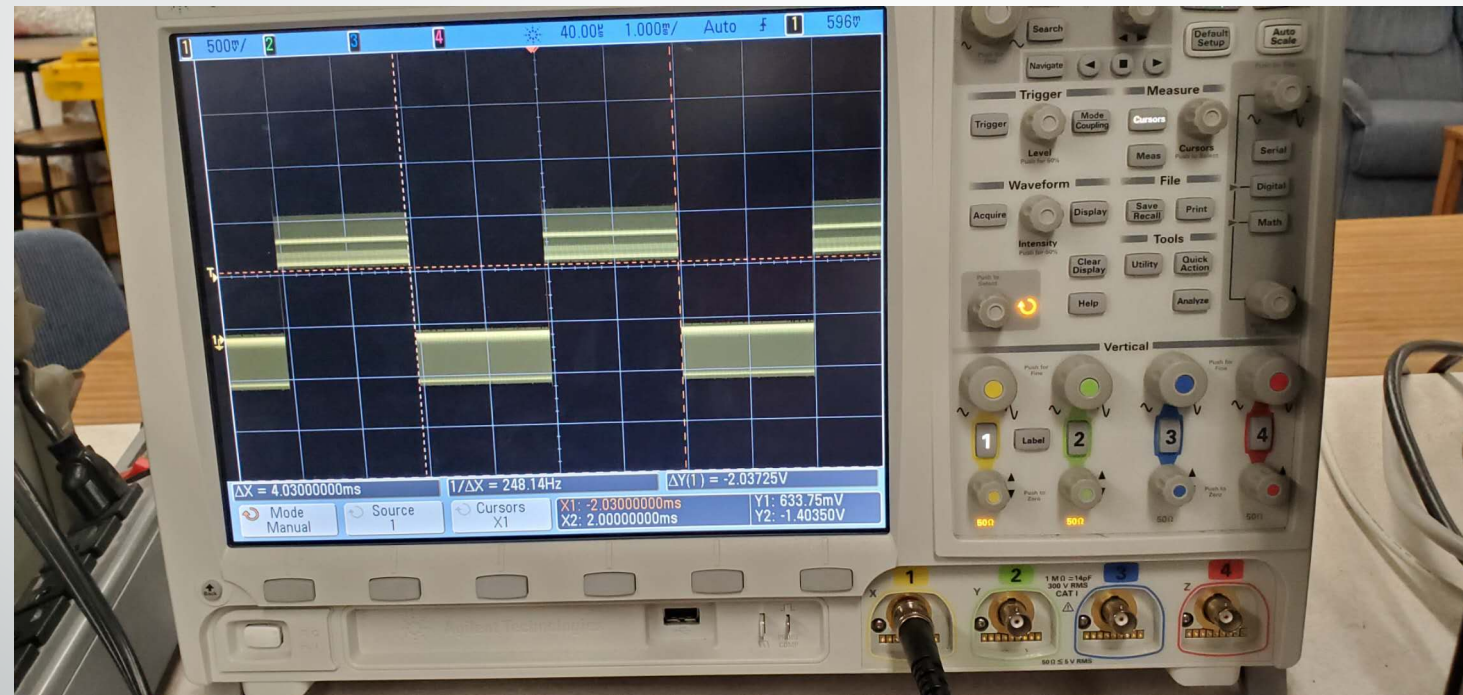
vibrationmotor $
const int cw = 12;
const int ccw = 13;
void setup() {
  pinMode(12, OUTPUT);
  pinMode(13, OUTPUT);
}
void loop() {
  digitalWrite(12, HIGH);
  digitalWrite(13, LOW);
  delay(2);
  digitalWrite(12, LOW);
  digitalWrite(13, HIGH);
  delay(2);
}

1 Arduino Uno 在 COM4
```



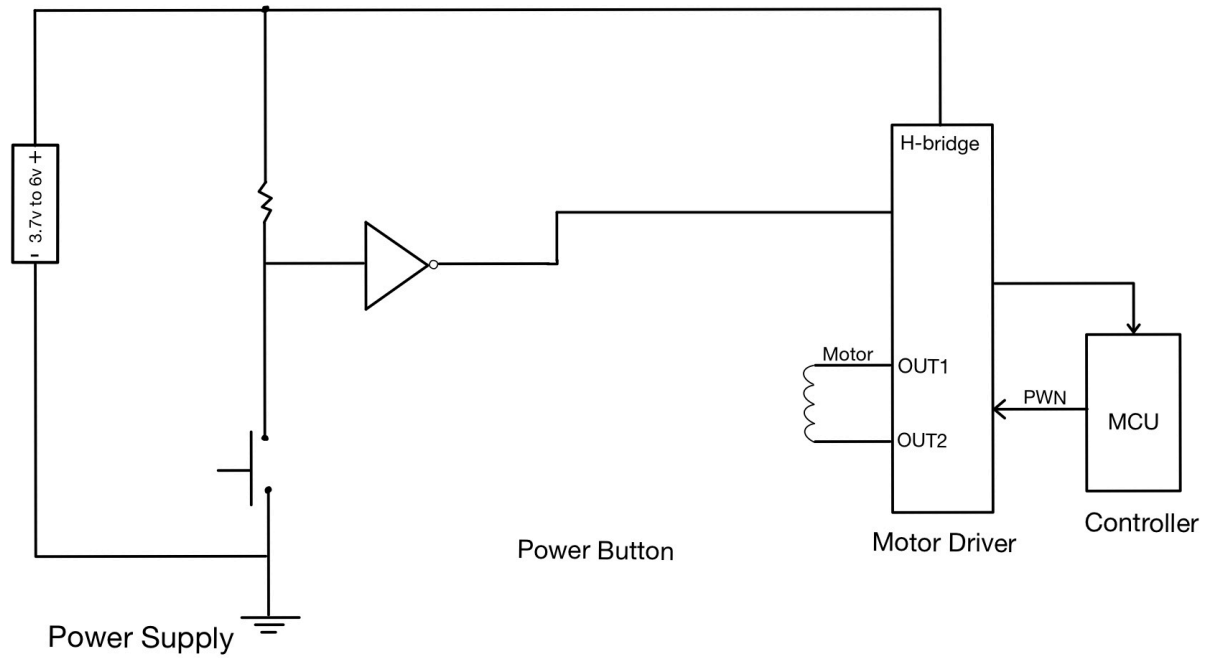
Design

The motor needs 3.7V voltage, but we are making this higher to give the motor more power.

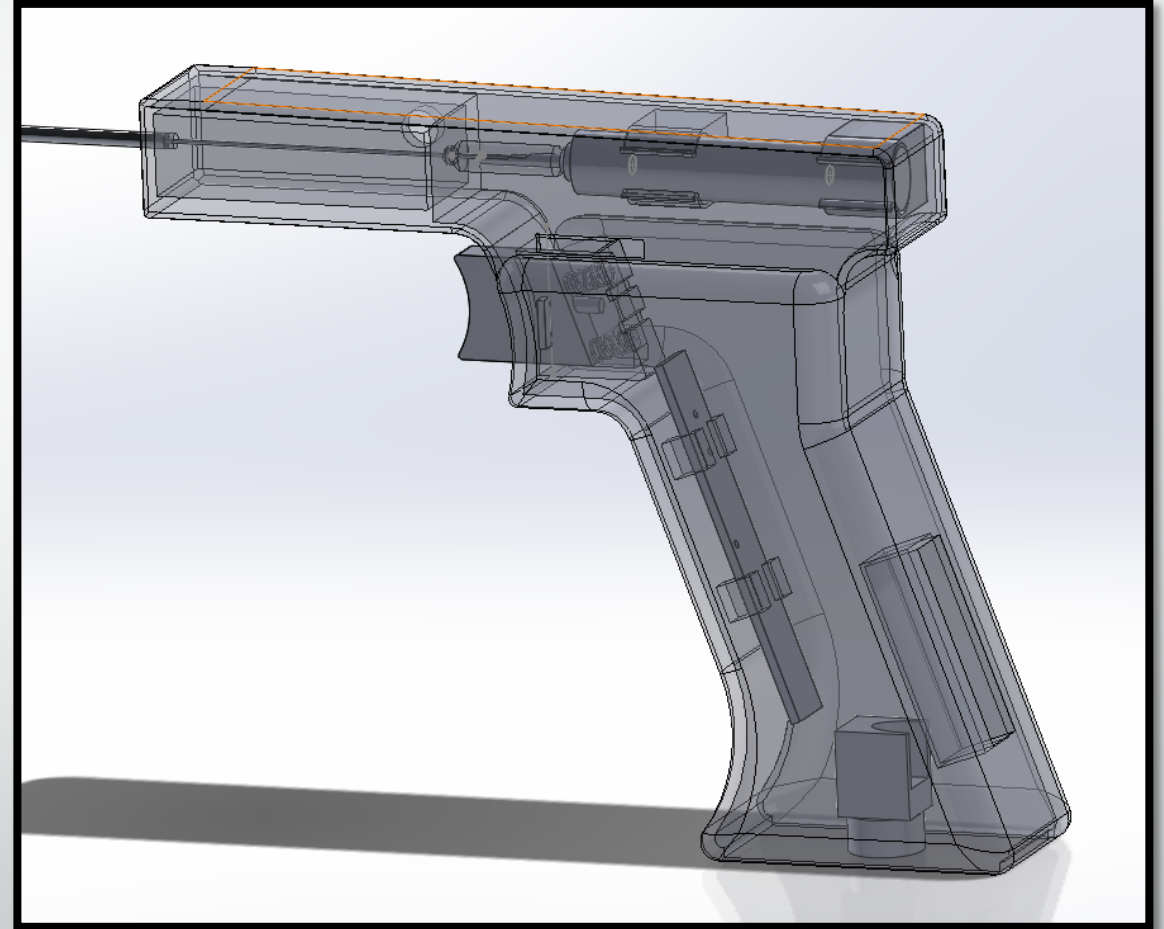
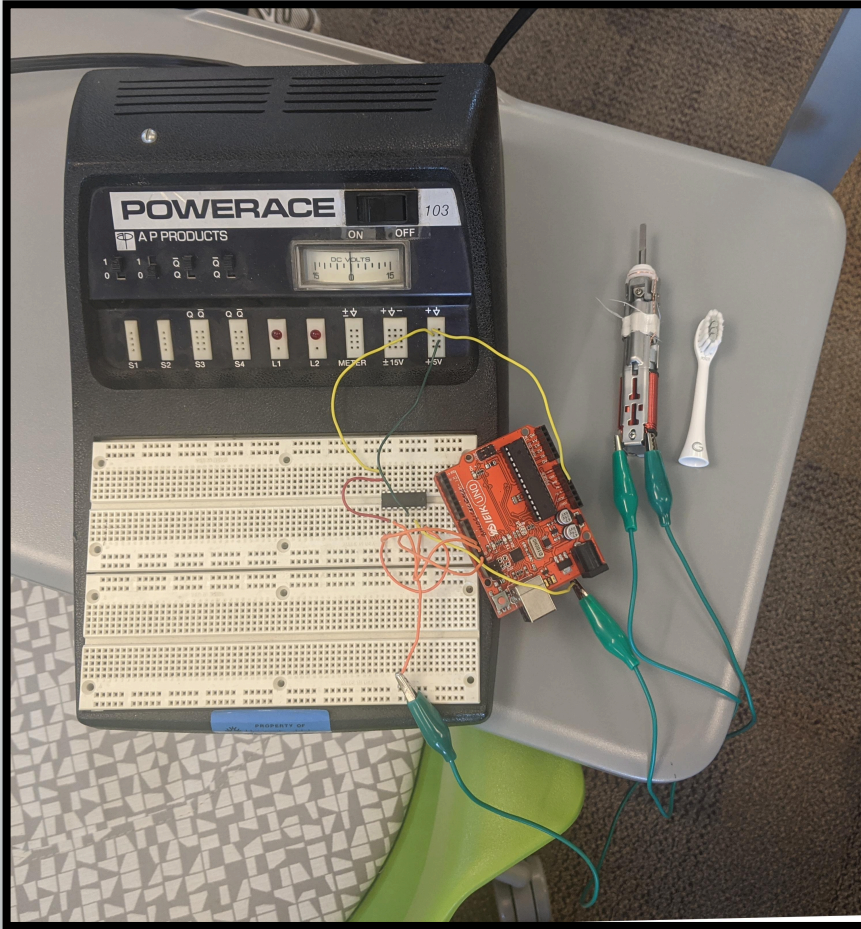


Design

Wiring diagram for vibration motor



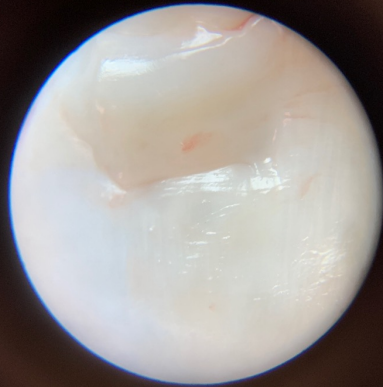
Proof of Concept



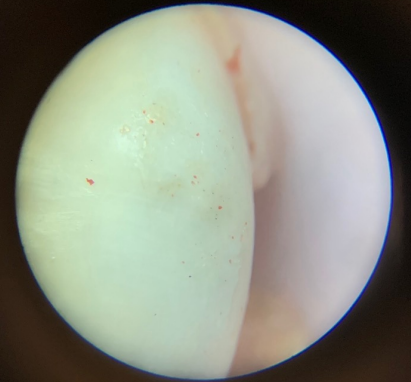
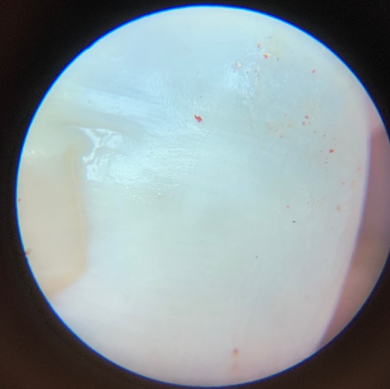
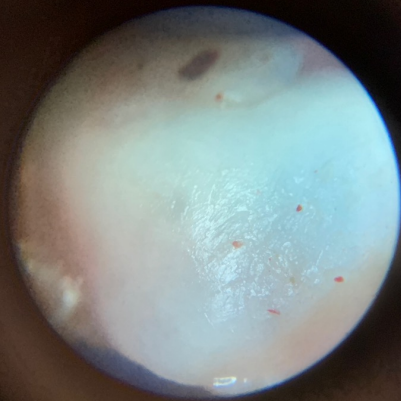
Testing

10x Magnification

healthy healthy



sandpaper sandpaper sandpaper



normal gritted

40 grit

gritted

gritted

Validation Plan

Requirement	Test	Test Subject	Target Date
Motor Power Test	Analyze the power outputted by the motor	Electrical Components	2/25/2020
Frequency replication	Replicate the frequency created by the <u>tooth brush</u>	Electrical Components	2/25/2020
Ability to shave down articular cartilage	Run shaver on bovine/porcine knee and measure articular cartilage before and after with a microscope	Fully Functional Prototype	2/26/2020.
Device is made of two components that can easily slide in and out of each other	Manually measure that there is not friction when sliding inside attachment in and out of handle shaft	Shaft and handle	3/2/2020
Thickness of shaft and tip should not exceed 4 mm in diameter	Measure diameter by inserting shaft into 4 mm straw to ensure fit	Shaft and tip	3/2/2020
Maximum weight shall not exceed 500g with 400g being the handle	Weigh the full system and the handle on the scale in GJ 126	Initial Prototype	3/2/2020

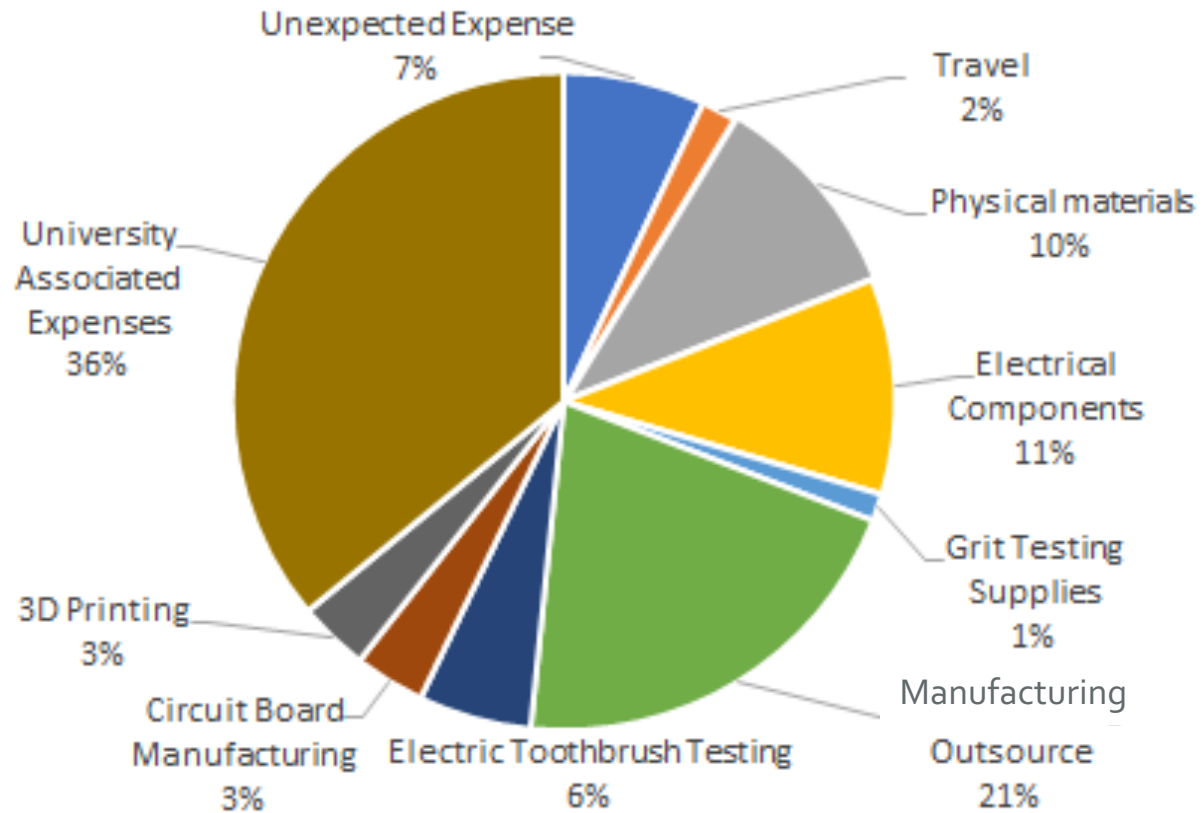
Validation Plan

Needs to be comfortable to hold for Dr. Hiller	Have Dr. Hiller hold and approve handle	Handle	3/2/2020
Battery Charger	Test if battery <u>is able to</u> charge and hold a charge	Electrical components	3/2/2020
Operate for 1.5 hours of continuous use	Use prototype continuously for 1.5 hours with load (shaving of bovine knee cartilage, etc.)	Fully Functional Prototype	3/31/2020
Operation power capability: 400W@200ohms and 200KHz	Use multimeter to measure the output voltage and current, then can get the operate power	Electrical Components	3/31/2020
Speed Control	Successfully vary speed of vibration	Electrical Components	3/31/2020
Ability for inner shaft to vibrate in outer shaft	Hook up motor to inner/outer shaft configuration and run, making sure it runs smoothly without catching	Fully Functional Prototype	3/31/2020

Validation Plan

Operate within temperature range of 25-39 °C	Use prototype at the both 25 °C and 39 °C with load to check functionality	Fully Functional Prototype	3/31/2020
Must not break or bend during use when max load is applied	Perform a 3-point bending test of material	Fully Functional Prototype Shaft	3/31/2020
Needs to be comfortable to hold and operate with for Dr. Hiller	Have Dr. Hiller operate on a bovine knee	Fully Functional Prototype	4/10/2020

Topic	Risk	Solution
3D Printing Case	3D printers on campus might not get to the level of precision we need, or not fit	Find a 3D printer off campus, possibly online to contract with OR find a way to manufacture it in shop
Circuit board design	We may not be able to create the correct pulse function to control the motor we want.	Use the current circuit board that came with the toothbrush.
Circuit board production	We may not be able to have the circuit board we design manufactured and come back in time	Use the current circuit board that came with the toothbrush, and we will get the circuit board later
Device assembly	Possibly not everything will fit in case, but case is as big as possible	Reorganize interior compartments
Inner shaft	Inner shaft may deform due to constant vibration/load	Inner shaft will be made thicker
Result on cartilage/bone	Sandpaper will loosen cartilage, leaving shredded as it is in arthritic joints	Make grit of sandpaper surface finer grit
Result on cartilage/bone	Pits/divots caused by flat shaving head	Will make head convex and rounder, so that there are less sharp edges
Vibration	Handle will vibrate too much in surgeon's hand	Increase damping materials inside case
Vibration	Vibration is not powerful enough to be effective	Voltage to motor will be increased (diff. Battery setup)
Vibration	Vibration motor will stall when shaft is loaded (pressed against bone)	Reevaluate motor choice and adapt accordingly (more torque, etc.)
Duration of use	Current battery will not allow continuous use for an hour	Batteries can be replaced easily
Handle size	Handle is incorrect size/shape/uncomfortable for surgeon	Notes will be taken and modifications will be made
Result on cartilage/bone	Sanding head will remove too much articular cartilage	Adjust vibrational speed and if needed redesign shaving head (potentially to cheese grater design)
Production of sanding head	We may not be able to produce an appropriate sanding head (grit) out of the correct materials in the shop	We will use appropriate sanding Dremel heads and burrs modified to our specs for shape and size instead of the metal we have for the sanding head



Updated Budget

Next Steps

SHORT TERM

- Incorporate Feedback into design
- Design/build concave/convex shaving heads
- Manufacture circuit board based on Arduino control system
- Confirm electrical setup

LONG TERM

- Test initial prototype based on validation plan
- Revise Design
- Edit validation plan and retest
- Complete fully functional prototype and CAD design
 - Based on proof of concept and several design iterations



Questions?