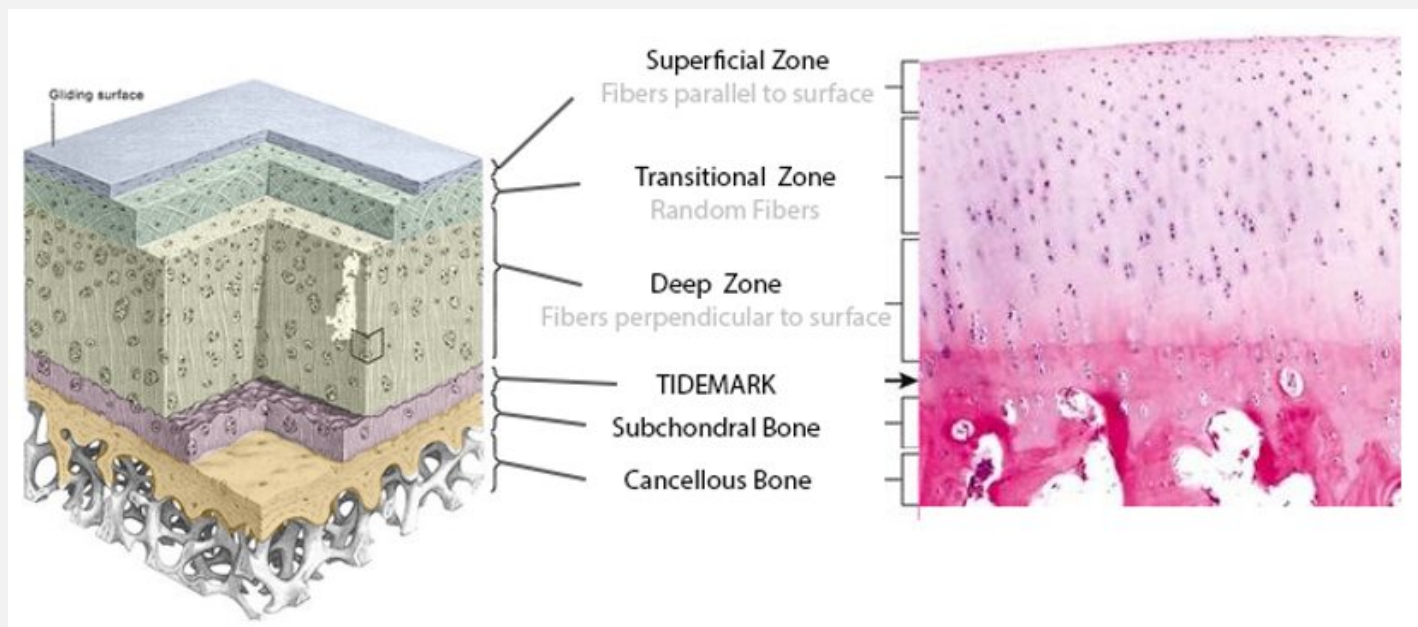


Concept Design Review

Articular Cartilage Shaver for Arthroscopic Surgery

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LeeAnn Hold, Katie Farris, Suhaim Altaieb

Cartilage



Value Proposition

- Surgical interventions for articular degradation:
 - Perform total joint replacements:
 - Some individuals are too young or simply unfit for a total joint replacement
 - Arthroscopic debridement:
 - Shave down damaged articular surfaces to minimize inflammation and pain
 - Current shavers utilize a rotating drum-shaped shaving head, that can cause ripples

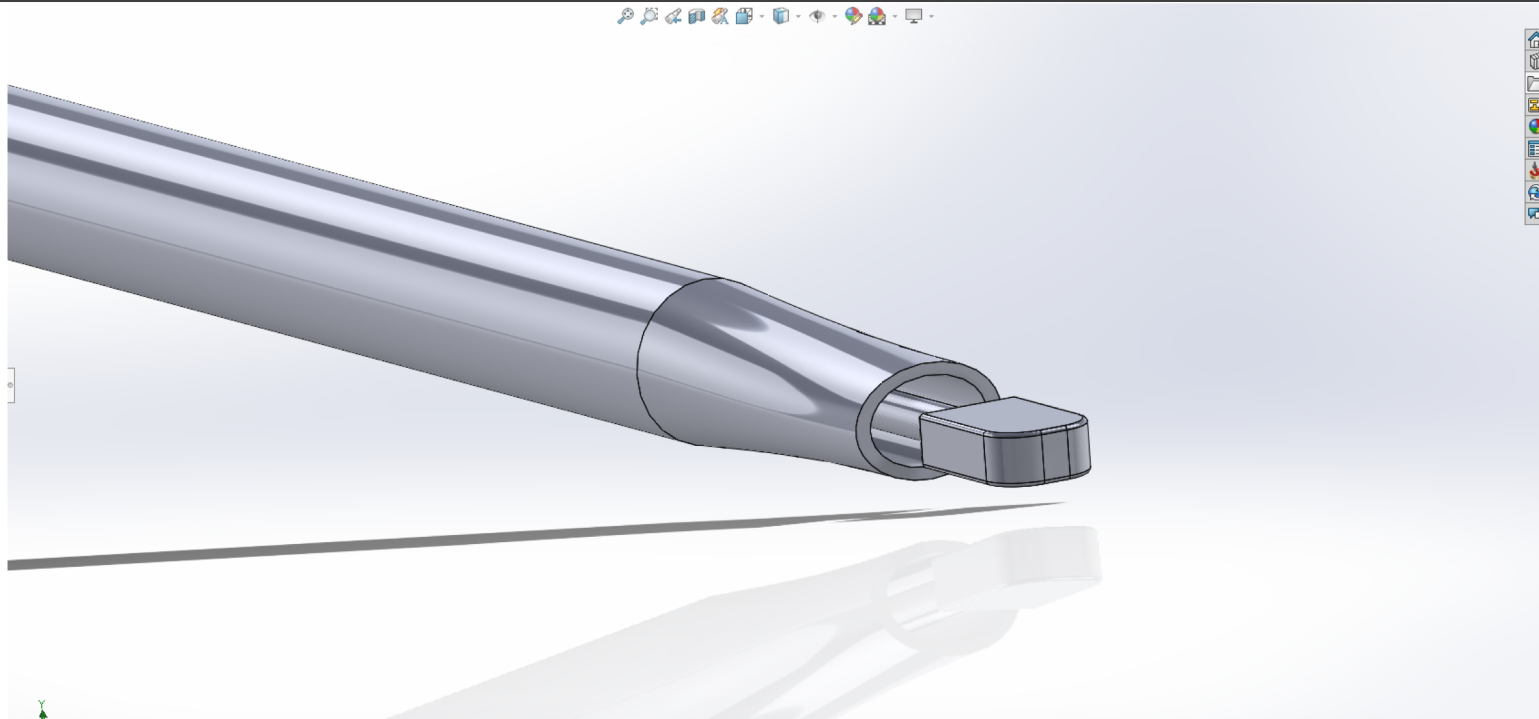
Our team is driven to improve this procedure by creating a novel arthroscopic shaver that can be used to create smoother articular surfaces

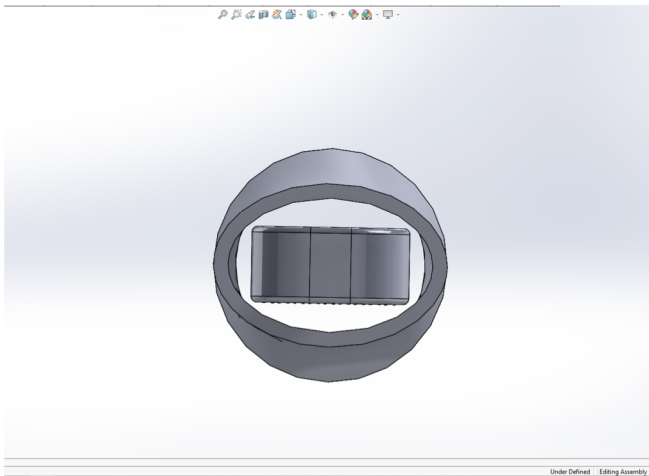
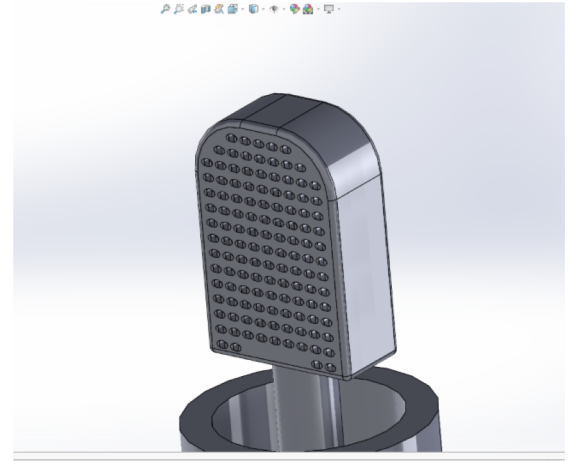
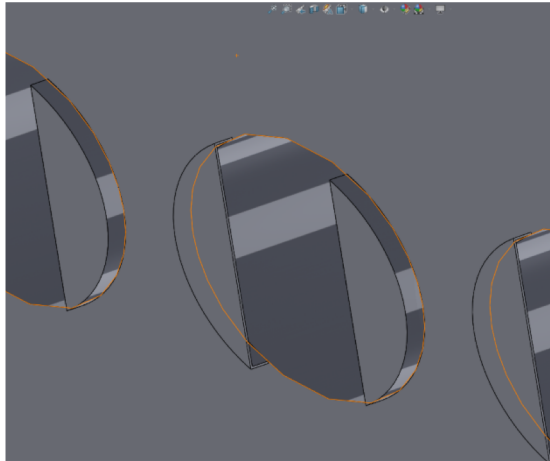
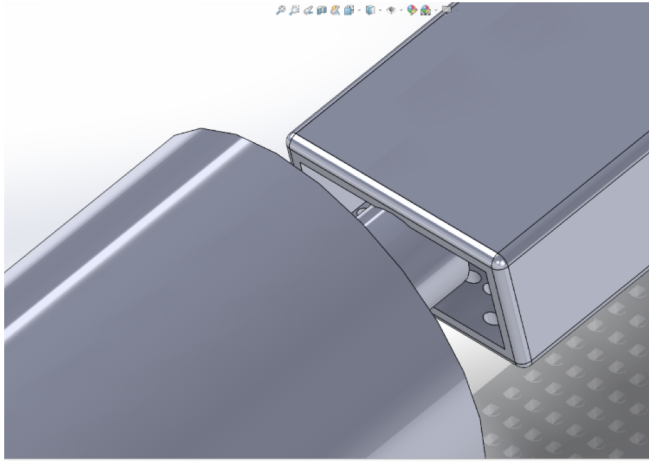
- Pistol-grip handle which will be more ergonomic and functional
- Result in a post-surgical joint that lasts longer and is more comfortable, improving the quality of life for patients.

Design Constraints

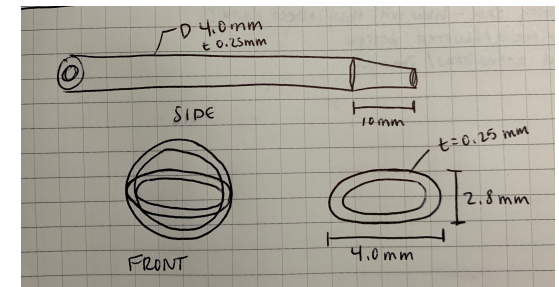
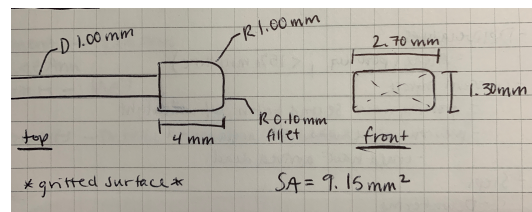
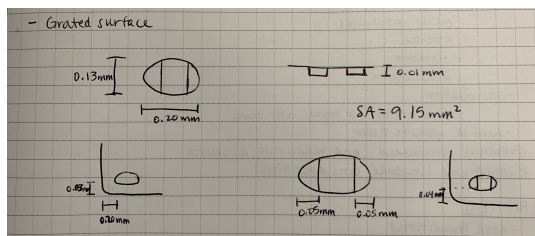
- Diameter of 4 mm or less
- Operate at 4000-6000 rpm (66-100 Hz)
- Biologically compatible with human tissue
- Able to create smooth articular surface with no divots
- Compatible with suction and fluid flow
- Lightweight and comfortable to hold

Design Idea #1 – Fixed Head Model





Grated Surface



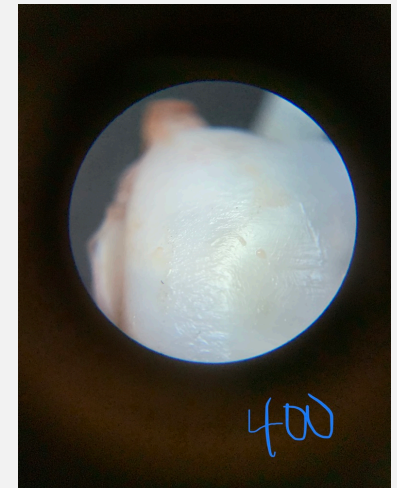
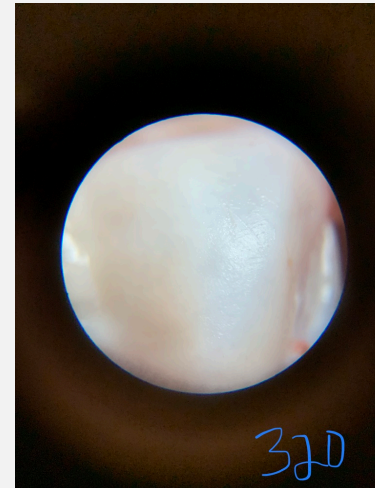
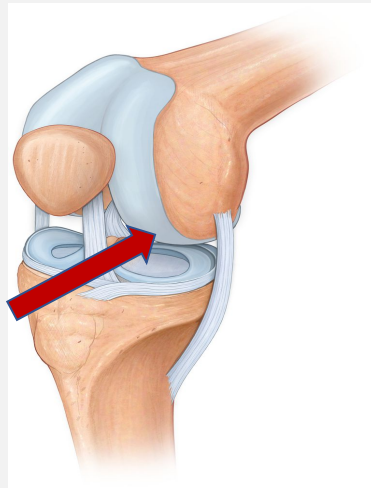
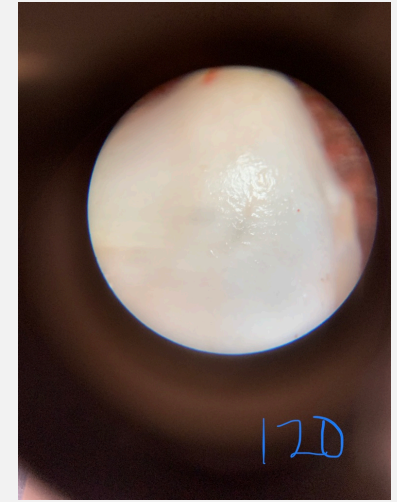
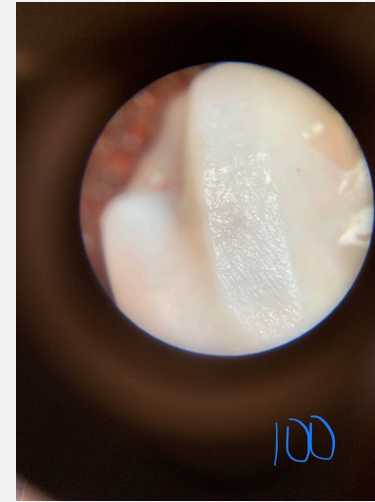
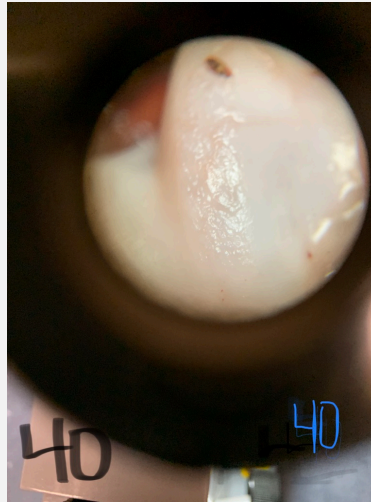
Dimensions

Flat Brush Logistics

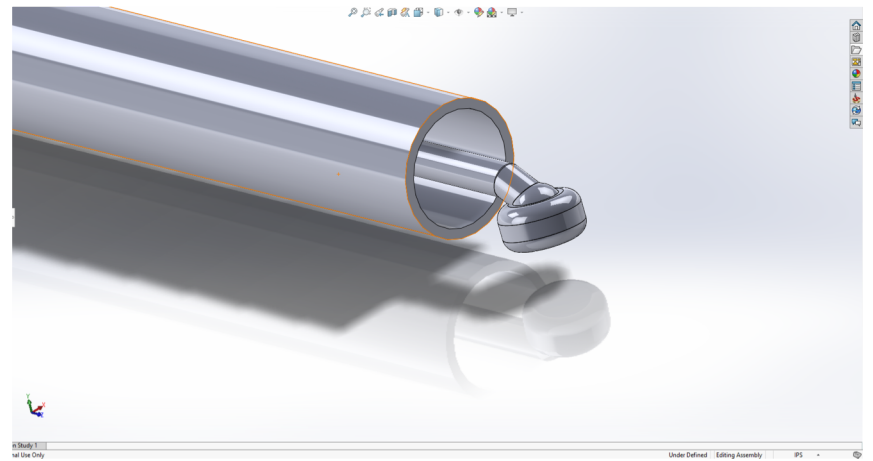
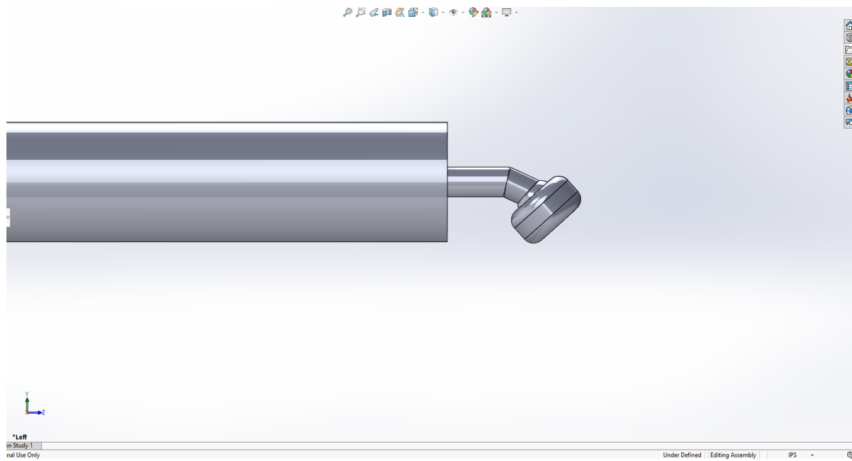
- Brushing side-to-side motion to reduce gouging
- Slight protruded edges to shave minimal depths of tissue
- Gritted surface to perturb fragments and shave off
- Less room for error in cutting and burrowing
 - Non-rotary and flat/convex surface
- Drive shafts and shaving surfaces are easily replaceable through outer shaft

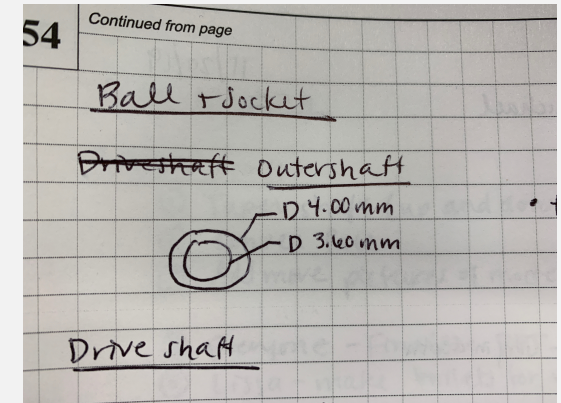
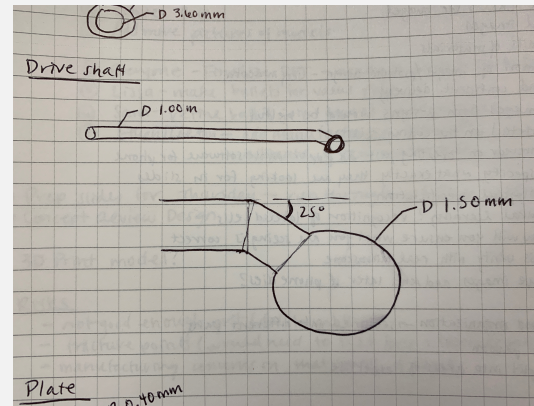
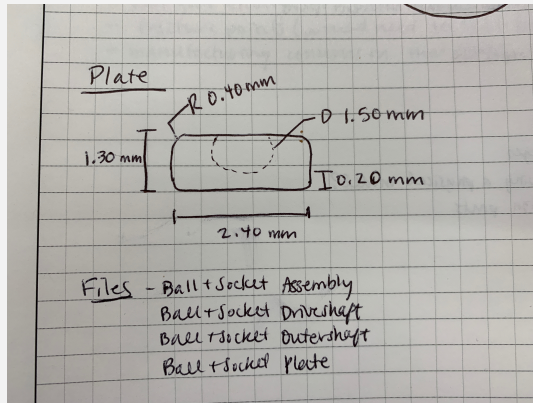
How much to grit surface?

- What do grit numbers represent?
 - Number of holes per square inch in sieve used to prepare particles for grit on sandpaper
 - Bigger number = finer grit
- We examined the effects of 8 different grits on the femoral condyles of chickens
 - 40 and 80 grit surfaces were visibly rough
 - We will aim for a grit between 300 and 400



Design Idea #2 – Ball Joint Model





Dimensions

Ball Joint Model Logistics

- Brushing side to side motion
- Easily rotatable joint for following smoothly along ridges
 - Less chance for gouging and divots
- Lubricated by fluid flow during surgery
- Gritted surface to perturb and shave off rough segments

Design Comparison

Flat Brush

- Pros
 - Larger surface area
 - Easily controllable and removeable
 - $SA = 9.15 \text{ mm}^2$
- Cons
 - Concerns about following ridged surface
 - Concern about up and down vibration (easily accounted for)

Ball Joint

- Pros
 - Adapt to uneven surfaces
 - Maneuverable
- Cons
 - Less surface area
 - $SA = 4.16 \text{ mm}^2$
 - Harder to retract through the outer casing
 - Concern with controlling angle with movement

Stainless Steel – Inner Shaft and Head

Pro: Cost

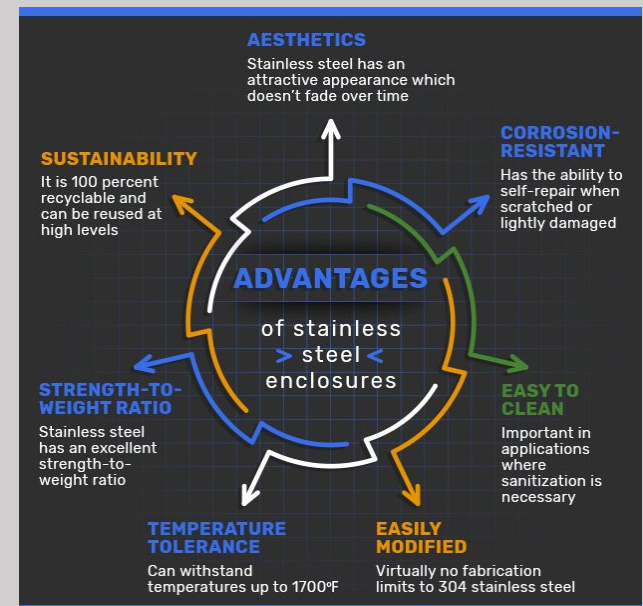
- ¼" thick, 6" by 6" sheet = \$17.26 on McMaster-Carr
- 1/8" diam. Rod, 1 ft long, =\$14.01

Alloy: 316(L) = "medical grade"

- Higher strength than other alloys
- Already used in surgical applications
- Resistance to pitting/chemical corrosion
 - Good in water and saline environments

Cons:

- Not for patients with nickel sensitivity/allergy
- Not 100% corrosion resistant
- "Softer" than bone
 - Mohs hardness of ~4.5, hydroxyapatite is 5



<https://www.polycase.com/techtalk/wp-content/media/xstainless-steel-advantages-graphic.jpg.pagespeed.ic.KehDWQKTWl.jpg>

Titanium – Inner Shaft and Head

Justifications:

- Superior strength to weight ratio than steel
- 100% corrosion resistant
- More flexible than stainless steel & 40% lighter
- Biocompatible
- Moh's hardness of 6 – bone won't scratch it

Alloy Types:

- Ti-6Al-4V
- Ti-6Al-ELV
- Ti-6Al-7Nb
- Cost
 - 1/4" thick, 6"x6" sheet = \$82.28 (Grade 2, on McMaster-Carr)
 - 1/8" diam., 1 ft long rod = \$12.19



<https://titaniumprocessingcenter.com/titanium-technical-data/titanium-strength-to-weight-comparison/>

Aluminum – Outer Shaft

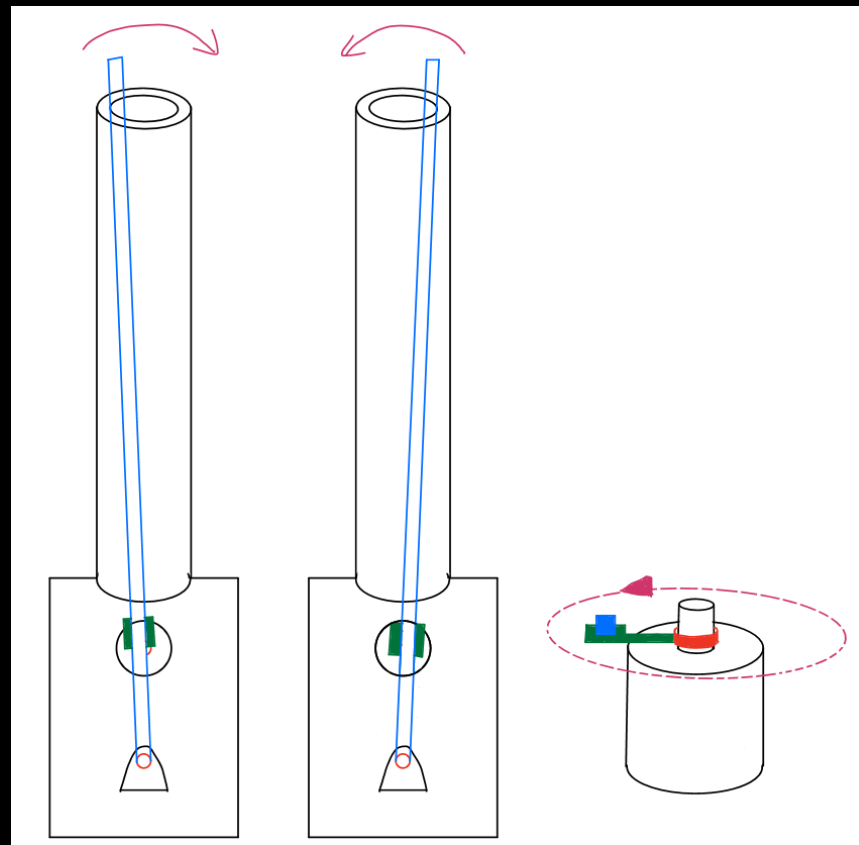
- Justifications:
 - High strength to weight ratio - lightweight
 - Alloy 6061-T6
 - Alloy 7075-T6
 - Commonly used in handles and bodies of surgical instruments
 - High thermal conductivity – good for sterilization
 - Aluminum salts are nontoxic, non-carcinogenic
 - Cheap (1 ft tube of wall thickness 0.035in (0.889mm) 6061 alloy = \$5.89 (McMaster-Carr))
- Cons:
 - Can be corrosive, likely should be coated
 - Precision Coating MICRALOX Ultra & Lumina coatings – Medical Applications

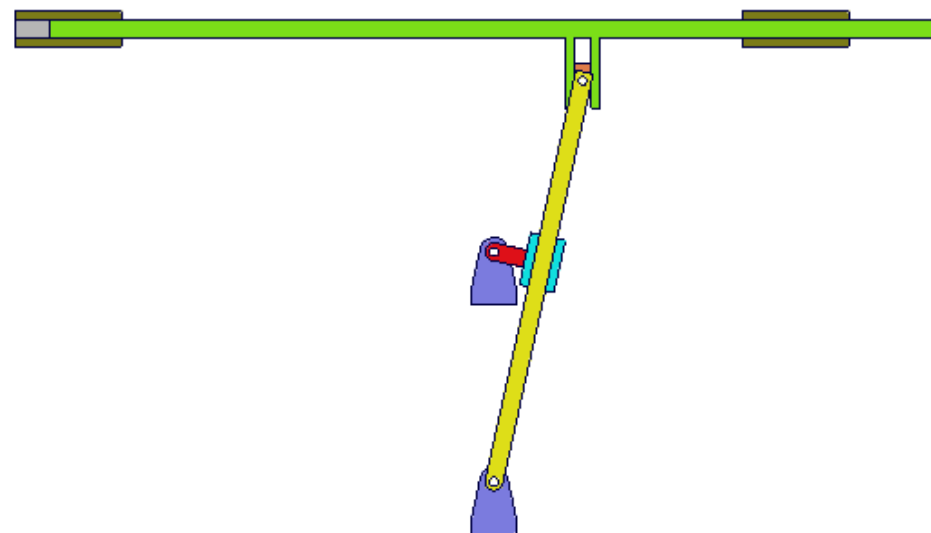
Metal Finishes

- Sandblasting: Abrasive blasting, is the operation of forcibly propelling a stream of abrasive material against a surface under high pressure to roughen a smooth surface
 - Average cost: \$45-65 per hour of labor, \$75 for specialty materials
- Lapping: controlled mechanical sanding or polishing process that involves an abrasive between two surfaces that are rubbed together to create an accurate finish on a part
 - Can be used to create a specific surface roughness
 - Can also be used to obtain a domed surface

Electrical Design Idea #1

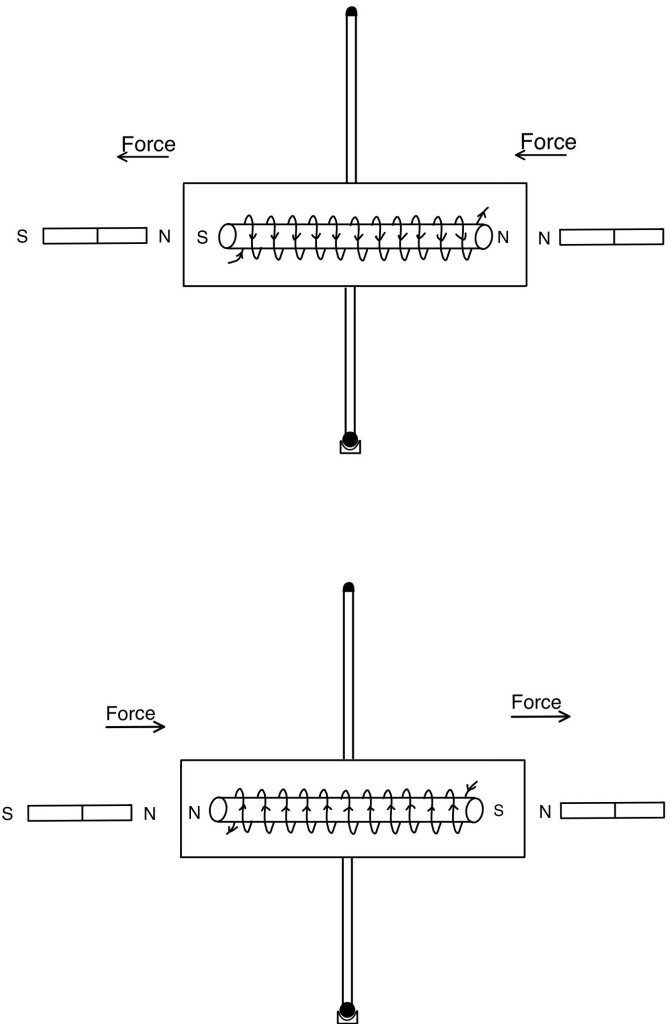
1. Use DC power
2. One end of the shaft is fixed and connected to the motor in the middle part
3. The rotation of the motor will drive the shaft together and cause the shaving head to move horizontally





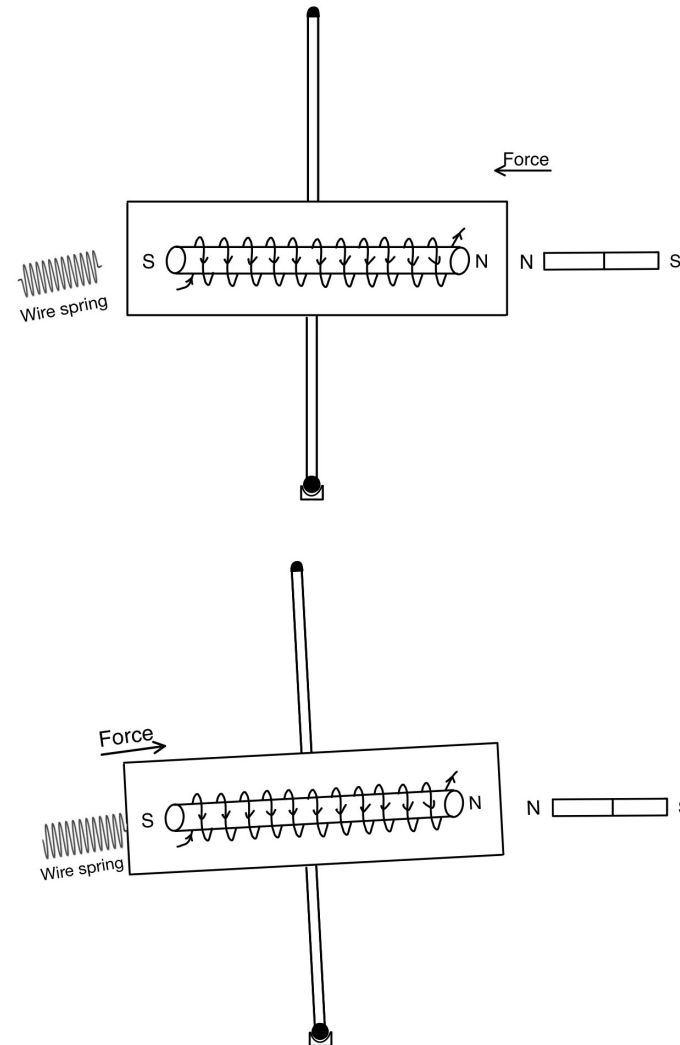
Electrical Design Idea #2

- Vibration is achieved by changing the magnetism of the current solenoid
1. Use AC power
 2. When the direction of the current changes, the direction of the solenoid's magnetic field also changes
 3. Use magnetic force to achieve oscillation of motion (vibration)



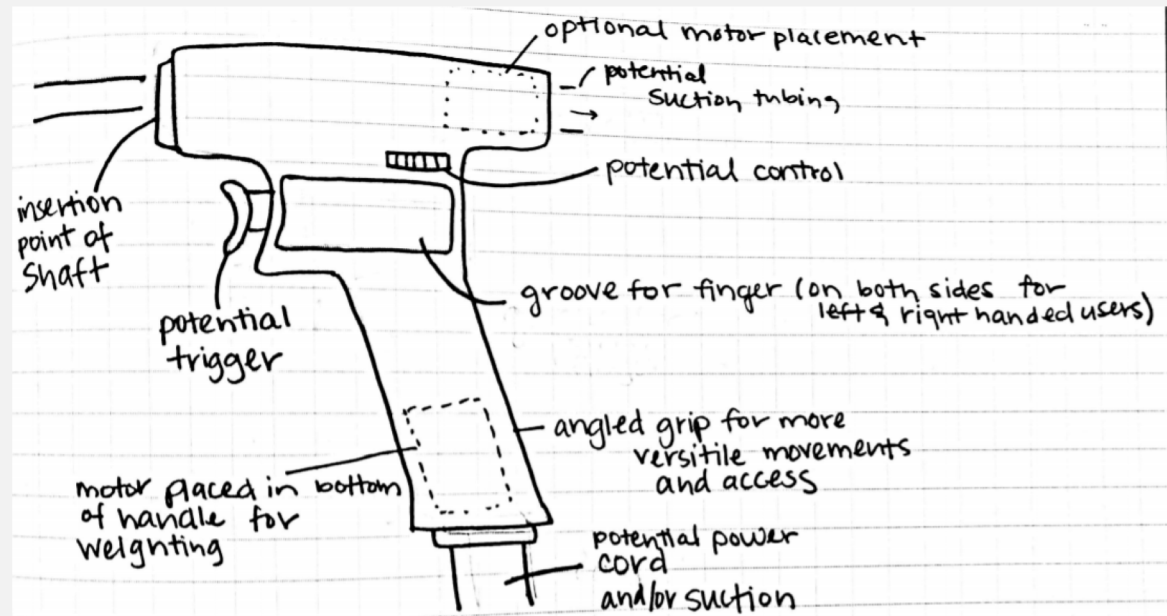
Electrical Design Idea #3

1. Use DC power.
2. When the circuit is switched on, there will be a magnetic repulsive force.
3. When it touches the spring, there is a reactive force.
4. The frequency of each vibration is the frequency of power on and off of the circuit.

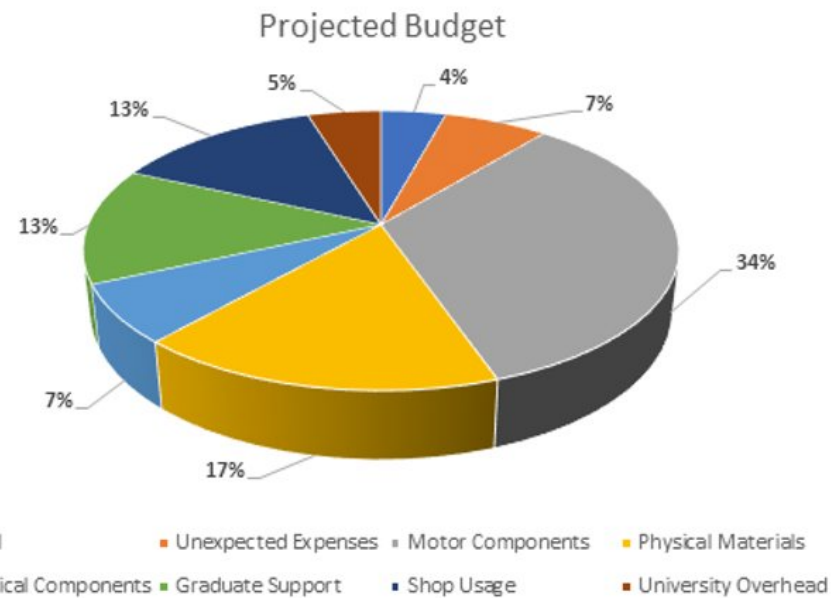


Pistol Grip Design

- Ergonomic and Functional
- Comfortable to hold for long periods of time
- Proper weight distribution



Budget Breakdown



Possible Problems

- Manufacturing issues with small equipment
- Creating a cohesive unit
 - Coordination between various components of the designs
- Gathering and quantifying data
 - Using higher magnification microscope

Next Steps

- Finalize a Design
- Pick Materials
- Contact companies for manufacturing options