

## Senior Capstone Design

Project: **Arthroscopic Bone Shaver**

Primary Author: **Maclean Landis**

Team: **The 1500 Dollar Shave Club**

Date: **10/22/2020**

### Design Validation Plan & Results (DVP&R)

Requirement	Test	Test Subject	Target Date	Result	Recommendation
Motor and servo are able to be activated by pulling the trigger	Ensure all electronics work properly when a toggle switch is pressed	Prototype #1	11/7/20	Toggle switch works to activate circuit and change speeds, but not to shut down circuit	A master toggle switch was inserted to flip the device on and off when desired
Prototype #1 battery life will last for two hours	Ensure that the device can be powered at maximum shaving speed for two hours	Prototype #1	3/15/20	1500 mAh battery will can power the device for 2 hours of intermittent use.	While in a real surgery, the shaver will only be used for short bursts of shaving.
Frequency Output	Ensure that the device has a variable speed output between 900 and 6000 RPM	Prototype #1	11/7/20	By calculation, motor speed is between 4,800 RPM and 11,100 RPM	Utilize a gearbox to alter motor output speed if needed, test motor speed w/ solenoids
New battery must conform to comfortable handle size	Ensure that the battery can be stored securely in handle and that new handle is comfortable.	Prototype #1	11/13/20	1500 mAh battery fits into handle profile of old shaving device	Downsize circuitry or lengthen upper receiver to accomodate all of device electronics
Maximum outer shaft diameter between 4 and 6 mm	Ensure that inner mechanics can achieve orbital sanding motion via the narrow shaft	Prototype #1	2/13/20	The device functioned as intended with a 6.35 mm diameter output shaft	Utilize a final output shaft of diameter = 6.35 or less
Compatible with 100-400 grit shaver heads	Ensure that head design does not have interference with shafts on Solidworks, test with actual components	Prototype #1	4/15/20	The shaving tips created had a higher grit that anticipated.	The aggressive motion of our shaving head requires a smaller grit to obtain adequate results.
Final Prototype battery will last for two hours	Conduct mathematical analysis, Test fully working circuit to battery failure	Final Prototype	4/29/21	The device was able to function for over 1.5 hours throughout testing.	The device will only run for 10-15 seconds periodically throughout a surgery.
Compatible with surgical suction pumps	Model suction pump in solidworks then test for interference in assembly	Final Prototype	4/29/21	Did not incorporate a pump into our design.	Create an opening in the front of the device where a common arthroscopic pump can connect.
Tip can be easily swapped out and sterilized via autoclave	Check that design can be disassembled in 3 minutes; handle casing can be autoclaved	Final Prototype	4/29/21	Final prototype shell can be disassembled quickly with a 2.5 mm hex key.	Having a drill bit for a 2.5 mm hex screw would make assembly/dissassembly faster.
Bone must be shaved	Ensure that the motors are able to overcome friction force to be able to shave bone	Final Prototype	3/4/21	The device was able to smooth out the edge of hole that was drilled in bone.	Our testing indicated that the medium speed was best for shaving bone.
Smooth shaving surface must be achieved	Qualitatively identify smoothness via feel after manual sanding of cartilage and bone vs. device	Final Prototype	3/4/21	High resolution images were taken of our testing results. For a control, we disabled linear	There is no linear actuation if the trigger isn't pulled.
Device must be thermostable	Ensure that circuit does not overheat	Final Prototype	3/4/21	The device didn't overheat after 1 hour of testing.	Device won't run for 2 hours straight during a routine surgery.

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Device must operate reliably under load	Shave cartilage and bone separately to ensure full shaving head articulation for > 1hr	Final Prototype	3/4/21	The device functioned and retained linear actuation after and during testing.	Obtaining better joints for testing would make it easier to test on ligament.
Multiple End Attachments	Making sure that the shaver can have different shaving heads on the output shaft.	Final Prototype	3/4/21	Lucas was able to machine 3 different shaving tips that had 3 levels of grit.	Use a large set screw so it is easier to change the tooltip.
Make device compatible with current Operation Room batteries	Power Device with Currently Used Batteries.	Final Prototype	3/4/21	Only used RC battery throughout prototyping.	Make device have a detachable battery on the bottom of the handle.
Make device able to switch from predetermined motor speeds.	Change speed of motor with buttons	Final Prototype	3/4/21	The potentiometer allows for variable speed.	Must start device on low speed.
Ensure that handle components are durable enough for back-to-back surgeries	Shave bone for > 1hr, disassemble and reassemble handle with new tip (simulate sterilization), and retest	Final Prototype	4/29/20	The device can be taken apart easily and the shell can be disinfected quickly	Having a drill bit for a 2.5 mm hex screw would make assembly/dissassembly faster.