Orthopedic Drill Stop Device

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Client: Tim O'Connor, Orthopedic surgical resident at University of Wisconsin Hospital
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Abstract

Orthopedic surgery relies on the precise motor skills of the surgeon. Currently, surgeons rely on their experience, feel, and auditory feedback to cease the advancement of the drill after passing through the far cortex of the bone. Our team has worked this semester to build an orthopedic drill stop device that will decrease the plunge depth of the bit by removing the variability from the sensory control of the operator.

Motivation and Background

Over penetration of the bone during orthopedic surgery is a significant problem. The current average plunge depth during surgery is approximately 1.5 – 3 cm, which has the potential to injure soft tissue on the opposing side of the bone. Our client, Tim O'Connor is concerned about this problem and is looking for a device that will eliminate plunge depth by removing the dependence on the surgeon's motor skills, the feel of the bone, and the auditory feedback.

Existing Devices

The current device used in most orthopedic surgeries is the drill sleeve seen in Figure 1 below. It ensures the drill bit will be drilled straight into the bone; however, it contains no stopping mechanism. We are going to try to replace this general orthopedic surgery device.
A drill guide used in spinal surgeries is shown in Figure 2. This contains an adjustable inner sleeve that can be preset a specific length prior to surgery. However, it is not able to be adjusted while the drill bit is inside the sleeve, and thus can be very cumbersome to adjust during surgery.
In emergency neurosurgery to release pressure inside the skull, the ACRA-CUT Smart Drill bit in Figure 3 is used. This contains two offset bits and the drill is only allowed to operate when these bits are engaged which occurs when pressure is applied to the inner bit. This concept would not be feasible if scaled down for a very small bit.

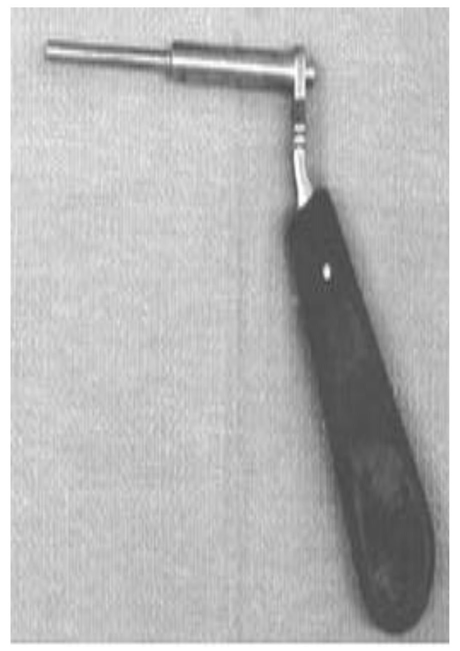

Figure 1 (above): Drill sleeve used in most orthopedic surgeries
Figure 2 (right):Drill guide used in spinal surgeries
Figure 3: (far right): ACRA-CUT Smart Drill bit used in emergency neurosurgery to release pressure inside skull

Client Requirements

- Decrease plunge depth to 1-3mm past the far cortex
- Change depth dynamically while drilling
- Able to be sterilized
- An accessory device that should not affect the drill function
- Withstand force exerted by the drill

Final Design

Prototype Construction
- Designed using Solidworks
- Printed using Dimension Elite 3D Printer (courtesy of UW Rapid Prototyping Consortium)
- Material: acrylonitrile butadiene styrene (ABS)
- Stainless steel drill bit sleeve, springs, and levers

Design Features
- Ergonomic handle and trigger
- Sleek and aesthetic design
- Intuitive design
- Precision depth control (1 mm/trigger pull)
- Depth gauge and markings
- Drill bit stabilization and alignment
- Variable, dynamic depth adjustment (10-50mm)

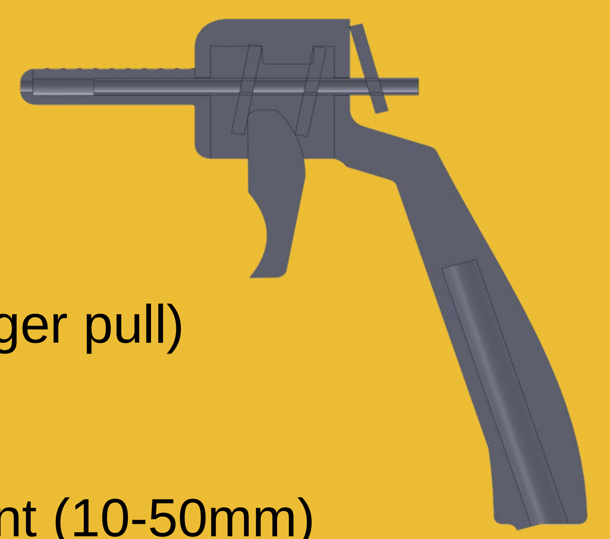

Figure 4: Section view of Design

How It Works - System of three levers and springs
Rear lever – locks position of drill bit sleeve after trigger pull and forward translation of drill bit sleeve, also releases drill bit sleeve to reset depth
Middle lever – locks position of drill bit sleeve when trigger is not activated (resists movement of drill bit sleeve from the force of the drill), activation of trigger disengages locking feature which allows forward translation of drill bit sleeve
Front lever – locks onto drill bit sleeve causing forward translation of the drill bit sleeve when the trigger is activated

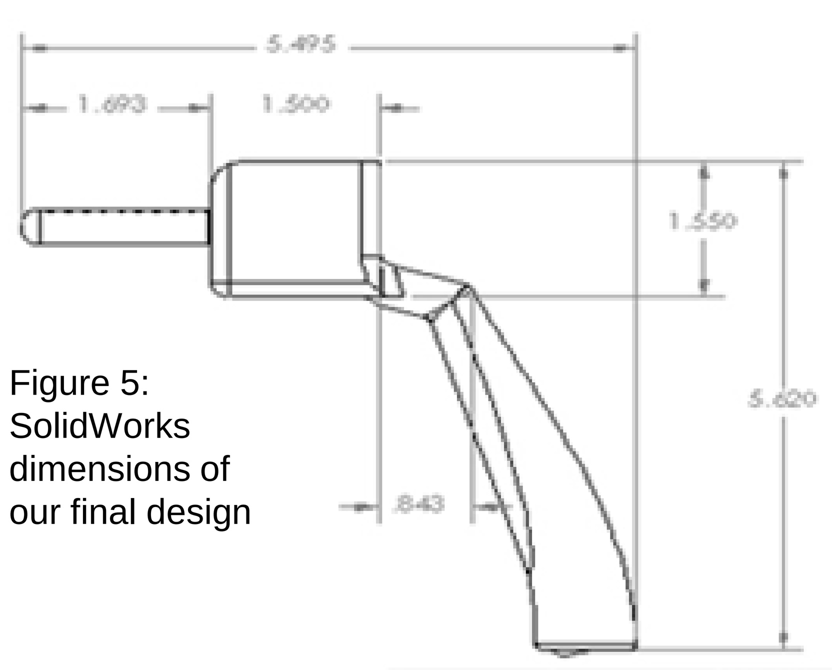

Figure 5: SolidWorks dimensions of our final design

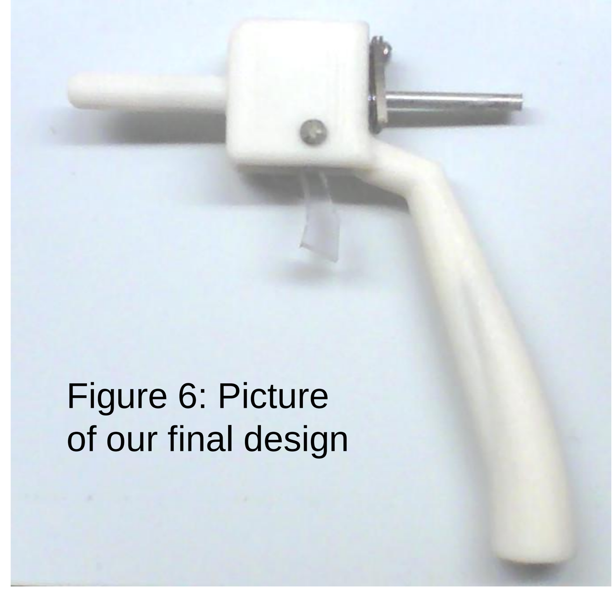

Figure 6: Picture of our final design

Testing

Testing Procedure
- Drilled through a bone and into a piece of foam first just with the drill bit, and then using our device. We drilled into a piece of foam and measured the plunge depth with caliper.

•There was a 91.5% improvement using our device.

Plunge Depth (mm)		
Trial	Without Device	With Device
1	13.36	0.84
2	9.75	1.83
3	9.35	1.5
4	9.88	1.93
5	15.9	0.74
6	14.45	0.69
7	15.47	2.51
8	12.98	0.48
9	7.39	1.68
10	6.6	0.11
Average	**11.513**	**1.231**

Budget

We were given an initial budget of $500, pending grants.
- McMaster Carr (spring, tubing, polycarbonate sheet) = $86.35
- Online Metals (tubing) = $16.86

*Special thanks to: UW Biomedical Engineering Department, Wisconsin Institute of Discovery, and Wisconsin Institute of Medical Research for funding the 3D prints of our plastic housing.

Future Work

- Testing – compatibility with the drill, ergonomic and ease of use for the user, plunging results, force testing of design
- Device improvements – making it more compact, usable by different drill bit sizes, adjustable initial depth, detents
- Fabricate design of medical grade materials capable of multiple uses and sterilization
- Apply to WARF for patent

Acknowledgements

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