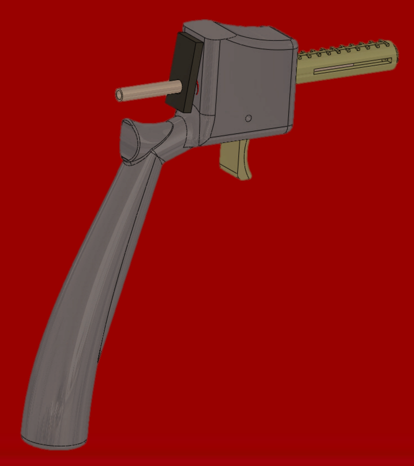

Orthopedic Drill Stop Device

Alex Bloomquist, Kara Murphy, Andy LaCroix, and Graham Bousley
Client: Tim O'Connor, Orthopedic surgical resident at University of Wisconsin Hospital
Advisor: Professor Naomi Chesler, Department of Biomedical Engineering

Motivation and Background

Orthopedic surgeons drilling through bone tend to over-penetrate the far cortex with plunge depths up to 3 cm. This is dangerous because in some cases soft tissue on the opposing side of the bone is injured since it cannot be seen by the surgeon.

Currently, there is no stopping mechanism to prevent over-penetration of the bone. The surgeon relies on experience, the feel of force applied from the bone, and auditory feedback to determine when the drill bit has cleared the opposing side of the bone.

Our client, Dr. Tim O'Connor has recognized this problem and asked our team to create a device that will eliminate errors due to plunge depth. Thus, this semester our team has worked on improving our dynamic drill advancement guide.

Existing Devices

Currently, the bi-cortical drilling procedure for most orthopedic surgeries requires two devices, a drill sleeve and a depth gauge. The drill sleeve, seen in Figure 1 below, is used to ensure that the drill bit is drilled straight into the bone. However, it provides no stopping mechanism to prevent over-penetration of the far cortex of the bone. The depth gauge, seen in Figure 2 below, is then used to measure the length of the drilled hole to determine what size screw to place in the bone. This device contains a very small hook which must snag the opposing side of the bone to get a measurement. This can be a difficult device to use, especially if the hole is drilled at an angle.

A pre-determined drill stop, seen in Figure 3, is used in spinal surgeries. This device contains an adjustable inner sleeve that can be preset and act as a stopping mechanism at a specific depth. 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.

Figure 1 (Far Left): Drill sleeve [$175]

Figure 2 (Left): Depth gauge [$267]

Figure 3 (Right): Drill stop

Client Requirements

- Decrease plunge depth to less than 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
- Aesthetic, ergonomic and intuitive design
- Depth gauge and markings
- Drill bit stabilization and alignment
- Precision depth control (1 mm/trigger pull)
- Variable, dynamic depth adjustment (10-50mm)
- Slits to release bone accumulation
- New trigger design to prevent sliding of tube
- Lock on inner tube to prevent disassembly upon reset

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

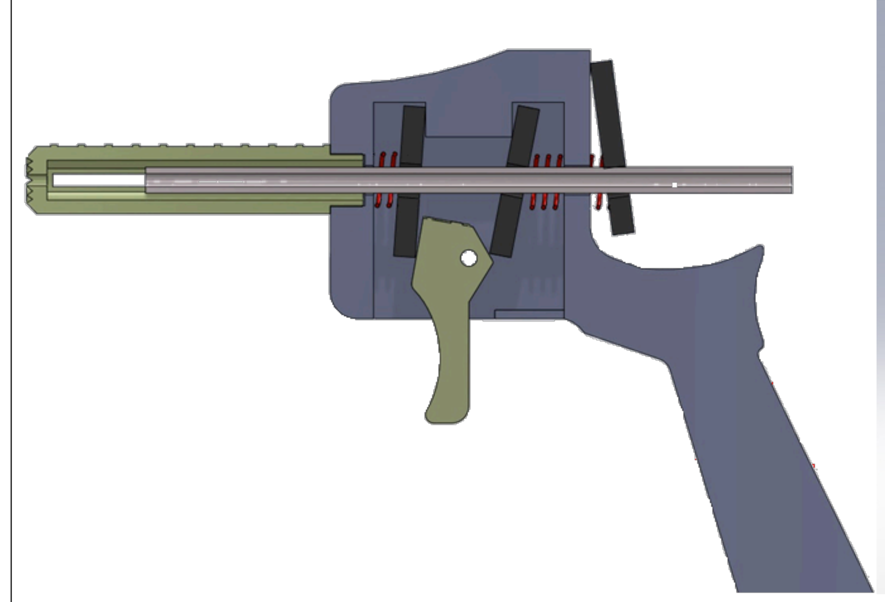

Figure 4: Mechanism of assembled device.

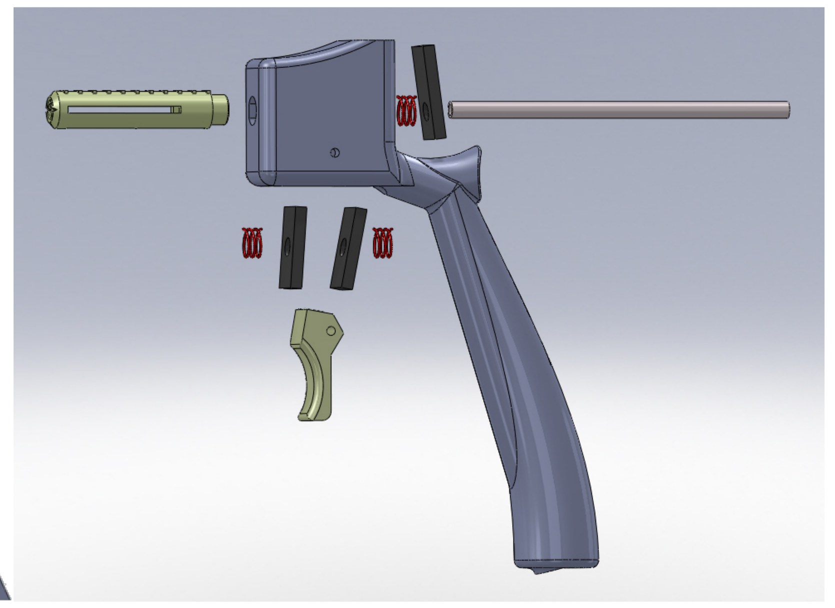

Figure 5: Components of the final device.

Testing

Set up: Cut off a slice of a block of foam 5mm deep and place a piece of aluminum foil to indicate the threshold. Strap a fresh pig bone on the block of foam in a secure wood frame.

Procedure: Each tester drilled three holes in the bone using the current drill sleeve and measuring device, then three holes using our device clearing the bone but attempting to not plunge past the 5mm threshold. Once drilling was complete, the bone was removed and the foil was used to determine if the threshold was passed. Test only timed for the expert tester (saw decrease in drill time using the our device).

NOVICE TESTERS		
Trail	Current device Pass Threshold (Y/N)	Our Device Pass Threshold (Y/N)
1	Y	N
2	Y	Y
3	Y	N
4	Y	Y
5	Y	N
6	Y	N
7	Y	N
8	Y	N
9	Y	N
10	Y	N
11	Y	N

Table 1: Novice test results. Yellow indicates the threshold was plunged.

Results: On April 21, 2011, four novices and one expert completed testing. Among novice users there was an 82% improvement when our device was used as seen when analyzing the plunge depth test results in Table 1. The expert results suggest a decrease in time of the procedure; however, not enough expert subjects were tested at this time.

Budget

Material costs of production: ~ $35/unit
Includes: housing, springs, clutches, trigger, tube

Future Work

Continue testing and widening our base of test subjects to include residents and surgeons. More accurately assess time improvement. Improve longevity of device.

Acknowledgements

Client – Tim O'Connor
Advisor – Professor Naomi Chesler
Mechanical design consultant – Professor Frank Fronczak
Last Semester Contributions: Jon Mantes & Professor Tompkins

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