# Self-measuring Drill Stop Device

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## Introduction

Often when a bone is severely fractured a hard cast is not enough to keep it in place throughout the healing process. For this reason, screws or plates and screws must be inserted into the bone to hold it in place during healing. To insert these screws, the surgeon must drill into the bone with a surgical hand-held drill and drill bit. Once the hole's depth has been measured, the plate can be placed and the screws inserted through the drilled holes. These screws come in 2mm increments and using the correct size screw is extremely important in the healing process.

Figure 1: X-ray of radius and ulna with screws used in orthopedic surgeries

## Background

The surgeon drills through the bone carefully as not to break through the opposite side of the bone too quickly, which leads to trauma. This action is known as plunging. Once the hole is drilled, the depth of the hole must be measured using a depth gauge (Figure 3). This process takes approximately 45 seconds per hole.

A device is desired that will accomplish two tasks. Firstly, the device must measure the depth of the hole so the proper size of screw can be selected for insertion. Secondly, the amount of plunge must be minimized. Reduction of the plunge distance will both decrease unnecessary trauma and increase the accuracy of the bone width measurement. This device will reduce surgical time and pain for the patient, saving the patient and hospital both time and money.

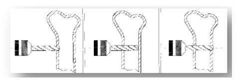

Figure 2: A diagram representing the different positions of the drill during surgery.

Figure 3: The depth gauge. Elimination of the need for this tool will save the orthopedic surgeon time during most of his surgeries.

**Motivation:** Eliminate the need for a depth gauge in orthopedic surgeries

## Final Design

**Orthopedic Drill Design Criteria**

- Accurate depth measurement (<1 mm)
- Reduce plunging
- Must not obstruct surgeon's vision
- Must cost under $1000 to produce
- Integration into current surgical instruments
- Autoclavable, non toxic, corrosion resistant

### Hydraulic Drill Stop

Materials: ABS, hard plastic zip-tie, rubber valves , viscous fluid

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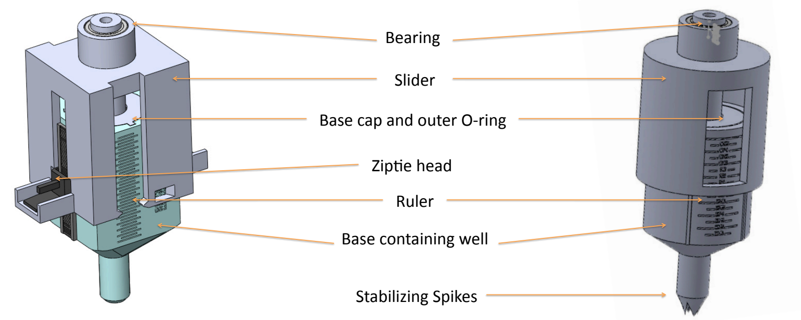


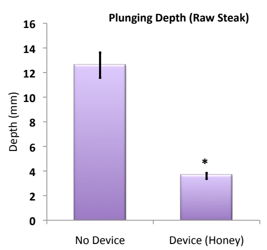

Figure 4. Prototype Drill-Stop The chuck of the drill engages the slider at the bearing (top). When incipient plunging occurs, the increased acceleration of the slider is negated by the force produced by the fluid in the chamber and reduces advancement of the drill. There is an external locking mechanism which prevents reverse motion. This and one-way valves allow prompt retraction of the slider so the measurement can be recorded and devices can be reused quickly and efficiently in time-sensitive surgeries.

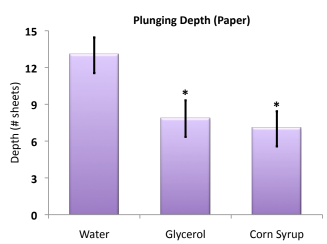
Figure 5. Final Hydraulic Slider A circular design was adopted to reduce the visual hindrance of the device during surgery. Additionally, the design minimizes the cost of production in accordance with stainless steel manufacturing techniques. Stabilizing spikes were added to introduce purchase between the device and the bone. The locking mechanism for the slider was internalized.

## Testing

The initial testing procedure was designed to indicate a suitable hydraulic fluid for the final iteration of the hydraulic slider. The primary candidates considered were glycerol (viscosity = 1200 cP) and corn syrup (2500 cP). The experimental control consisted of filling the device with water (0.9 cP). Standard stock paper was used as the measurement medium. Although this material does not accurately represent soft tissue, emulation of the material was not necessary for determining the appropriate fluid. Additionally, the testing protocol was kept consistent, which implies that the differences shown below are correlational to a surgical setting. The user was blinded to the material and initial tests were thrown out to accommodate user adaptation to plunge "feel". Glycerol was chosen as a suitable hydraulic liquid for the device.

After deciding on a fluid, subsequent testing was performed to more accurately detect the effect of the device in a surgical setting. The measurement medium was changed to a gelatin matrix (0.34g/mL or 1.5oz/cup). The change to gelatin was made to more accurately represent the density of post-cortical soft tissue. Tests were conducted with no device, device attached but empty, and the device loaded with glycerol. Testing with an empty device was performed to detect the device's tendency to impair the user's 'feel' for the plunge.



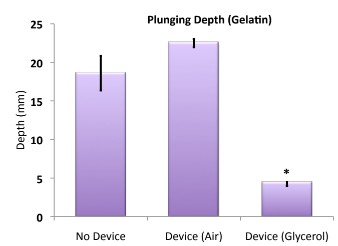




Figure 6: (Left) Initial testing with a previous iteration of the device. Raw beef steak was used as a measurement medium (n=20).

Figure 7: (Right) Testing with the device and a paper measurement medium. Three liquids, water(0.8cP), glycerol (1200cP), and corn syrup (2500cP) were tested. Statistics tests (n=20) showed a significant drop in plunge depth with the use of glycerol (p = .048) and corn syrup (p=.042). Additionally, there is no significant difference among the use of the two viscous fluids (p=0.69).

Figure 8: (Above) Testing of glycerol and controls on a gelatin medium. Testing showed the empty device acting as a hindrance to the user, decreasing the ability to guess when plunge was imminent. Once glycerol is loaded, however, this point is moot as breaking the bone/tissue barrier is readily perceptible. Glycerol was shown to significantly lower plunging over an empty device (n=20, $p = 1 \times 10^{-15}$) and device absence (n=20, p = .0001).

## Conclusion

- ✓ Reduced plunging > 4 fold
- ✓ Accurate hole measurements
- ✘ Physician testing
- ✓ Determined optimal hydraulic fluid
- ✓ Characterized hydraulic fluid
- ✘ Stainless steel prototype

We have constructed a functional hydraulic drill stop prototype which both reduces plunging and accurately measures drilling depth. The device utilizes a bio-inert, viscous fluid; when it was tested with a novice user (minimal orthopedic experience), plunging was significantly reduced. This reduction will lead to an accuracy measurement of 1mm resolution. When the final prototype is fabricated and this is confirmed, the hydraulic drill stop device will be marketed to a variety of orthopedic companies

## Future

**Immediate Future**

- Apply for additional grant
- Submit IDR to WARF
- Fabricate stainless steel prototype

**Future Semester**

- Test measuring mechanism to status quo
- Have UW physicians test device
- Market hydraulic drill stop to companies

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