Orthopedic Suction Tip Unclogging Device
Alicia Auduong, Janice Chung, Cole Thomson, Jeffrey Zhang
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Abstract
In orthopedic surgery, suction devices often become clogged by small bone fragments at the tip, reducing suction power or blocking suction altogether. The process of unclogging stalls the surgery, increases the risk of patient infection, and breaks the surgeon’s concentration.

For this project, our group developed a device that effectively resolves the issue of clogged suction tips. Our design concept is an external device that complements the suction device and provides a simple unclogging method. The prototype of this concept proved to be an efficient solution for the problem and can be easily adapted into surgery kits.

Need Specifications
- Unclog effectively
  - removing debris 70% of the time is acceptable, while 90% is ideal
  - Unclog quickly
    - <1min acceptable, <15 sec ideal
- Patient Safety
  - device does not break nor have potential to injure patient while operation takes place
- Maneuverability
  - easy control of device
  - does not impede process of surgery

Primary Concept Realization
Analysis of Concept 1 and 2:
- inhibited maneuverability
- risked patient safety
- failed to reduce unclogging time significantly

Figure 2. The first realization of the peripheral concept, an array of cone-shaped spikes.

Analysis of Concept 3:
- Compatible with all suction tip sizes
- One piece with an adhesive on the bottom

We decided this design was not ideal as we found that getting the tip onto the spikes was unnecessarily difficult.

Figure 3. The final design of our selected concept (Units in millimeters).
We chose a single spike of the same dimensions as our array bristles, with the same base and an additional funnel.

The funnel model:
- Effectively guides the suction tip to the spike
- Guarantees no misses
- Reduces unclogging time and the amount of concentration the doctor requires to unclog

Figure 4. To make a biological debris substitute for testing, (A) we added three parts corn syrup to one part water and flour. (B) We added red dye to complete the effect. (C) Then, we added one part sand per two parts of our blood substitute and (D) chicken bone fragments with an average size of 5mm, ending up with a grainy solution.

Conclusion
After we finished our mixture, we proceeded to simulate suction and clogging with various yankauers. When the yankauers clogged, we timed the unclogging with the bovie and then with our prototype.

Methods and Testing (cont.)

Figure 5. Our testers attempting to clog a suction tip.

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Results
Seven successive unclogging trials with a representative yankauer and biological debris substitute are displayed above.

Our device provided significant improvement.

Conclusions/ Future Work
Our device serves as a versatile accessory for various types of suction tips and offers a reliable unclogging solution that reduces the time and concentration needed.

With more time, the next step would be to target clogs at the junction points. Since clogging occurs most often at suction tips, we considered the junction points as being of secondary priority.

Methods and Testing

Competitor Analysis

Figure 1. Other solutions.
(A) Super Sucker
  - Suction device with removable filter
  - Clogs in 71% of cases, taking 3.9 minutes to unclog [5]
(B) Yankauer
  - Basic suction tip, doesn’t have a filter
  - Clogs in 47% of cases, taking 2.6 minutes to unclog [5]
  - surgeons commonly use the bovie (C - an electrical cautering tool) to unclog
(C) Carbon Dioxide Unclogger
  - Uses CO₂ to remove clogs from tip, 100% effective [5]
  - Most complicated and expensive technology by far

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One of every two adults, or 110 million, in the U.S. reported a musculoskeletal condition in 2008, costing the nation $849 billion [2]. Orthopedic surgeries specifically target the hip, allowing many to walk or regain movement in their legs. They include procedures such as fusion (the use of bone grafts to meld and heal bone), osteotomy (cutting and replacing bone), and joint replacement (the use of prosthetic in place of a joint) [1].

During surgeries such as bone replacements, blood and debris (biological and surgical) coagulate and obscure the view of the surgeon. This debris must be removed with suction devices. However, these devices clog frequently; 90% of the time at the tip and 10% at the junction points between the device and the tubing that connects it to the vacuum [3]. When clogs occur, the surgeon must interrupt the surgery to unclog the suction tip, stalling the surgery and increasing the patient’s risk of infection.

Introduction

Need Statement

A way to minimize unclogging time of orthopedic suction tips to reduce surgeon inconvenience and orthopedic surgery time.

References

2. Steven T. Woolson, M.D., Veteran’s Hospital, Palo Alto, CA

Initial Concepts

1. Integrated Tip Dislodger - Tip contains mechanism to dislodge clogging substance at tip and is modelled after yankauer tip.
2. Filter Changer - Device filter can be quickly changed after yankauer tip.
3. Peripheral Device- Extra device used to unclog suction tip. Modelled after bovie unclogging method.

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Results

Figure 6. Simulation results.
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