Dead-Blow Hammer for Orthopedics

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Presentation Overview

I. Problem Statement
II. What is a Dead Blow Hammer?
III. Broader Impact
IV. Previous Work
V. Upcoming Plans
VI. Other Considerations

Problem Statement

- Orthopaedic surgeries involving joint replacement take a lot of force to perform effectively
- Want to find a way to…
  - Limit blowback from the hammer when striking the target
  - Increase the amount of force generated by a single strike with the same swing velocity

Figure 1: Coronal (left) and sagittal (right) views of a knee replacement [1].

Dead Blow Hammer

- Primarily used in the construction industry
  - Minimize damage to the struck surface
  - Allow one to help control their striking force
  - Produce minimal rebound comparatively
- **Important Criteria:**
  - Approximately 2 pounds
  - Exert 30 kN of force
  - Withstand 40 kN of force
  - Withstand the autoclave sterilization process (121℃) [4]
  - FDA rule set by Code of Federal Regulations Title 21, Sec. 878.4800 [5]

Figure 2: Dead-blow hammer for construction and manufacturing (top) [2] and orthopedic mallet (bottom) [3].

Broader Impact/Competing Designs

Broader Impact

- Make orthopedic surgeries more efficient and less strenuous
- Increase the longevity of the orthopedic surgeons themselves
- Give people a variety of options when it comes to their health and well being

Competing Designs

- Several foreign patents exist currently
- None are very alarming in terms of similarity
- Not utilized effectively in the medical industry as of right now

Previous Work

Final Design

- Components:
  - Chamber with one threaded hole
  - One threaded end cap
  - One pressed end cap
  - Pressed handle
- Materials:
  - 304 Stainless Steel
  - Compare to 316L Stainless Steel

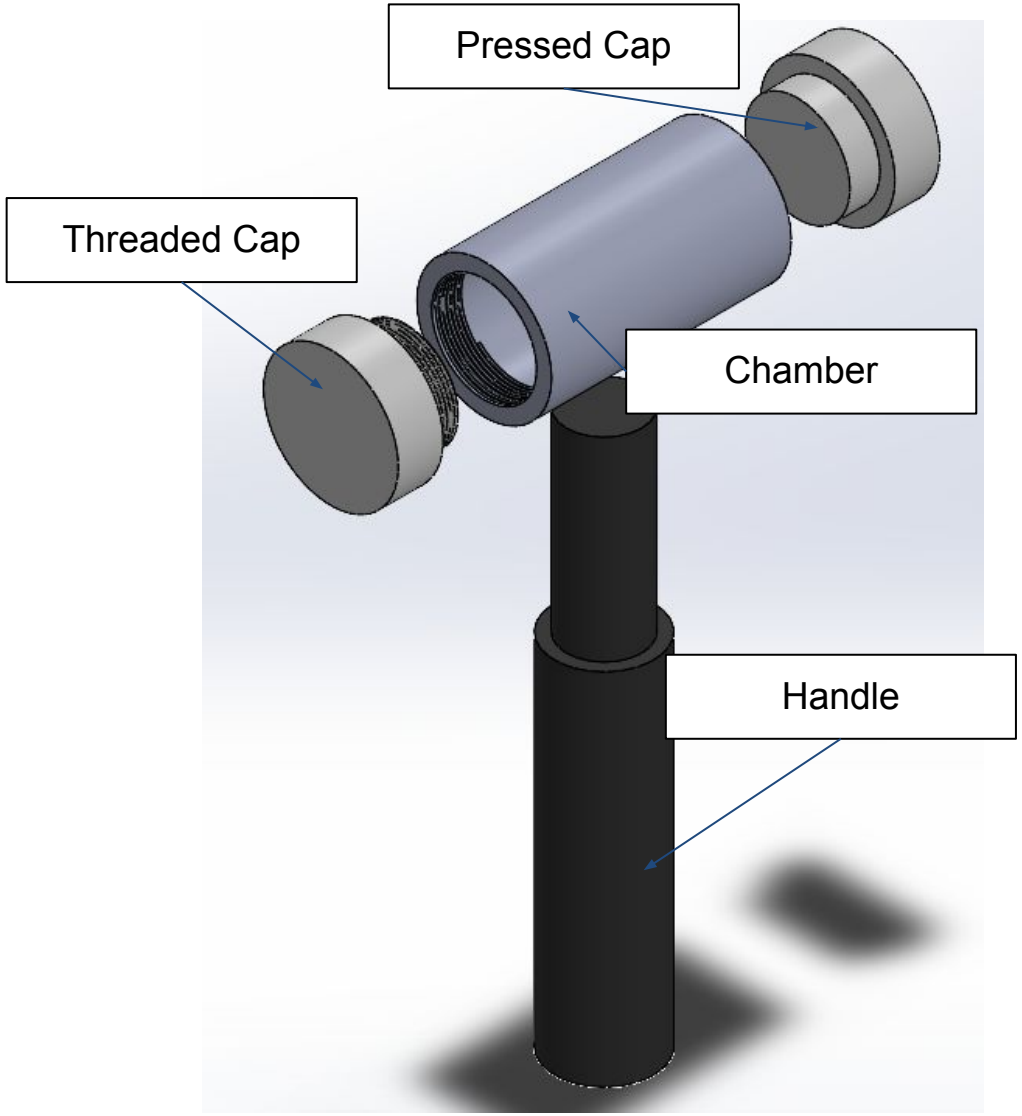

Figure 3: Solidworks Design for final mallet

Preliminary Results

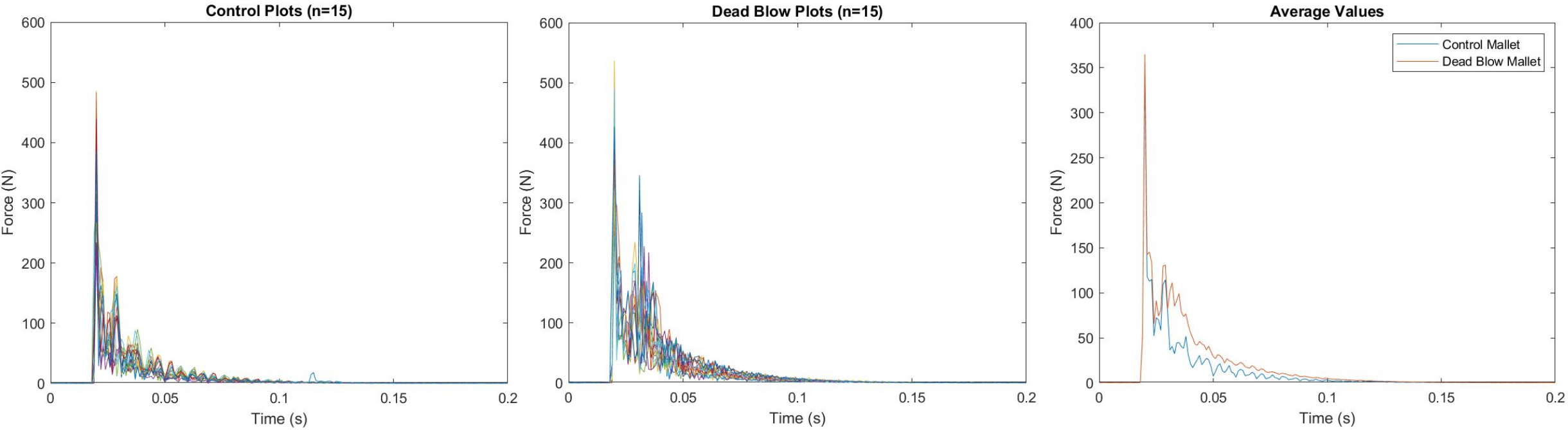

Figure 4: (a) Impact curve of 15 strikes with the PLA control mallet. (b) Impact curve of 15 strikes with the PLA dead-blow mallet. (c) Impact peak of the average values for the two testing conditions at each time point

Lessons Learned

- Fabrication
  - Stainless steel is very difficult to fabricate - Outsourcing Fabrication
  - Threads may add extra unnecessary costs (for prototype validation)
  - Use of spanner wrench
- Materials
  - 316L stainless steel is particularly expensive, 304 stainless is similar in properties
  - Galling occurs with stainless on stainless contact (Anti-Seize)
- Testing
  - The force plates do not withstand the max force of a swing
    - Requires creative solutions

Upcoming Plans

Semester Overview

- Order parts and materials for our design (Feb. 16)
- Ship out to a fabricating company of our choice (Feb. 23)
- Begin drawing up and finalize intricate testing protocols (March 1)
- When our design is fabricated
  - Conduct testing with proper protocols (March 15)
  - Make conclusion(s) based on those results
  - Retest if needed (April 1)

Fabrication

- Cost of fabricating original design was too much
- Changes must be implemented to reduce the cost
  - Weld the shaft and the head together; creating one piece
  - Decrease the thread length on the screws of the caps
  - Buy our own materials and ship it out to the fabricator
- Rough Cost Estimate:
  - Original: $1400 -$1500
  - New Model: $300 - $400
- Physical Sciences Lab (PSL)

Testing

- Retest using force plate
  - IF allowed (talk with Dr.Willie)
- Change percentage of beads to find maximum effect
  - Literature states 75-85%
- Compare impulse peaks with different percentage of beads

Other Considerations

Budget

- Flexible budget
- Next prototype less than $500
  - Projected cost from Team Lab - about $300
- Continue to check in with Dr. Wollaeger with quotes

Table 1: Budget for the remainder of the semester. Note the 20% contingency added to the total.

Name	Class	Description	Cost
Round Steel (304) - Caps	Material	McMaster-Carr	$47.16
Round Steel (304) - Handle	Material	McMaster-Carr	$24.98
Tube Steel (304) - Chamber	Material	Speedy Metals	$24.93
Higher Pressure Anti-Seize	Material	McMaster-Carr	$14.82
PSL Costs	Fabrication	Best estimate to date	$200.00
Contingency	Misc.	20% contingency	$62.38
		Total	**$374.27**

Packaging/Documentation

- How this will be packaged is still unknown
- Will include a safety manual
  - Safety information regarding the metal beads
  - What do do if anything breaks before/during/after use
  - Storage information and estimated duration of the product

References

[1] “Knee Replacement” *Mayo Clinic.* [Online]. Available at: <https://www.mayoclinic.org/tests-procedures/knee-replacement/about/pac-20385276> [Accessed 10 Oct. 2021].

[2] “Bon Tool 4 lbs. Dead Blow Hammer” *The Home Depot.* [Online]. Available at: <https://www.homedepot.com/p/reviews/Bon-Tool-4-lbs-Dead-Blow-Hammer-21-144/302568545/1> [Accessed 10 Oct. 2021].

[3] “Bone Mallet” *Integralife.* [Online]. Available at: <https://www.integralife.com/bone-mallet/product/surgical-instruments-hospitals-surgery-centers-tissue-banks-jarit-orthopedic-mallets-bone-mallet> [Accessed 10 Oct. 2021].

[4] “Autoclave Use.” *Princeton.* [Online]. Available at: <https://ehs.princeton.edu/book/export/html/380> [Accessed 23 Sept. 2021].

[5] Accessdata.fda.gov. 2021. *CFR - Code Of Federal Regulations Title 21*. [Online] Available at: <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=878.4800> [Accessed 24 Sept. 2021].

Questions?