Powered Acetabular Cup Extractor

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Johns Hopkins University | Mechanical Engineering Senior Design 2026 | Sponsor: Shukla Medical

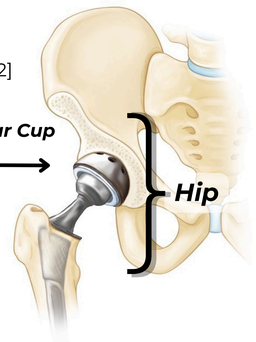
Background

Relevance

- 9% of people have hip replacement [1]
- 15% of them will have to be removed [2]

Problem

- Bone grows into cup
- The cup is hard to remove
- Manual extraction instruments are diffuclt to use and require great skill



Key Requirements

Cup Removal Time
< 5 minute removal time
Time = blood loss & higher infection rates

Battery Powered
20V rechargeable battery

Biocompatible
and sterilizable materials

Excess Bone Loss
Less than 7.2 ml bone loss outside of kerf of cut

Safety Features
Sensors and E-stop button

Ergonomic
Usable with 2 hands, < 30 lbs

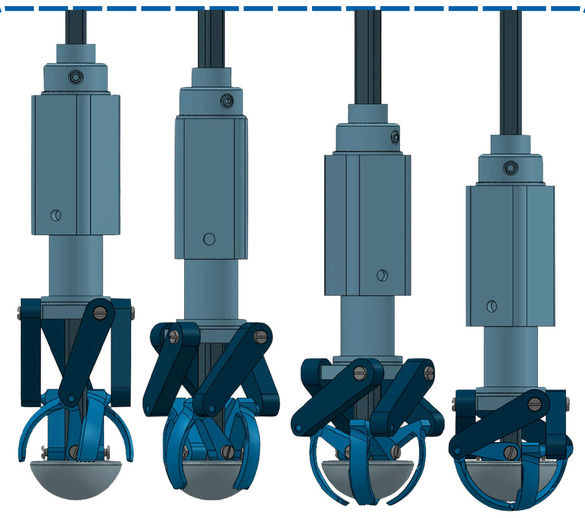
Design

Centering Bob
Keeps device seated in cup and aligned

Drill Attachment
Device is detachable from drill by hand

Blades

- *4* blades for stability
- 2 **toothed blades** cut bone
- 2 **smooth blades** excavate bone fragments
- Designed to withstand **16 Nm** of continuous torque



The centering bob is pressed firmly into the acetabular cup. The device turns on, spinning the central shaft and blades. The blades are manually advanced via the square-profile grip.

Internal Electronics

- *ESP32-S3 microcontroller*
- *Current sensor*
- *9-Axis IMU*
- *SD card breakout for data logging*

Battery
20V
5Ah

Power Management

- Rechargeable battery
- Battery life of 120 min at continuous 2Nm torque

Testing & Results

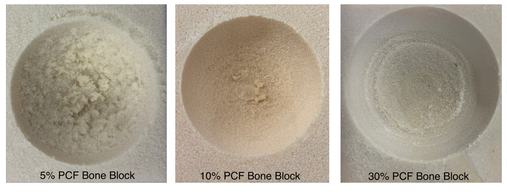
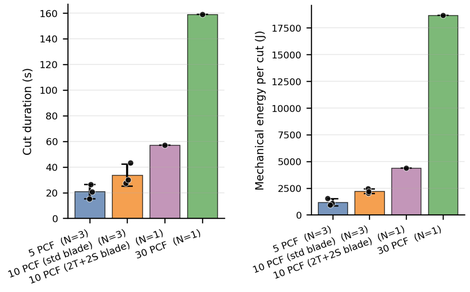


Figure 1: Surface finish in commonly found bone densities after the acetabular cup is removed.

Figure 2: The mean cut duration and mechanical energy of each cut increased with bone density



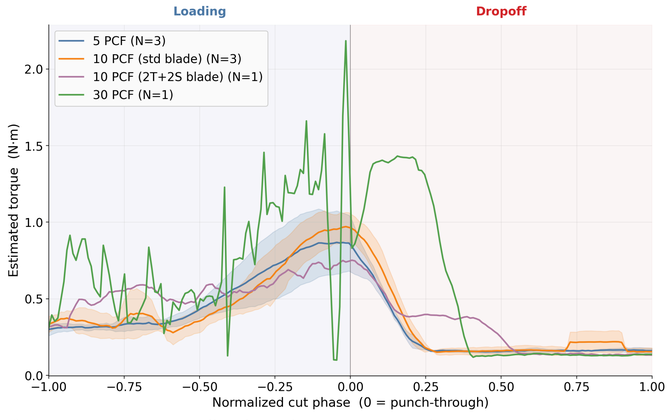


Figure 3: Mean, normalized cutting torque vs. phase across bone densities. Peak torque 2.3 Nm; nominal torque 0.5–1.0 Nm, **supporting device power requirements.**

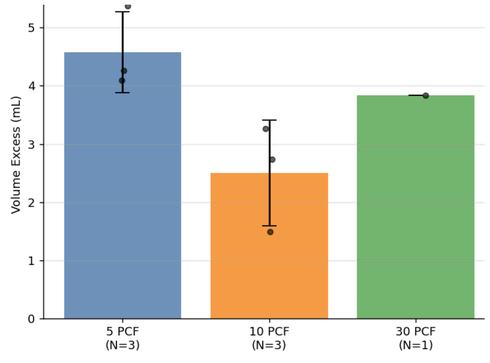


Figure 4: The mean excess bone loss (bone loss volume outside kerf of cut) at each density was well **under the upper bound of acceptable excess bone loss.**

Future Work

- Electronics: biocompatible, sterilizable housing and geometry
- Trained classifier for auto safety stop
- Fast OR assembly
- Shukla product line compatibility

Acknowledgements

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[1] Ackerman, I. N., Bohensky, M. A., de Steiger, R., Brand, C. A., Eskelinen, A., Fenstad, A. M., ... Garellick, G. (2017). Lifetime risk of primary total hip replacement surgery for osteoarthritis from 2003 to 2013: A multinational analysis using national registry data. Arthritis Care & Research, 69(11), 1659–1665. https://doi.org/10.1002/acr.23197
[2] Bozic, K. J., Kurtz, S. M., Lau, E., Ong, K., Vail, T. P., & Berry, D. J. (2009). The epidemiology of revision total hip arthroplasty in the United States. The Journal of Arthroplasty, 24(6 Suppl), 86–93. https://doi.org/10.1016/j.arth.2009.05.032
[3] American Academy of Orthopaedic Surgeons. (n.d.). Osteoarthritis of the hip. Retrieved April 22, 2026, from https://orthoinfo.aaos.org/en/diseases--conditions/osteoarthritis-of-the-hip/