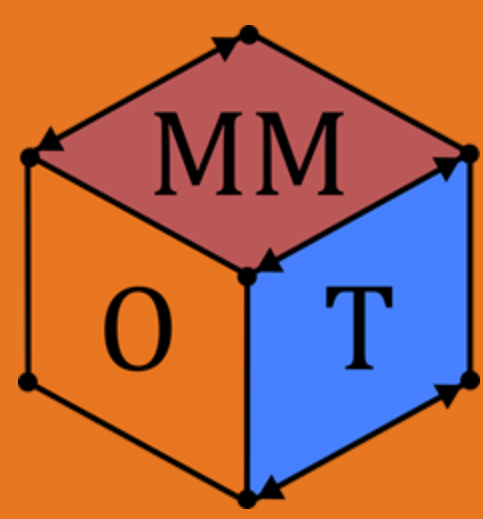




Mechanics and Modeling
of Orthopaedic Tissues
Laboratory

The Design of a Bioinspired Impact Mitigation System Towards the Prevention of Brain Injuries

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Introduction

- Chronic traumatic encephalopathy (CTE) causes progressive dementia due to repeated impacts to the head [1]
- Male Bighorn Sheep (Fig. 1) ram, yet show limited brain injury [2]
- Computational modeling studies have shown medial-lateral horn tip oscillations reduce brain cavity accelerations (Fig. 2) [3,4]
- Our **long term goal is to design horn-like oscillators for safety applications using dynamics finite element models**



Figure 1. Male bighorn sheep ramming

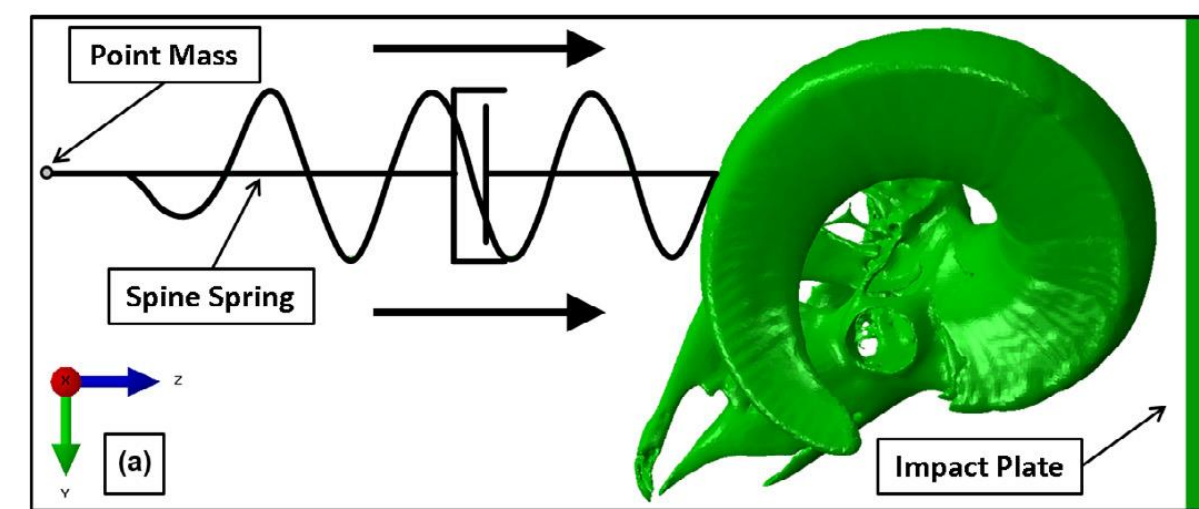


Figure 2. Finite element model of bighorn sheep ramming [3]

Goal: Develop a coupled experimental-computational system for the purpose of testing different horn-like oscillators.

Methods

- Drop-test system: silicone horn-like oscillator and acceleration, force, and displacement measurements (Figs. 3 and 4)
- Associated dynamic finite element models of system developed in Abaqus (Fig. 5)
- Models were calibrated to experimental data using acceleration data, and validated using horn-tip displacement data

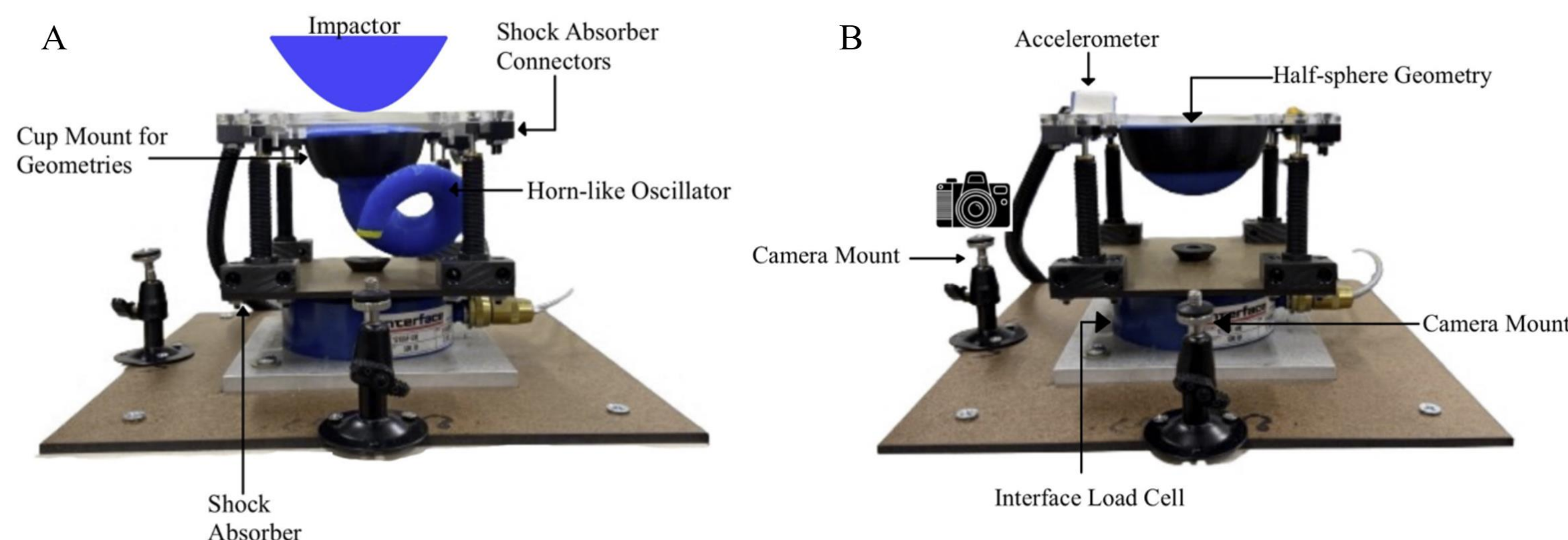


Figure 3. Experimental impactor system, with shock absorbers, instrumented load cell, one-axis accelerometer, and cameras. A) Impactor system with horn-like oscillator. B) Impactor system with control half sphere.

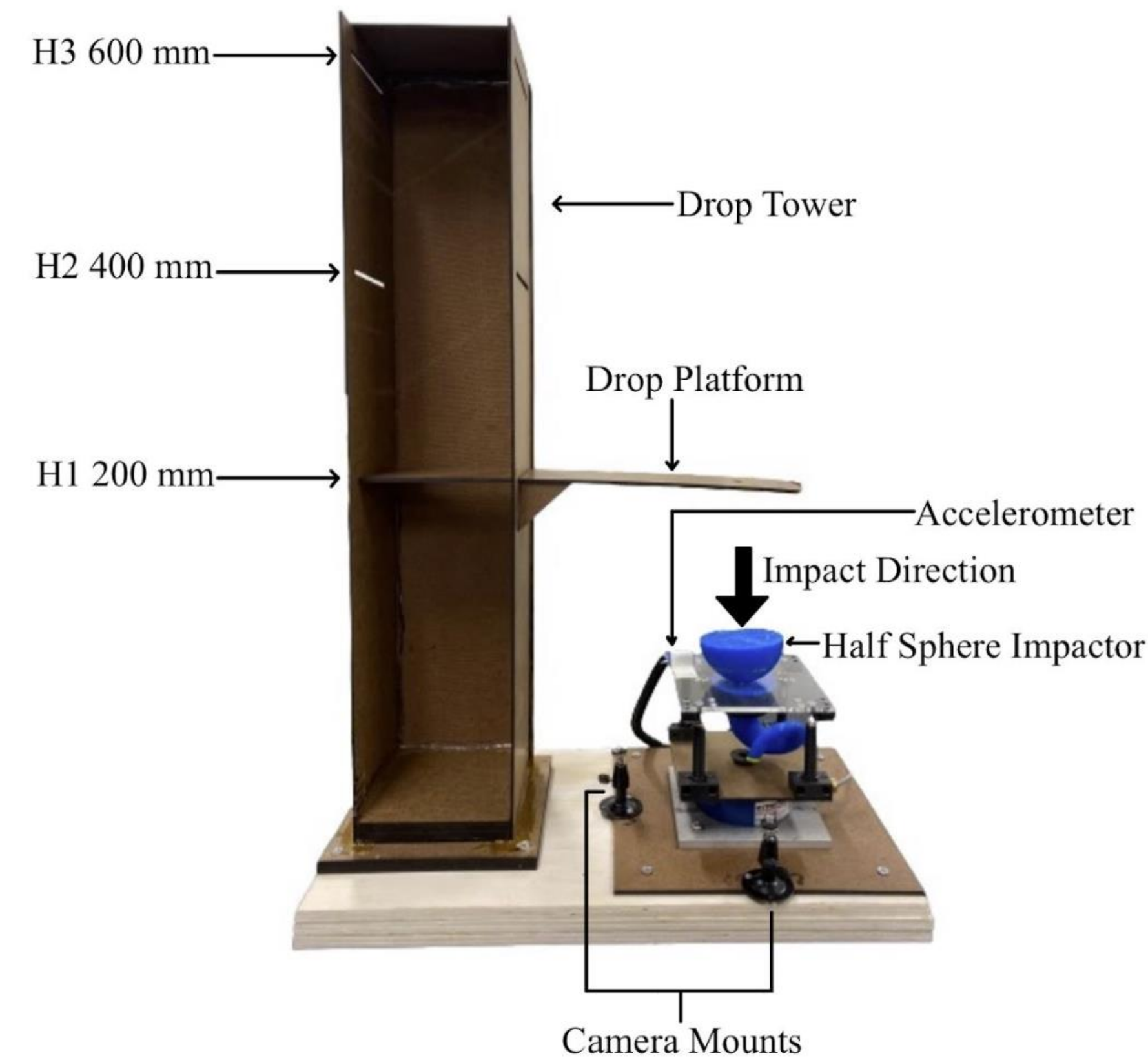


Figure 4. Experimental impactor system with drop tower, showing three different drop heights.

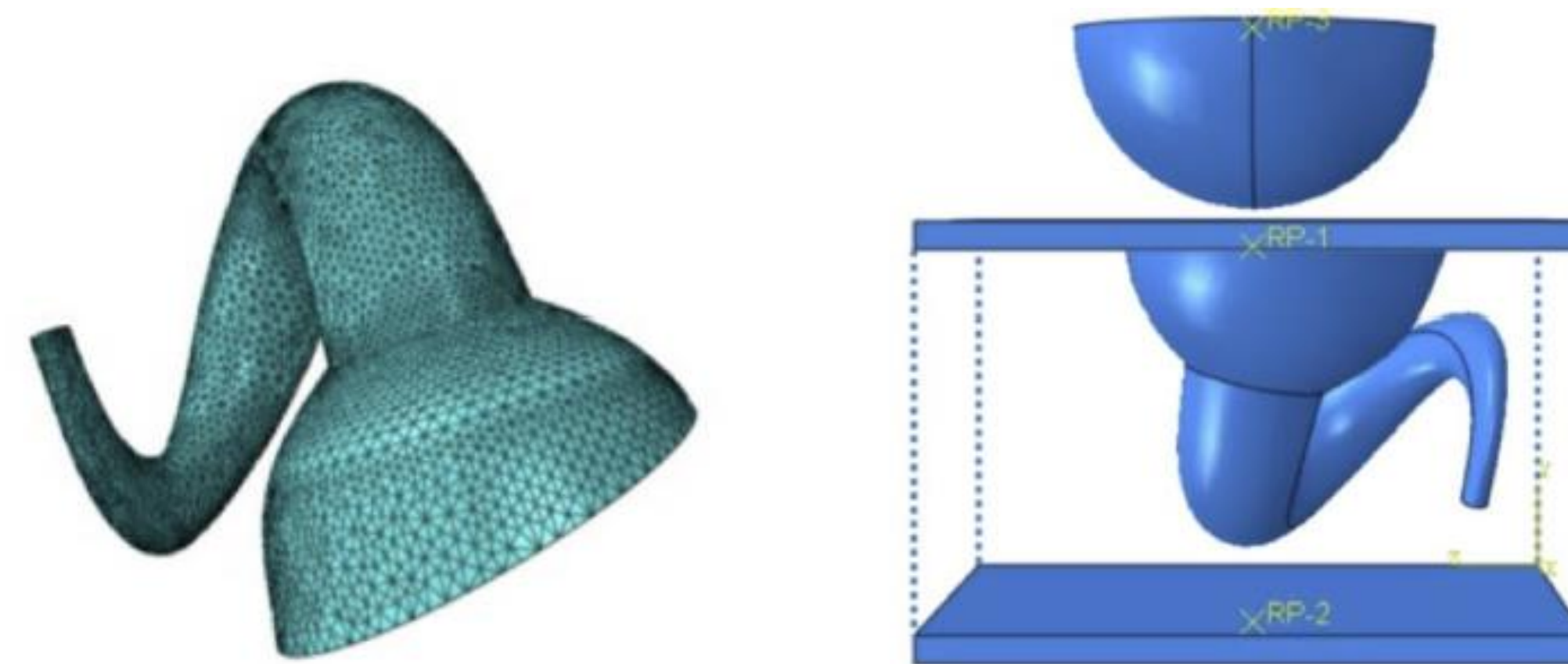


Figure 5. Finite element model of impactor system, showing mesh (left) and whole model geometry (right).

Results

- Successful model calibration (less than 9% acceleration error at all three heights, Fig. 6)
- Model calibration showed good agreement to medial-lateral horn tip displacements (less than 15% error at all three heights, Fig. 7)

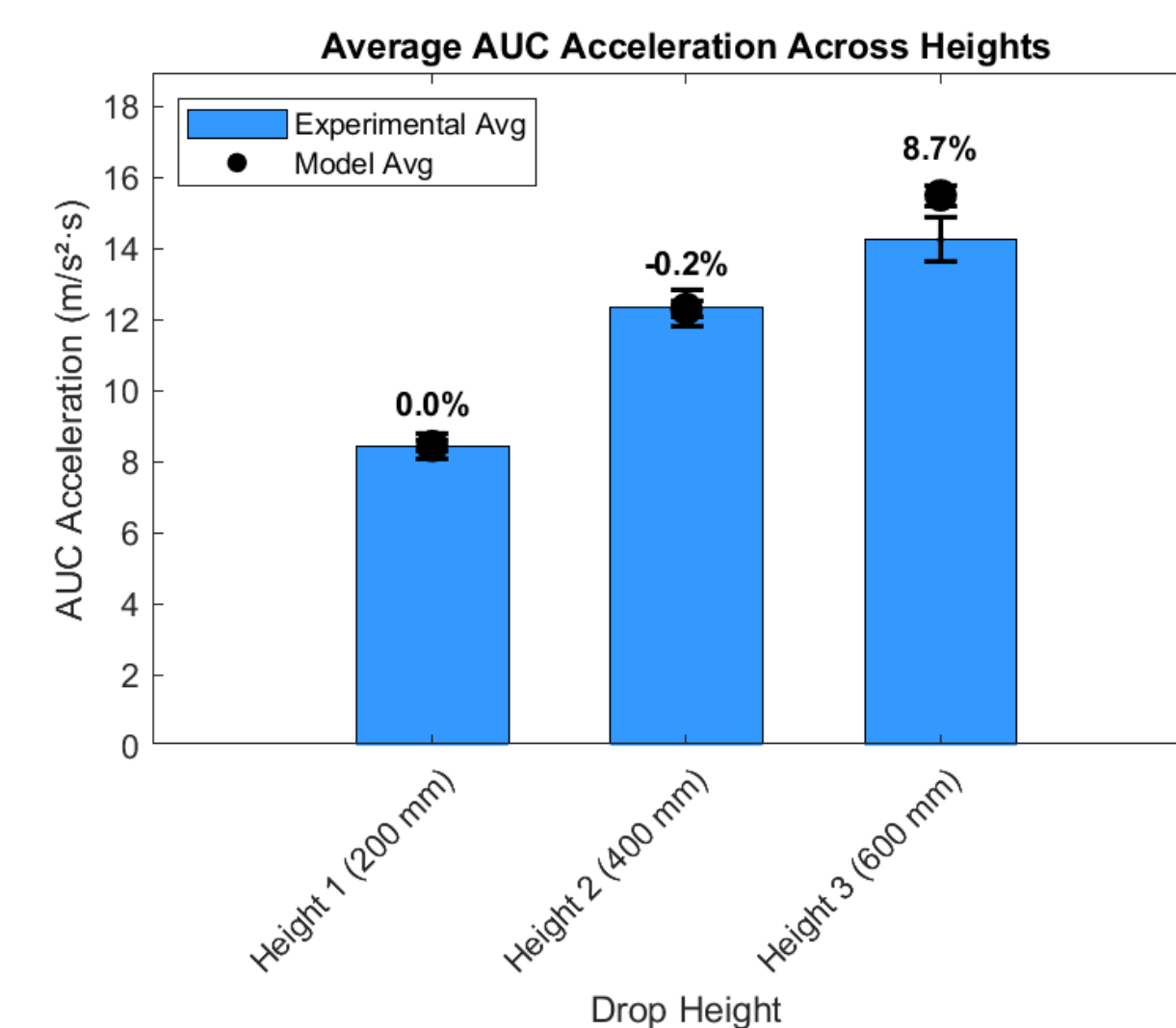


Figure 6. Finite element model calibration results.

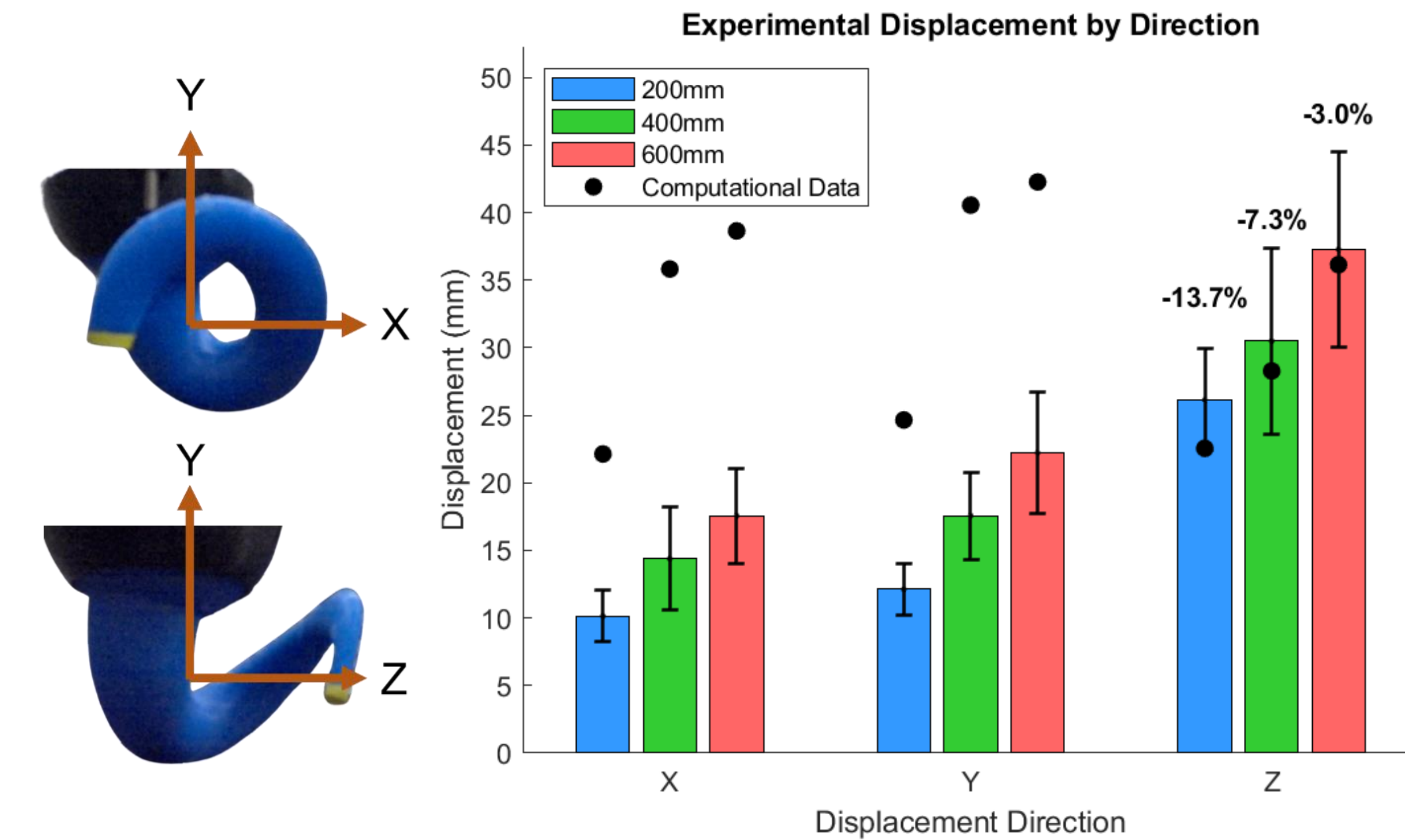


Figure 7. Model validation results, showing experimental horn tip displacements and computational data points.

Discussion and Conclusions

- This work developed a validated finite element model of horn-like oscillators for studying impact mitigating properties
- A miniature experimental drop-test system was developed, with ongoing optimization for improved repeatability of data
- Current work seeks to expand model geometries, materials, and impact conditions using parametric analyses (Figs. 8 and 9)
- Future work could optimize specific oscillators for applications such as an automotive or blast impact

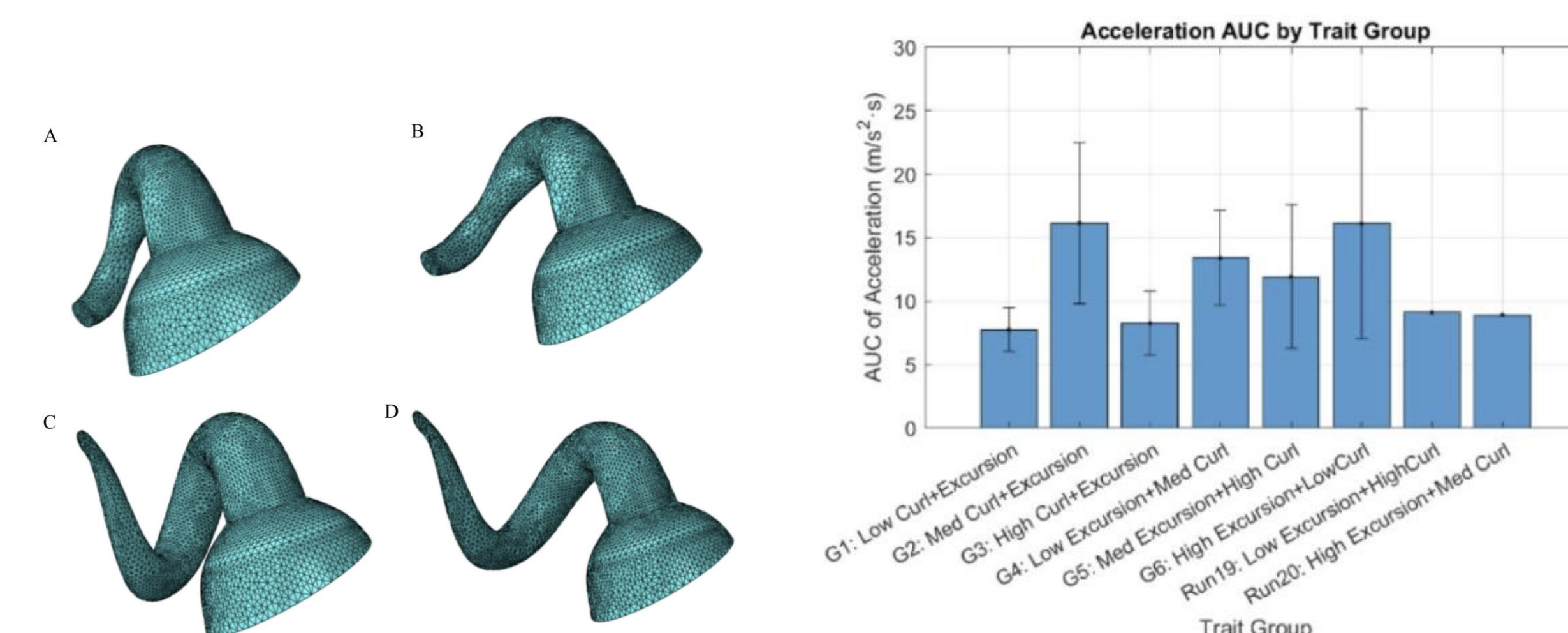


Figure 8. Parametric modeling geometries.

Figure 9. Initial parametric modeling results.

References

[1] Van Ommeren, *Academic Forensic Pathology* (2018). [2] Ackermans, *Acta Neuropathologica* (2022). [3] Drake, *Acta Biomaterialia* (2016). [4] Wheatley, *Bioinspiration & Biomimetics*, (2023)..