

# Osteochondral Transplant Delivery System

Team Leader: *Alex Teague*

BPAG: *David Fiflis*

Communicator/BWIG: *Alex Babinski*

BSAC: *Zach Wodushek*

Client: *Dr. Brian Walczak, DO*

Advisor: *Dr. Tracy Puccinelli, PhD*



# Client Overview

- **Dr. Brian Walczak, DO**
  - Orthopedic Surgeon
  - Faculty, University of Wisconsin School of Medicine and Public Health
- **Specialties**
  - Joint Preservation
  - Knee Arthroscopy
  - Pediatric Sports Medicine

*Proposes a novel approach to osteochondral allograft (OCA) transplantation*



University of Wisconsin Hospitals and Clinics Authority,  
“Brian E. Walczak, DO,” *UW Health*. [Online].

# Current OCA Transplantation Procedure

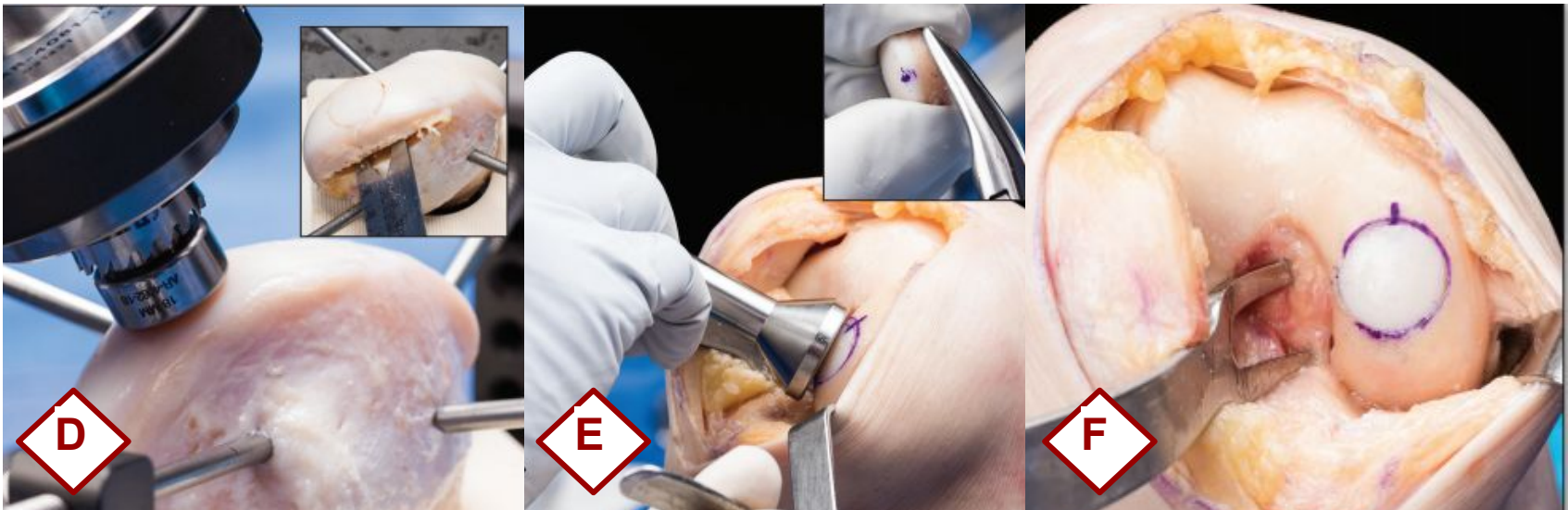
- Chondral defect is exposed and measured to determine the appropriate tool size (A)
- Guidewire is drilled into the center of the defect and surgical reamer removes defective tissue (B)
  - Depth markings on the reamer allow surgeon to drill to the proper depth
- Depth measurements taken about donor hole (C)





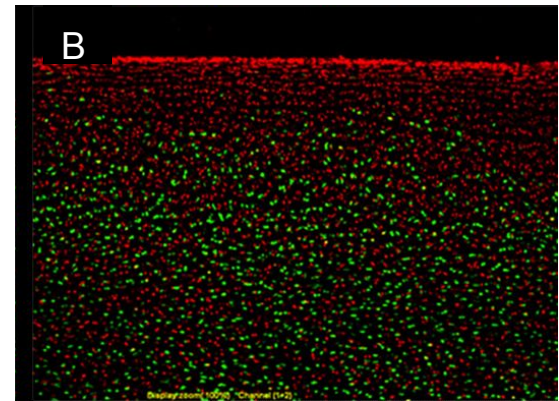
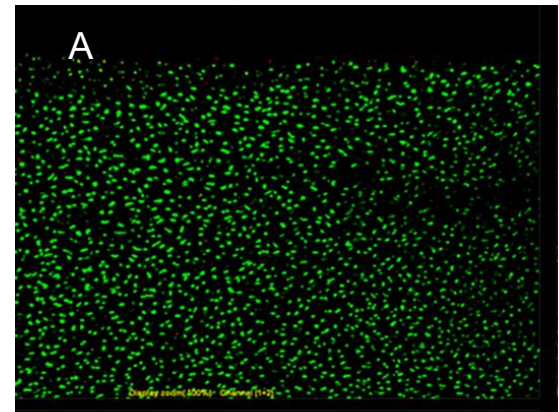
# Current OCA Transplantation Procedure

- Allograft harvested from cadaver condyle using hole-saw and oscillating saw (D)
  - Graft height trimmed to match depth of receiving hole
- Impaction rod and hammer secure the donor graft in the receiving hole (E)
- Donor graft aligned within  $\pm 1$ mm of native cartilage (F)



# OCA Transplant Challenges

- Impaction is deleterious to chondrocyte viability [5]
  - Reducing impulse during impaction prevents chondrocyte damage
- Donor chondrocyte viability is a key determinant of OCA success [4]
  - Promotes graft integration, and maintains biomechanical function
  - All successful grafts showed viability >70% (t = 6 months)



Live/dead stain after chondral impaction [5]

A: Control

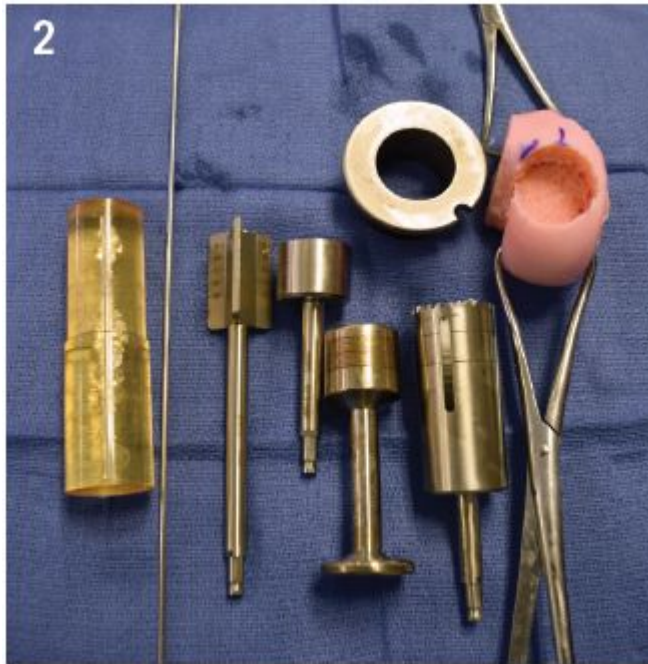
B: 300 N

Live: **Green**

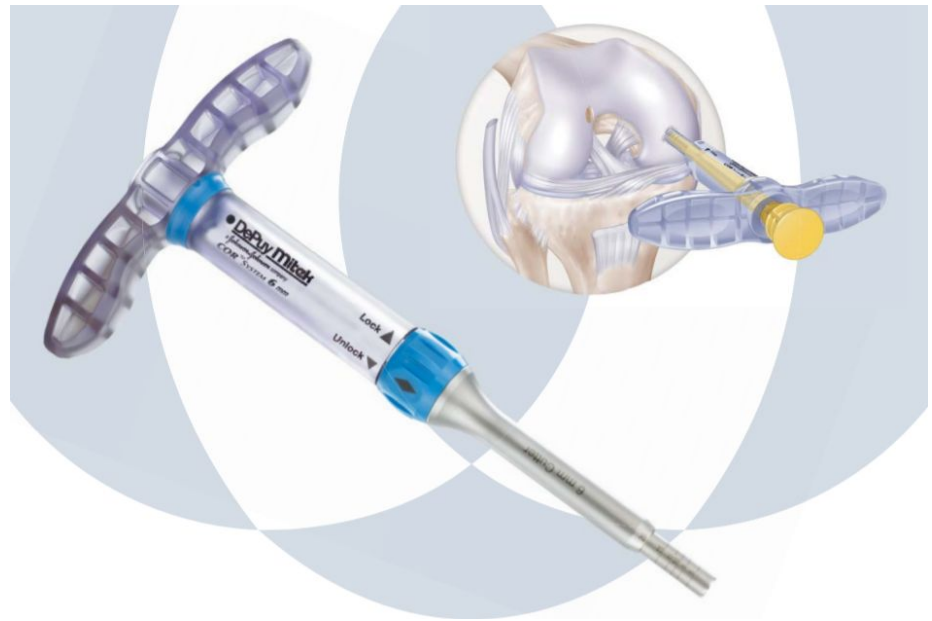
Dead: **Red**

# Current Surgical Systems

Arthrex Osteochondral  
Allograft Transfer  
System (OATS)



DePuy Synthes COR<sup>®</sup>  
Precision Targeting  
System





# Problem Statement

- Number of surgeries performed is **increasing by 5% annually** with an expected **3500 annual procedures by 2020**. [2]
- **Overall failure rate is 18%** [3]
- Current impaction method **reduces chondrocyte viability** [1]
- Chondrocyte **viability of 70%** is the threshold for procedure success [4]
- Design a device to allow easy insertion of the graft while minimizing chondral damage

## Approach

*We propose a screw-in allograft to replace the current impaction method*



“Osteochondral Allograft Transplantation (OCA),” *Illinois Sports Medicine and Orthopaedic Centers*. [Online]. Available: [Accessed: 05-Oct-2017].

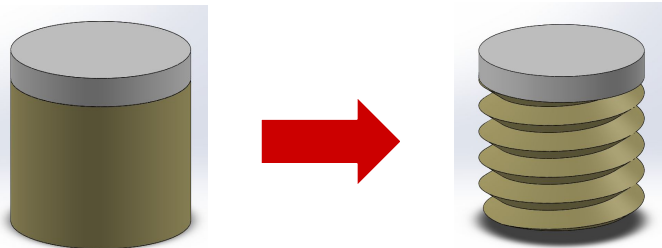
# OCA Threading Prototype

## Patient Receiving-Site Threading

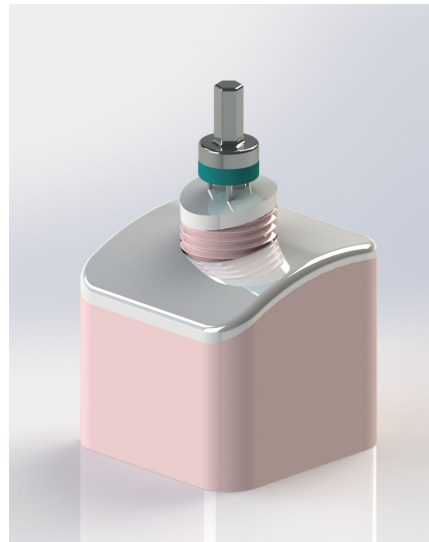
- Stainless steel tap
- Guide-wire alignment

## Cadaver Graft Threading

- Stainless steel die
- Graft holding cup
- Die orientation guide



Idealized graft threading.



Graft insertion screwdriver.

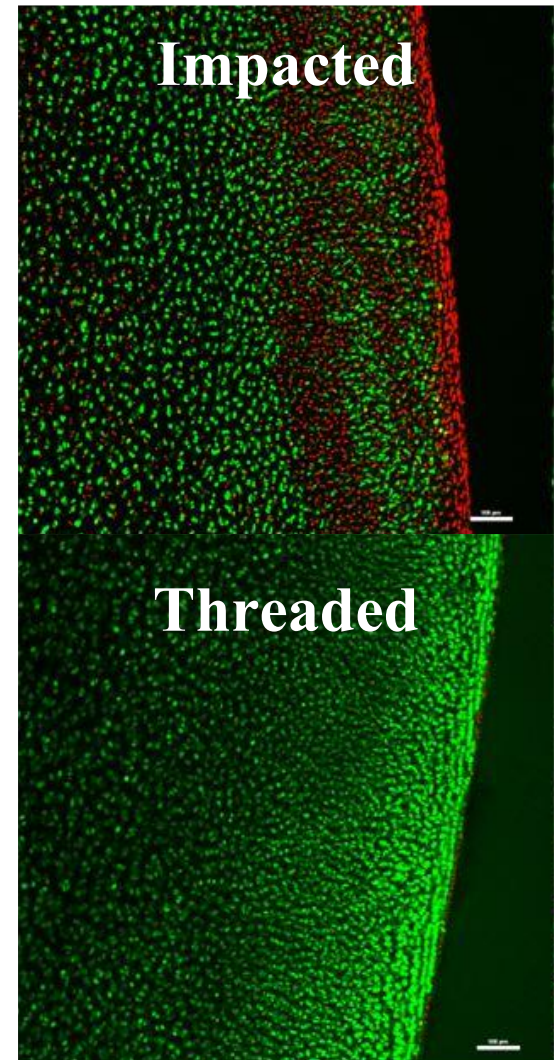
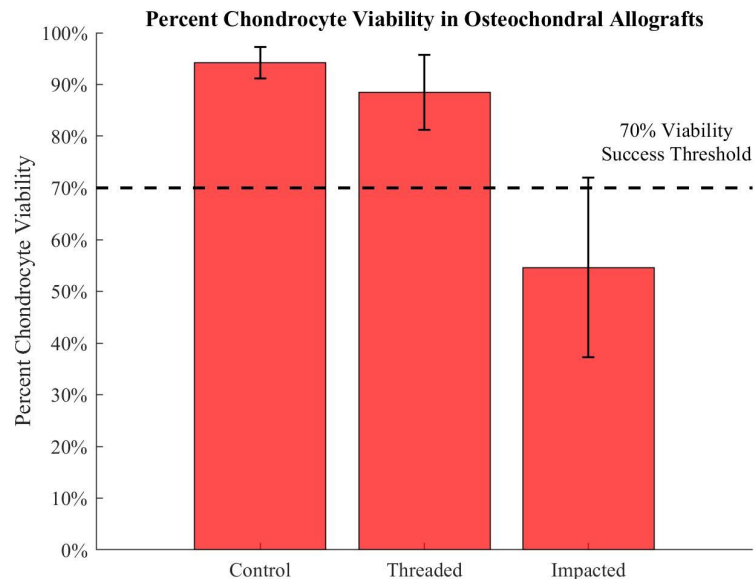


Graft threading die orientation guide.



# OCA Threading Prototype Testing

- Live/dead assay of implanted porcine tissue
  - Confocal microscopy
  - Cellprofiler viability analysis



Live/dead stain after graft implantation  
Live: **Green** Dead: **Red**

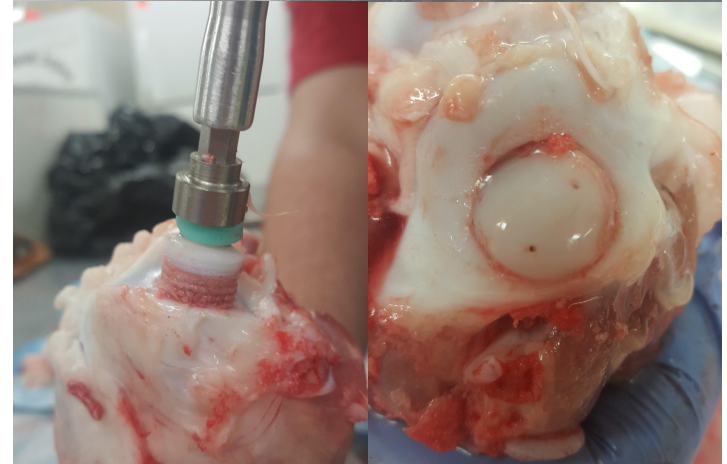
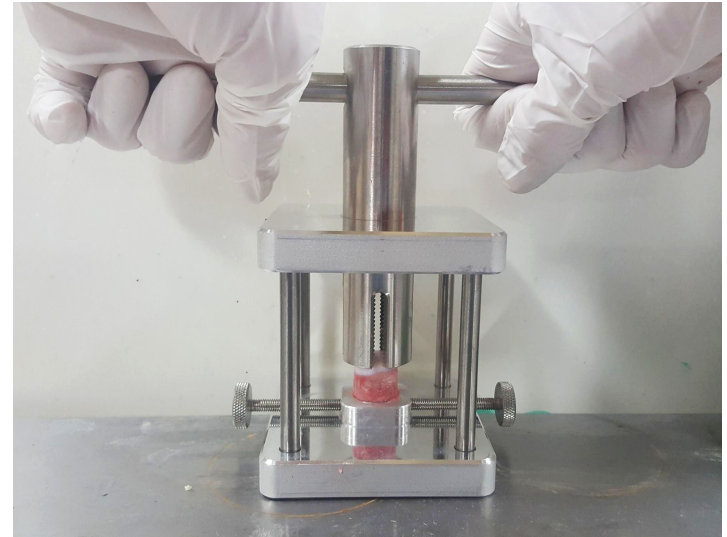
# Summary of Previous Design Work

## Design Successes

- Successfully showed that allograft threading can preserve chondrocyte viability

## Design Shortcomings

- Did not address matching of allograft and native articular surfaces
  - Must match graft rotation and depth
  - Rotation and depth are coupled in a screw system
- Smaller pitch doesn't work with softer bone



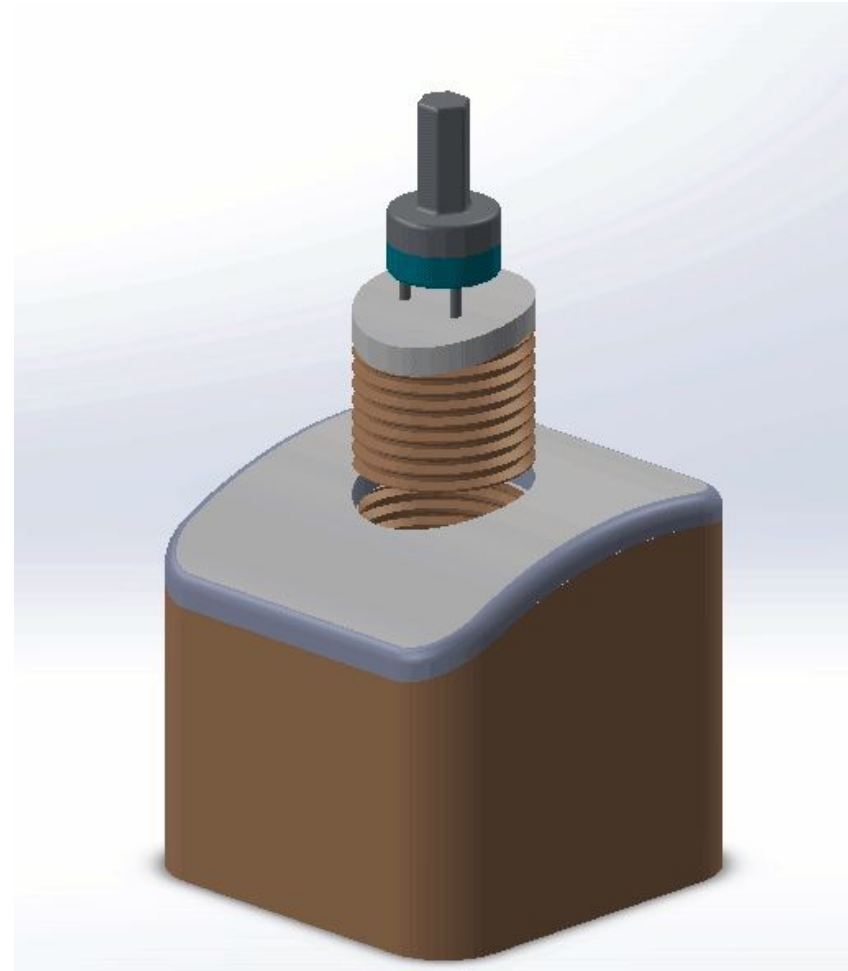
# Current Design Challenges

## Matching graft to native surface

- Determine relationship between rotation and depth of graft
- Heights must differ by no more than 1mm

## Measuring height offset

- Need to measure a small (1mm) height offset on a rounded surface
- 3D point cloud measurement
  - Obtained using laser scanners
  - Overlay and compare point clouds

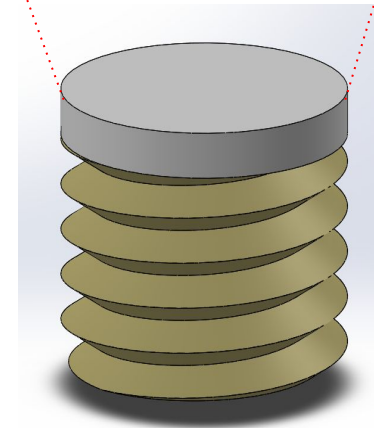
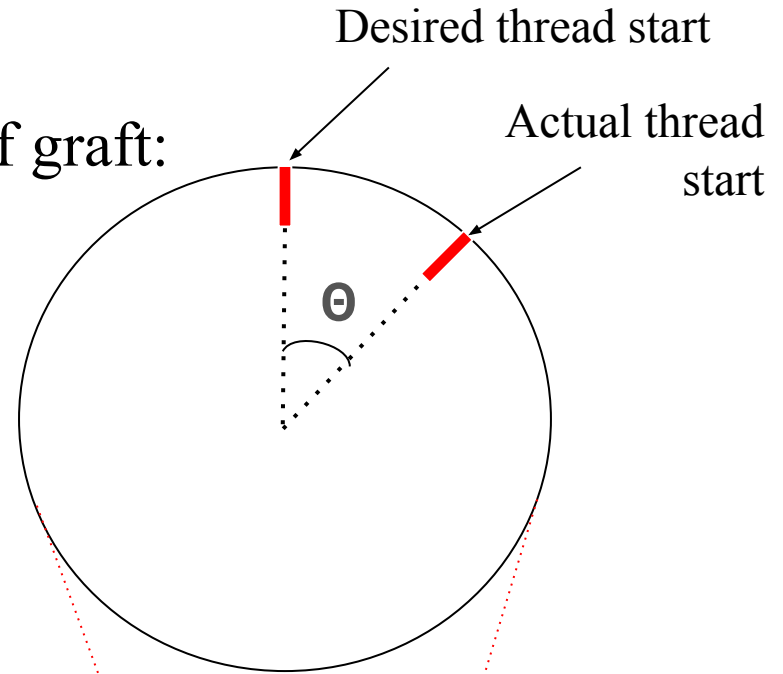




# *Aim 1*

**Threading  
Consistency**

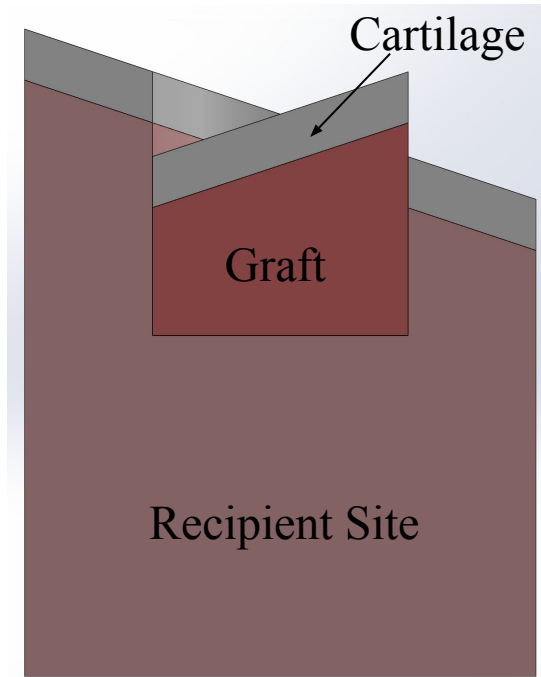
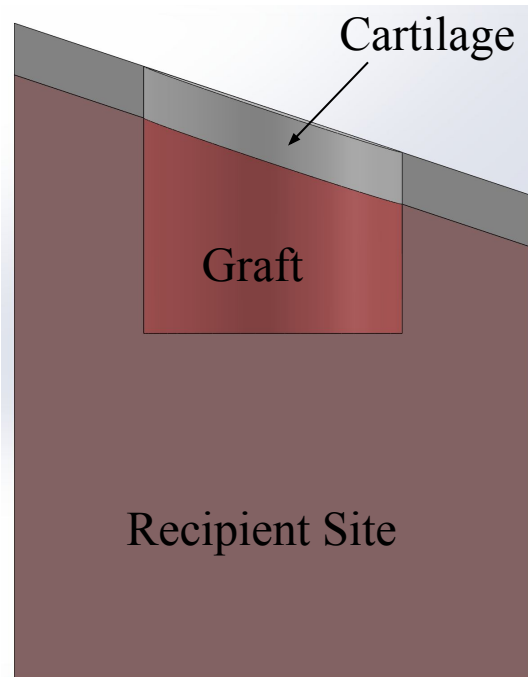
Top view of graft:



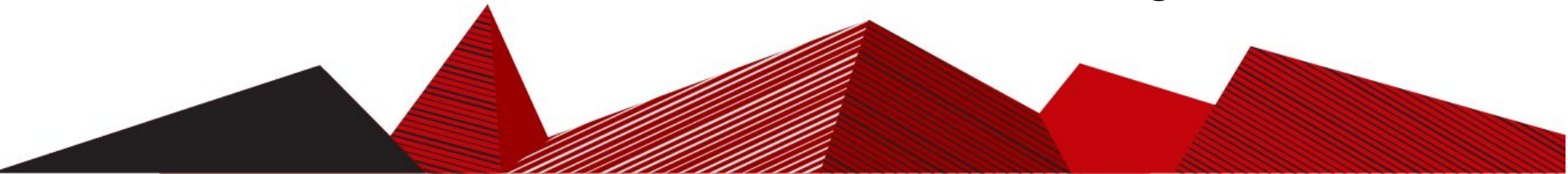
# *Aim 2*

**Plastic  
Testing**

Desired Graft Rotation    Undesirable Graft Rotation



Achieving intended graft rotation is essential for minimizing articular surface incongruities.



# *Aim 3*



**Model Bone  
Testing**



**Viable Tissue  
Testing**

- Use non-viable porcine tissue or Sawbone
- Evaluation of surface geometry with 3D laser scanners
  
- Perform full procedure with chondrocyte viability and surface geometry considerations



# OCA Prototype Future Work

**Threading  
Consistency**

- Can we start threading where we want to?
- October 2018

**Plastic  
Testing**

- Can we match the surfaces of the graft and receiving site?
- October-November 2018

**Model Bone  
Testing**

- Does our testing in plastic translate to bone geometry?
- November-December 2018

**Viable Tissue  
Testing**

- Does our method improve procedural outcome?
- Spring 2019

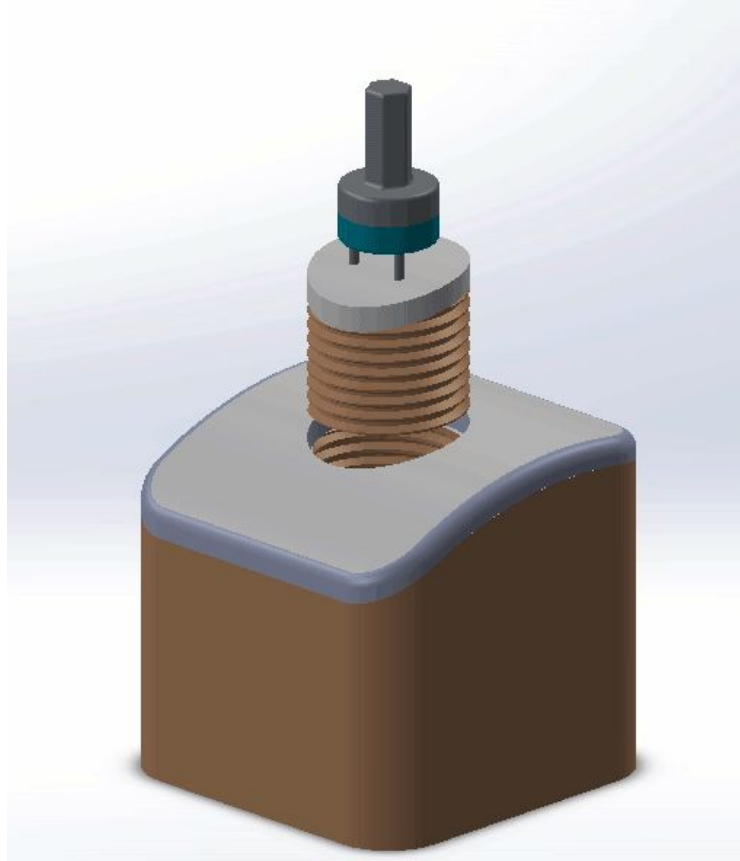
# Acknowledgements

We would like to thank our advisor Dr. Puccinelli, and our client Dr. Walczak for their help with the design process.

Thank you!



# Questions?





# References

- [1] A. M. Torrie, W. W. Kesler, J. Elkin, and R. A. Gallo, "Osteochondral allograft.," *Curr. Rev. Musculoskelet. Med.*, vol. 8, no. 4, pp. 413–22, Dec. 2015.
- [2] F. McCormick et al., "Trends in the Surgical Treatment of Articular Cartilage Lesions in the United States: An Analysis of a Large Private-Payer Database Over a Period of 8 Years," *Arthrosc. J. Arthrosc. Relat. Surg.*, vol. 30, pp. 222–226, 2014.
- [3] Chahal JI, Gross AE, Gross C, Mall N, Dwyer T, Chahal A, Whelan DB, Cole BJ.(2013). Outcomes of osteochondral allograft transplantation in the knee. [Arthroscopy](#). 2013 Mar;29(3):575-88. doi: 10.1016.
- [4] Cook JL, Stannard JP, Stoker AM, et al. Importance of donor chondrocyte viability for osteochondral allografts. *Am J Sports Med.* 2016 May;44(5):1260-1268
- [5] Kang RW, Friel NA, Williams JM, Cole BJ, Wimmer MA. Effect of impaction sequence on osteochondral fraut damage: the role of repeated and varying loads. *Am J Sports Med.* 2010 Jan;38(1):105-113.

