Osteochondral Transplant Delivery System

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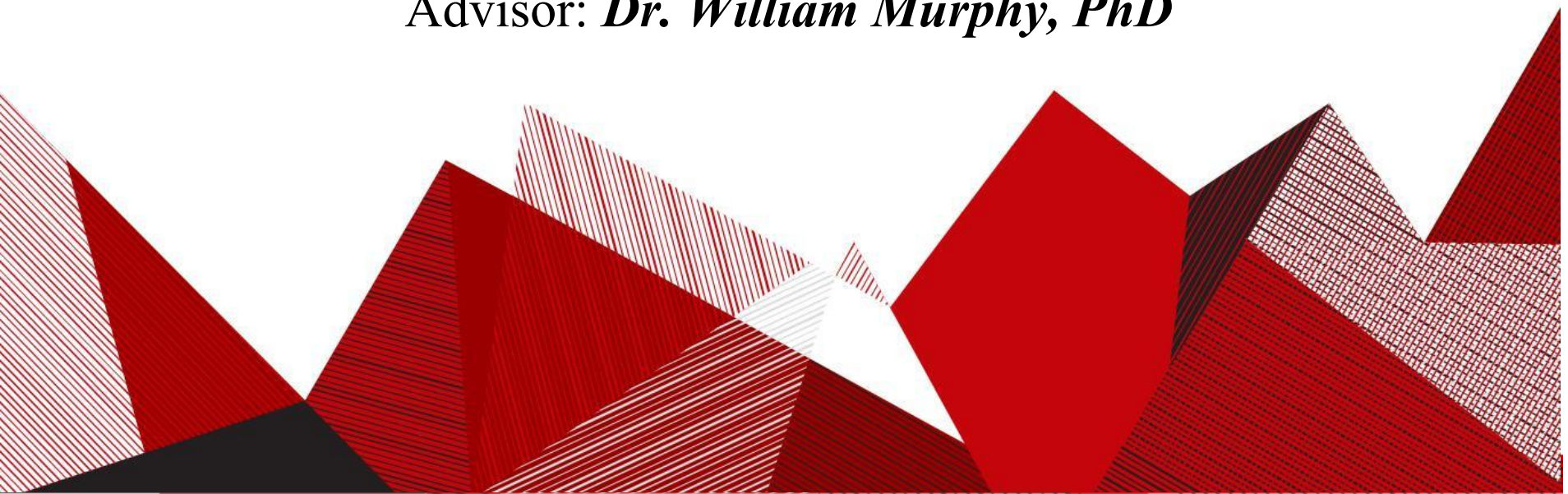
Advisor: ***Dr. William Murphy, PhD***



Overview

- Client Overview
- Problem Statement
- Surgical Procedure
- Current Products
- Previous Design Work
- Design Ideas
- Proposed Final Design
- Future Work

UW BME Design

Client Overview

- **Dr. Brian Walczak, DO**
  - Faculty, University of Wisconsin School of Medicine and Public Health
  - Orthopedic Surgeon

- **Specialties**
  - Pediatric Sports Medicine
  - Joint Preservation
  - Knee Arthroscopy

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

Problem Statement

- Osteochondral allografts (OCA) **repair defects** in cartilage and underlying bone
- Over **200,000 procedures** occur each year (2016) [1]
- Number of performed surgeries **increasing by 5% annually** in the US from 2004-2011[2]
- **Overall failure rate** is 18% [3]
- Current impaction method for graft placement **reduces chondrocyte viability** and **limits vertical adjustment**
- Client proposes a **screw-in graft** allograft to replace the press-fit method

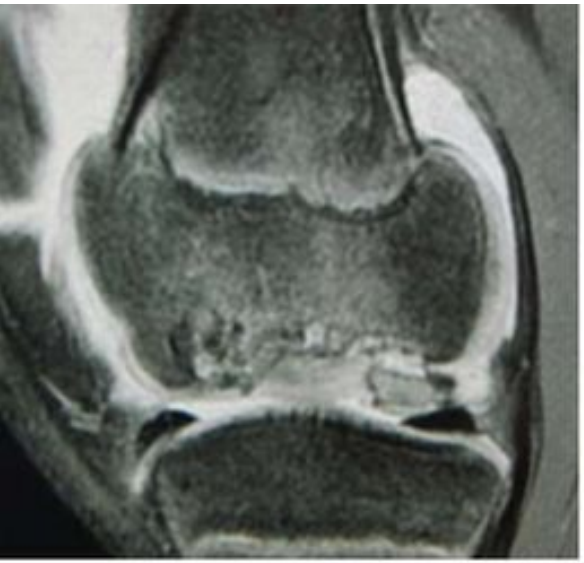
"Osteochondral Allograft Transplantation (OCA)," *Illinois Sports Medicine and Orthopaedic Centers*. [Online]. Available: [Accessed: 05-Oct-2017].

Approach:

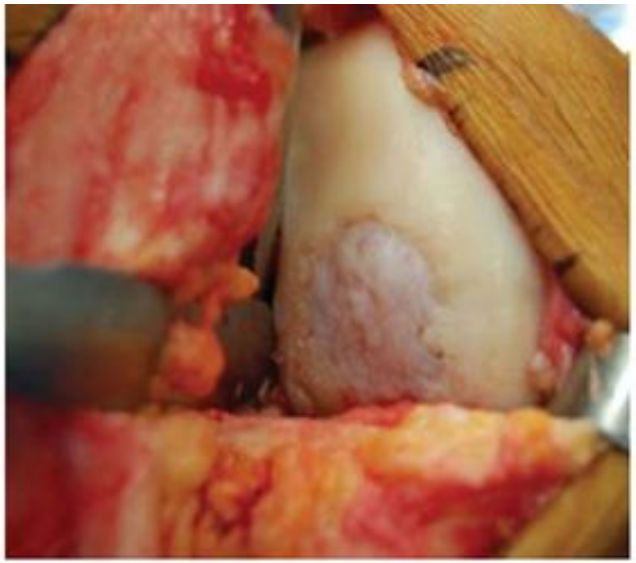
- Design the tools necessary to thread the recipient site and donor graft with the ultimate goal of maintaining chondrocyte viability above 70% [4]

Current Surgical Procedure

- Chondral defect identified via MR imaging (A)
- Defect exposed and sized with surgical guides (B)
  - Allows surgeons to select the smallest effective tools
- Guidewire is drilled into the center of the defect to direct the surgical reamer (C)
  - Depth markings on the reamer allow surgeon to drill to the proper depth



A



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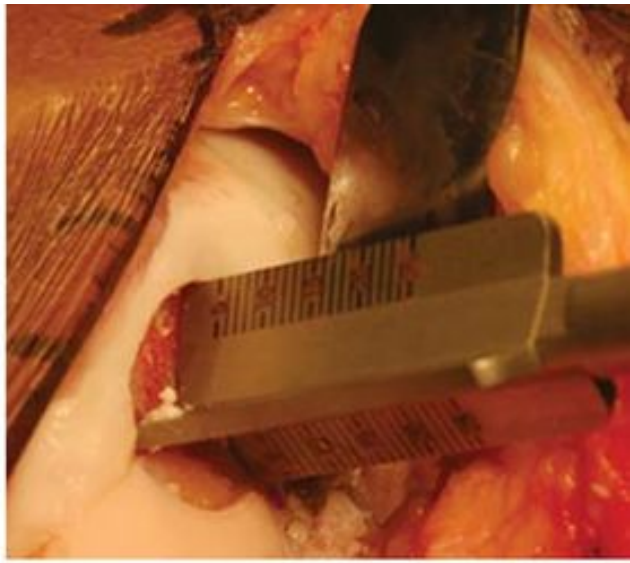


C

Current Surgical Procedure

- Allograft harvested from donor tissue (E)
  - Surgical hole-saw and oscillating saw cut the donor plug from the matched or contralateral condyle.
  - Plug height trimmed to match depth of receiving hole
- Impaction rod and hammer secure the donor plug in the patient (F)

D

E

F

S. L. Sherman, J. Garrity, K. Bauer, J. Cook, J. Stannard, and W. Bugbee, "Fresh Osteochondral Allograft Transplantation for the Knee: Current Concepts," *Journal of the American Academy of Orthopaedic Surgeons*, vol. 22, no. 2, pp. 121–133, Feb. 2014.

Procedure Shortcomings

- Impaction is negatively correlated with chondrocyte viability [4]
  - Reducing impulse during impaction increases viability
  - Number of strikes not correlated with chondrocyte death
- Donor chondrocyte viability primary determinant of OCA success [5]
  - Viability ranged from 23-99% at 6 months in canine model
  - All successful grafts showed viability >70% (t=6 months)
  - Success factors included hyaline cartilage maintenance, subchondral graft integration, and lack of fibrous tissue infiltration

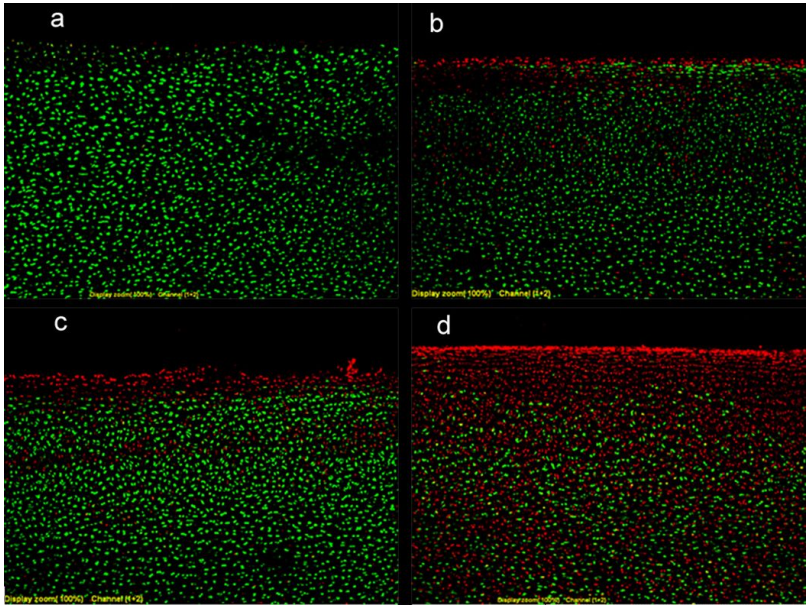
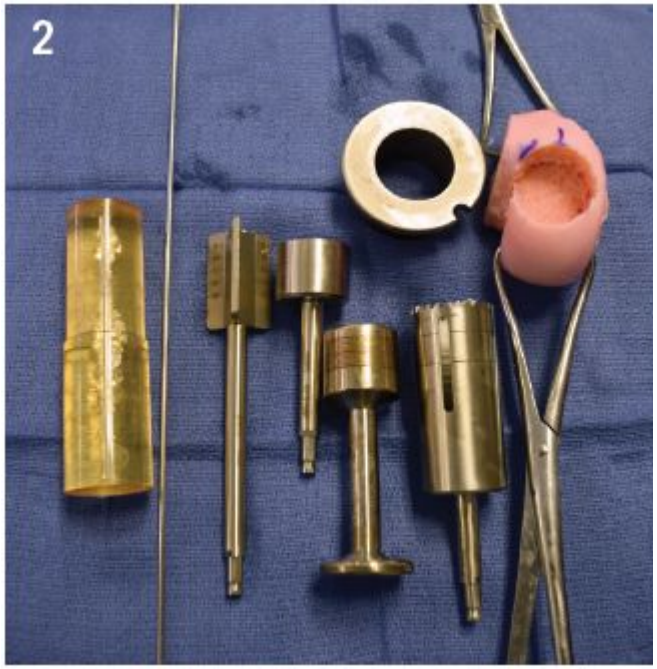


Figure 1. Live/dead stain after chondral impaction. (a) control (b) 75 N (c) 150 N (d) 300 N [5]

Current Surgical Systems

Arthrex Osteochondral Allograft Transfer System (OATS)



Zimmer® Chondrofix® Osteochondral Allograft

Previous Design Teams

Design

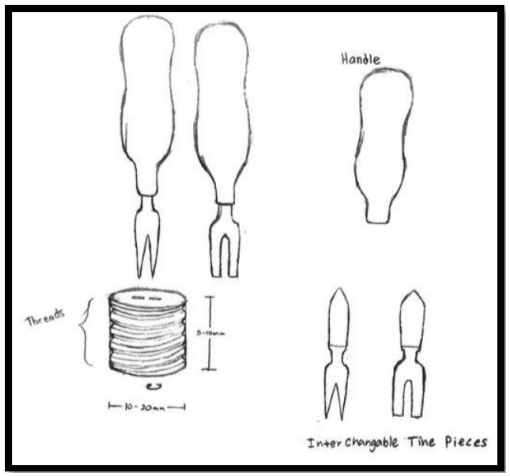
- Standard machine tools thread graft and donor site
- Suction cup to screw in threaded graft
  - Simple hand turning can set the graft

Testing

- Live/dead staining of porcine and bovine tissue
  - Porcine tissue is a better human analog

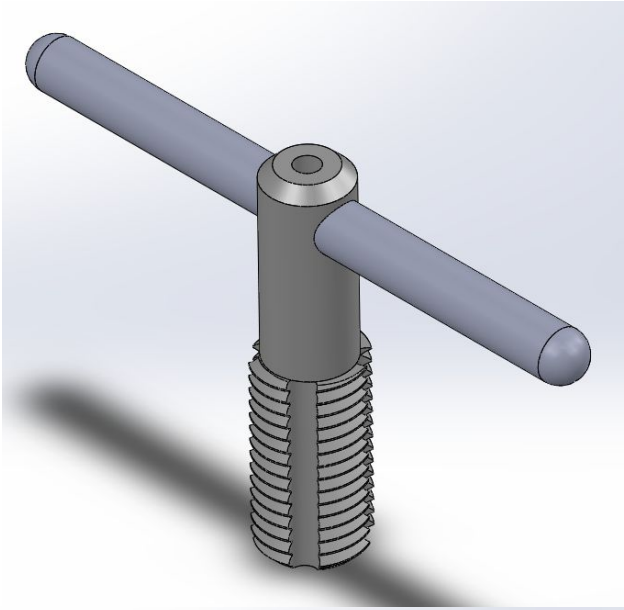
Shortcomings

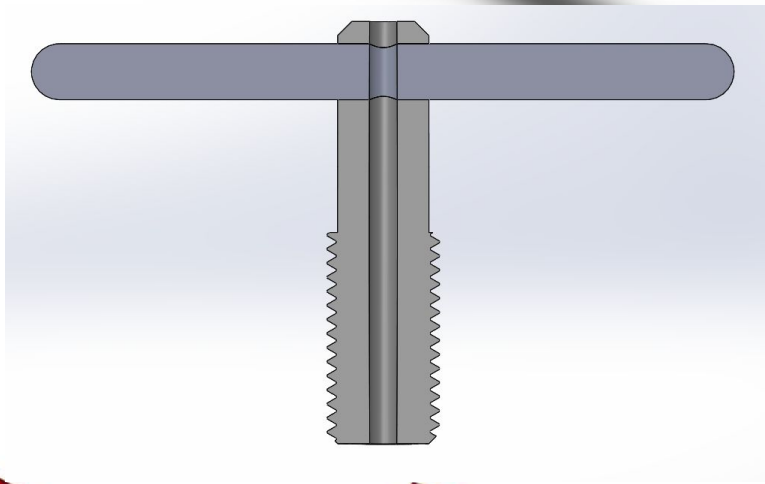
- Testing showed conceptual promise, but a surgical device was not designed
  - Relied on machine tools that are incompatible with surgery
- No difference in chondrocyte viability compared to press-fit method



Recipient Site: Guidewire Tap

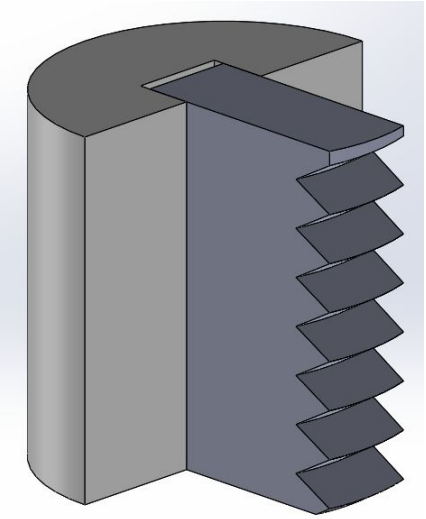
Criteria	*Weight*	*Rank*	*Score*
Chondrocyte Viability Maintenance	20	4/5	16
Internal Thread Cutting Accuracy	20	5/5	20
Ease of Use (Procedure Integration)	15	5/5	15
Procedure Time	15	4/5	12
Sterilizability	10	5/5	10
Safety	10	4/5	8
Manufacturing Time	5	4/5	4
Cost	5	4/5	4
Total	**100**		**89**

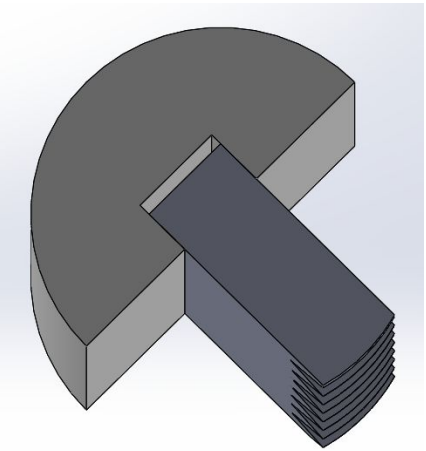




Recipient Site: Spring Design

Criteria	*Weight*	*Rank*	*Score*
Chondrocyte Viability Maintenance	20	3/5	12
Internal Thread Cutting Accuracy	20	2/5	8
Ease of Use (Procedure Integration)	15	2/5	6
Procedure Time	15	3/5	9
Sterilizability	10	4/5	8
Safety	10	2/5	4
Manufacturing Time	5	4/5	4
Cost	5	4/5	4
Total	**100**		**55**





Recipient Site: Protracted Tap

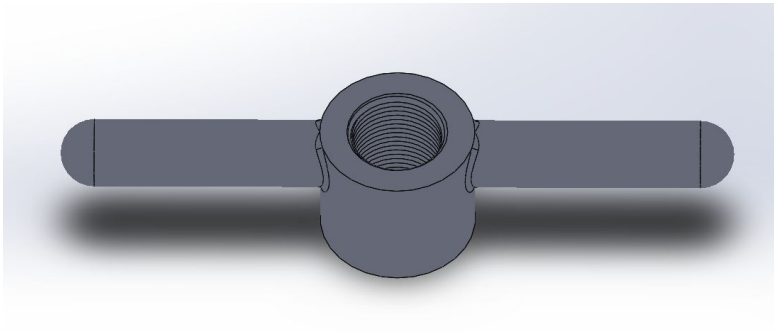
Criteria	*Weight*	*Rank*	*Score*
Chondrocyte Viability Maintenance	20	3/5	12
Internal Thread Cutting Accuracy	20	3/5	12
Ease of Use (Procedure Integration)	15	4/5	12
Procedure Time	15	4/5	12
Sterilizability	10	4/5	8
Safety	10	3/5	6
Manufacturing Time	5	3/5	3
Cost	5	5/5	5
Total	**100**		**70**

Donor Plug: Retracted Tap and Thread Design

Criteria	*Weight*	*Rank*	*Score*
Chondrocyte Viability Maintenance	20	3/5	12
External Thread Cutting Accuracy	20	3/5	12
Ease of Use (Procedure Integration)	15	4/5	12
Procedure Time	15	4/5	12
Sterilizability	10	4/5	8
Safety	10	3/5	6
Manufacturing Time	5	3/5	3
Cost	5	5/5	5
Total	**100**		**70**

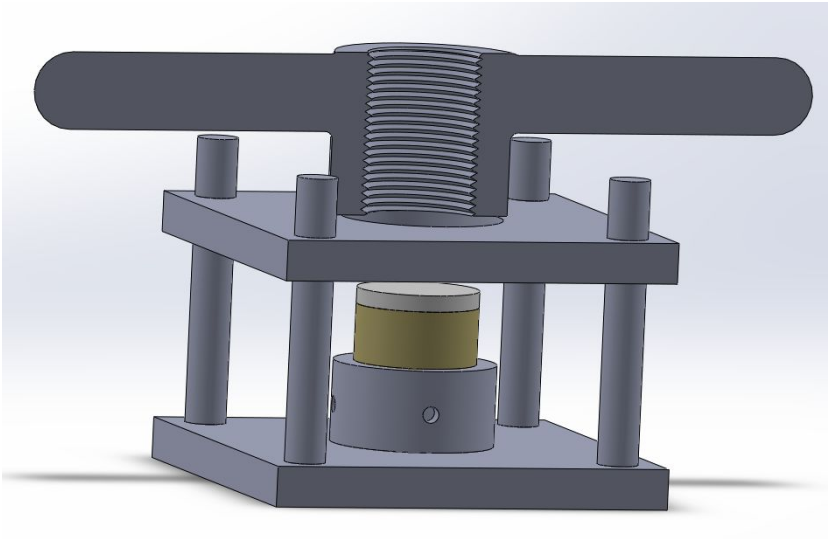
Donor Plug: Die Design

Criteria	*Weight*	*Rank*	*Score*
Chondrocyte Viability Maintenance	20	3/5	12
External Thread Cutting Accuracy	20	2/5	8
Ease of Use (Procedure Integration)	15	2/5	6
Procedure Time	15	4/5	12
Sterilizability	10	5/5	10
Safety	10	3/5	6
Manufacturing Time	5	4/5	4
Cost	5	5/5	5
Total	**100**		**63**



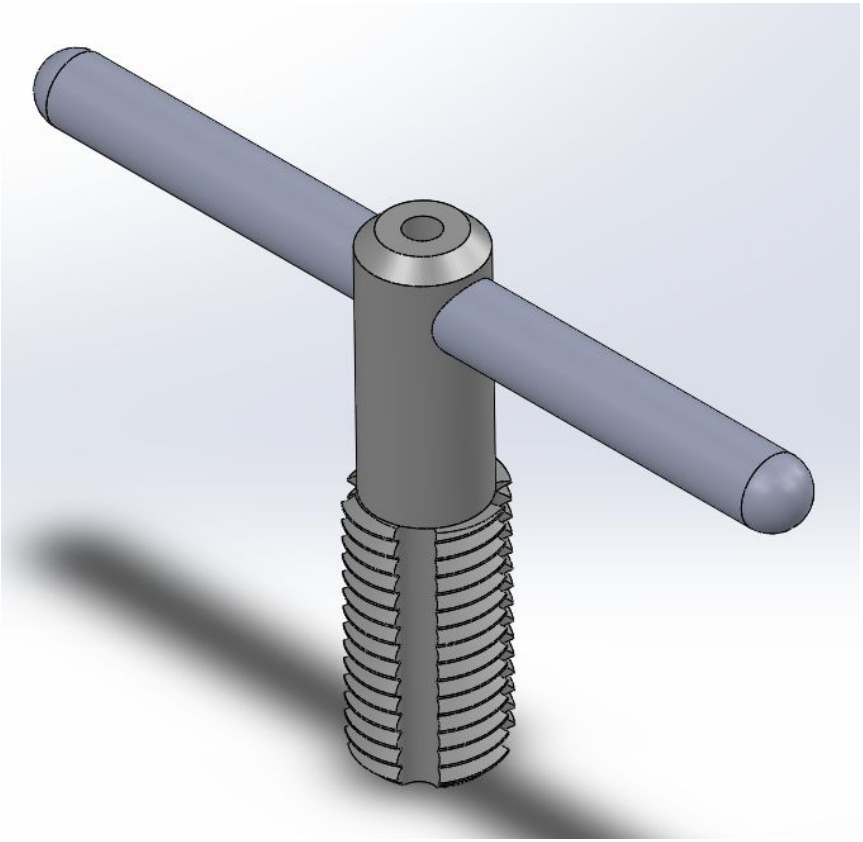
Donor Plug: Guided Die Design

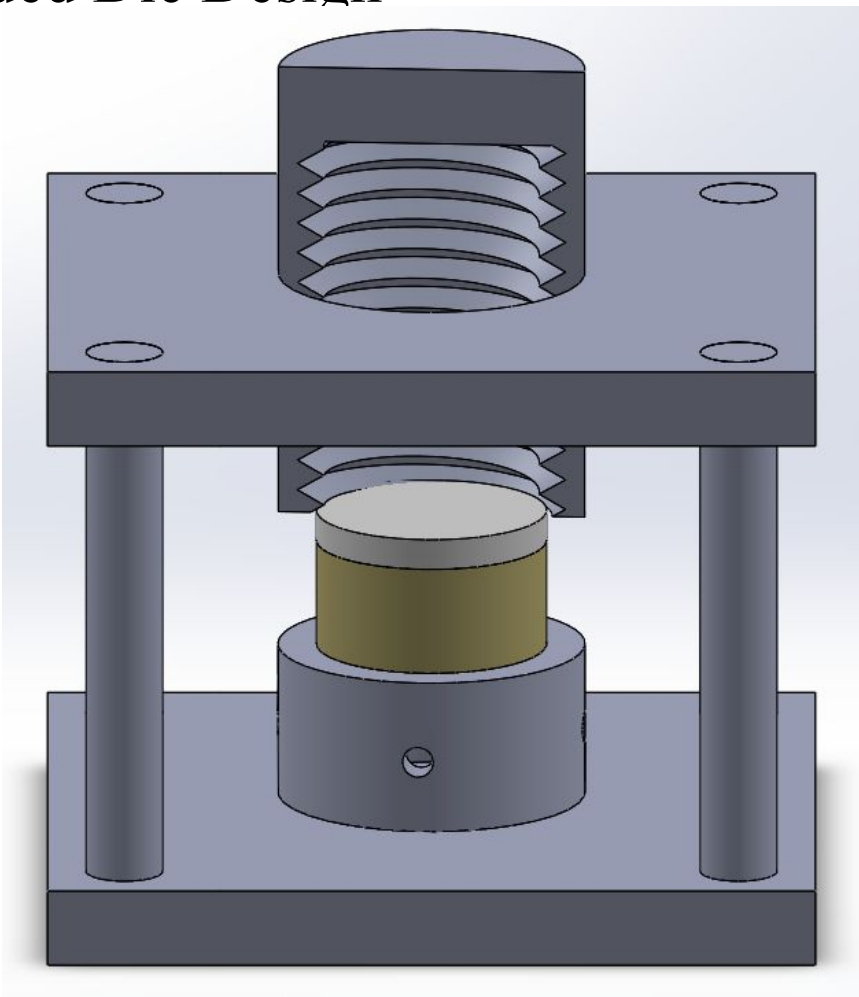
Criteria	*Weight*	*Rank*	*Score*
Chondrocyte Viability Maintenance	20	3/5	12
External Thread Cutting Accuracy	20	5/5	20
Ease of Use (Procedure Integration)	15	3/5	9
Procedure Time	15	4/5	12
Sterilizability	10	4/5	8
Safety	10	4/5	8
Manufacturing Time	5	3/5	3
Cost	5	4/5	4
Total	**100**		**76**



Proposed Final Designs

Guide Wire Tap & Modified Guided Die Design

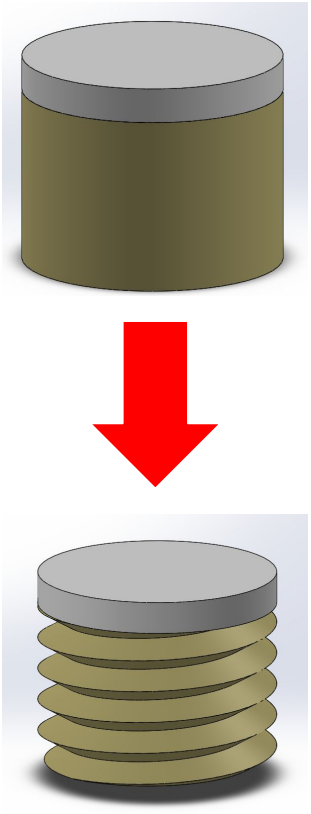




Future Work

Design

- Present final design to client for feedback
  - Make any suggested modifications
  - Refine design specifications



Fabrication

- Material selection and purchase
- Machine prototype

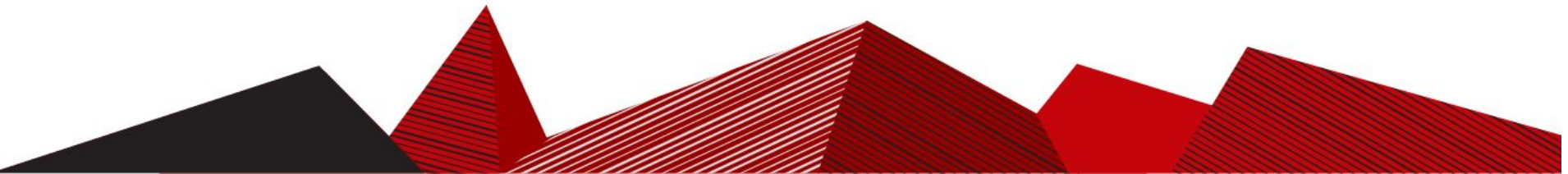
Testing

- Acquire viable porcine tissue
- Thread graft and recipient site
- Assess chondrocyte viability (live/dead staining)

Acknowledgements

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

Questions?



References

[1] W. J. Long, J. W. Greene, and F. D. Cushner, "Early Clinical Outcomes Associated with a Novel Osteochondral Allograft Transplantation System in the Knee," *Advances in Orthopedic Surgery*, vol. 2016, p. 1, 2016.

[2] Torrie, A. M., Kesler, W. W., Elkin, J., & Gallo, R. A. (2015). Osteochondral allograft. *Current Reviews in Musculoskeletal Medicine*, *8*(4), 413–422 http://doi.org/10.1007/s12178-015-9298-3

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[5]Kang RW, Friel NA, Williams JM, Cole BJ, Wimmer MA. Effect of impaction sequence on osteochondral fraft damage: the role of repeated and varying loads. Am J Sports Med. 2010 Jan;38(1):105-113.