



Metacarpophalangeal Joint Replacement

March 5, 2010

Team Members:

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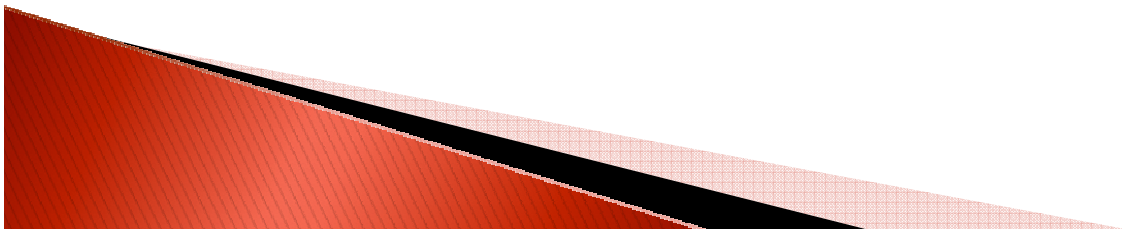
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Client- Dr. Ramzi Shehadi, St. Mary's Hospital

Overview

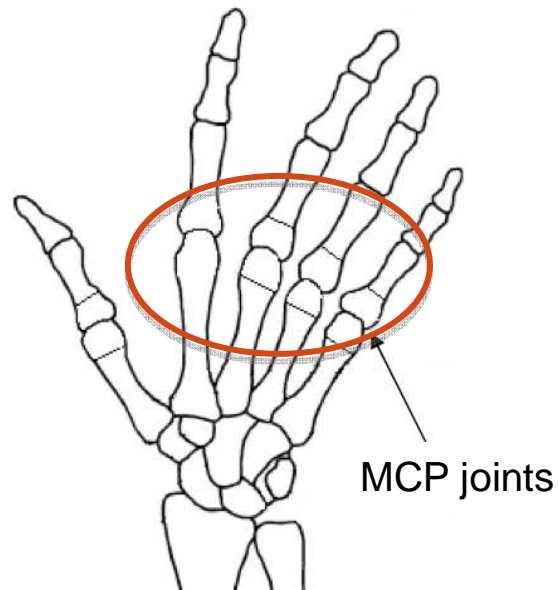
- ▶ Background
- ▶ Problem statement
- ▶ Previous design
- ▶ Midsemester progress
- ▶ Current design
- ▶ Future work

★ This presentation is not to be considered a public disclosure ★

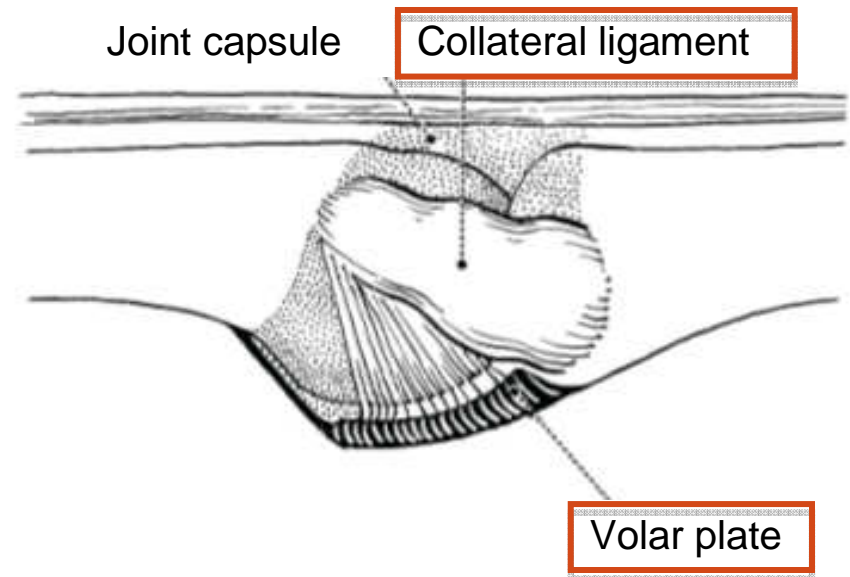


Background

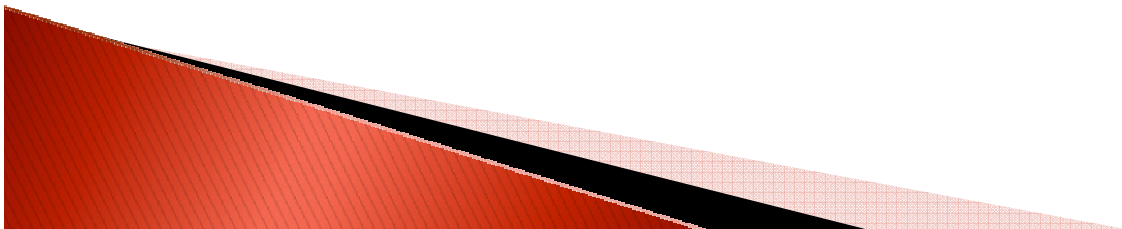
- ▶ Metacarpophalangeal (MCP) joint



[Pylios, T. et al. 2007]

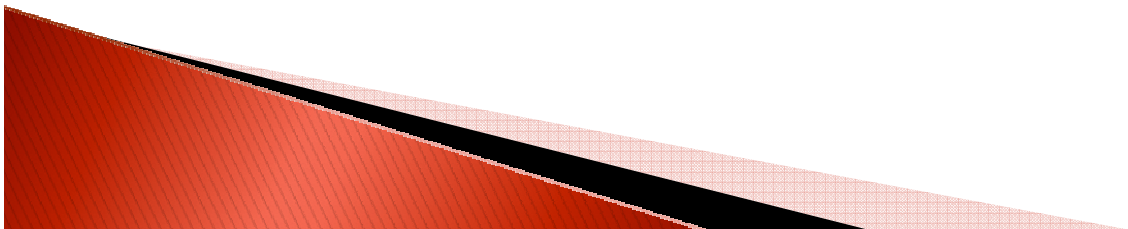


[Kleinert, HE. et al. 2005]

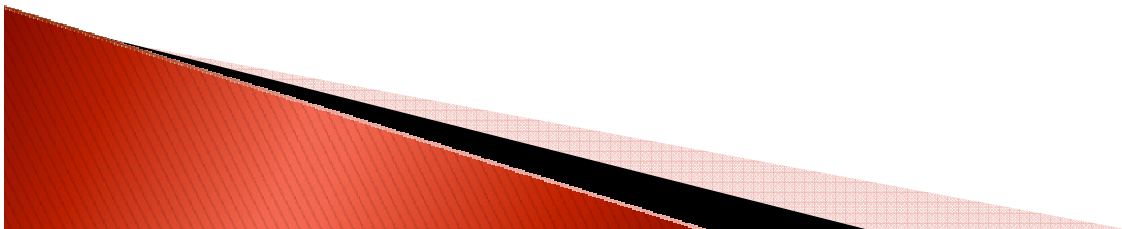
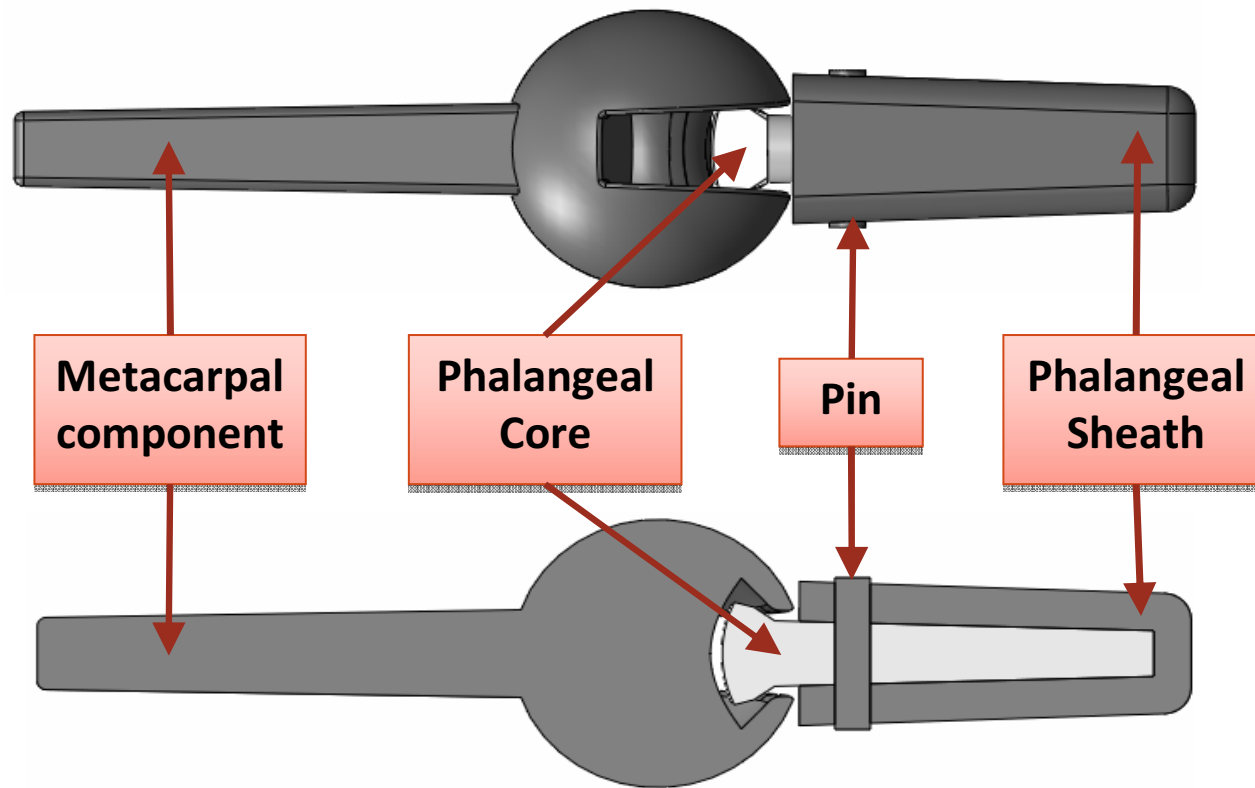


Problem Statement

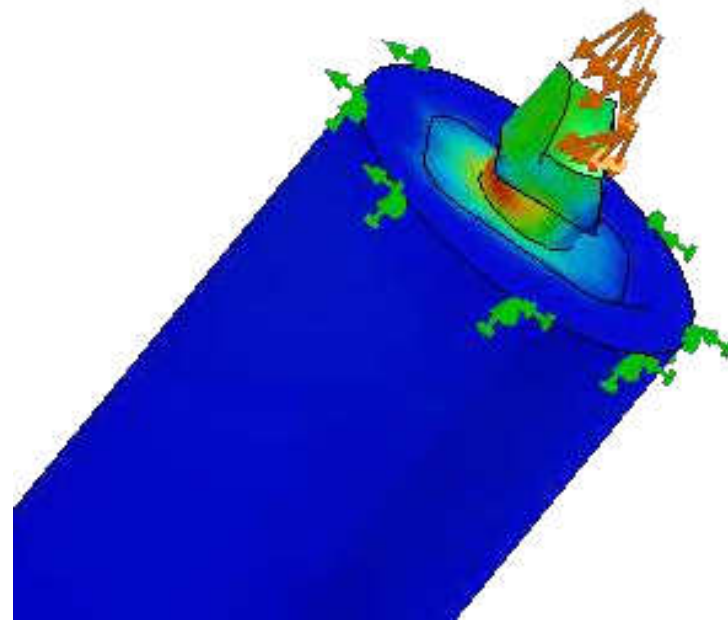
- ▶ Design an MCP joint replacement that:
 - ▶ Does not require collateral ligaments or volar plate
 - ▶ Has an anatomically correct range of motion
 - ▶ Has a lifespan of 10 years
 - ▶ Is capable of osteointegration
 - ▶ Does not fail at the bone-implant interface



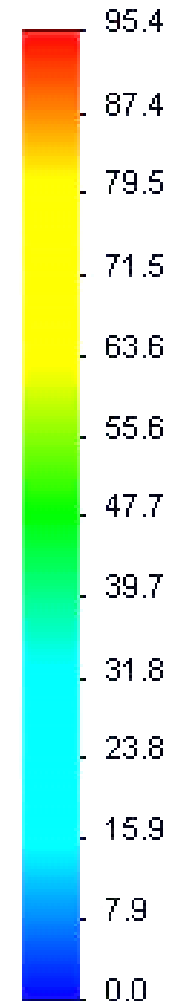
Interlocking Groove



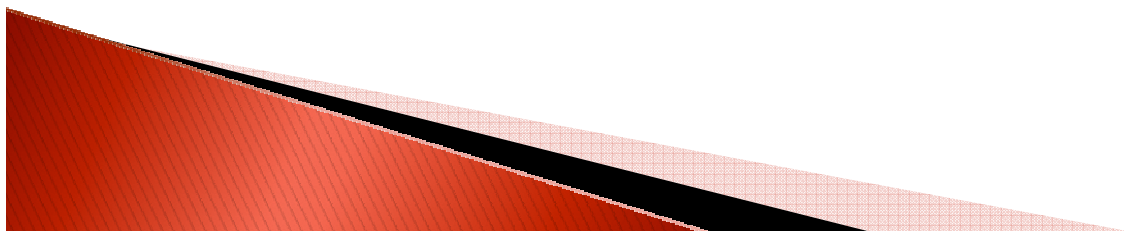
Finite Element Analysis



von Mises (N/mm² (MPa))

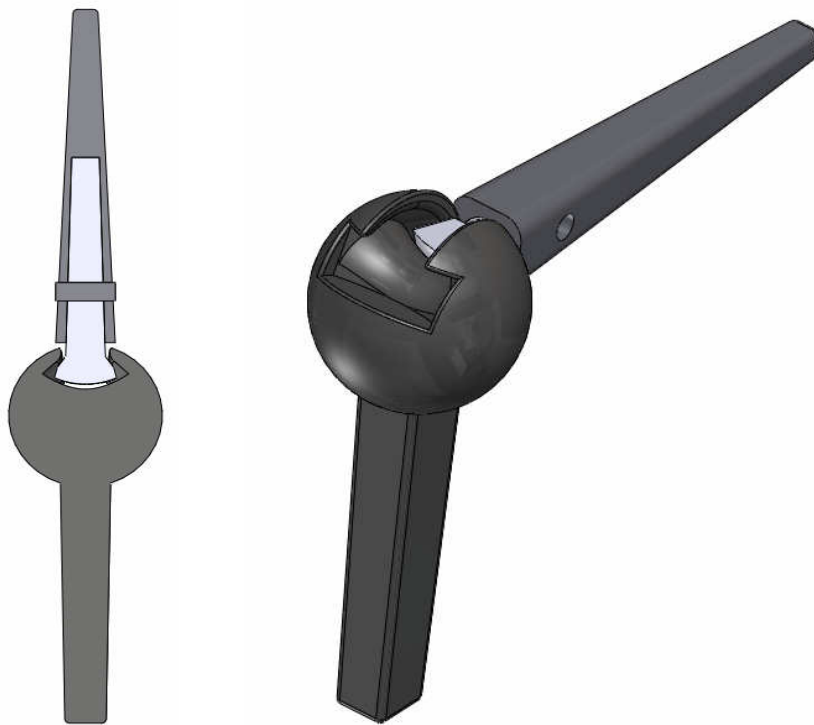


- ▶ UHMWPE yield strength: 19.6 MPa →

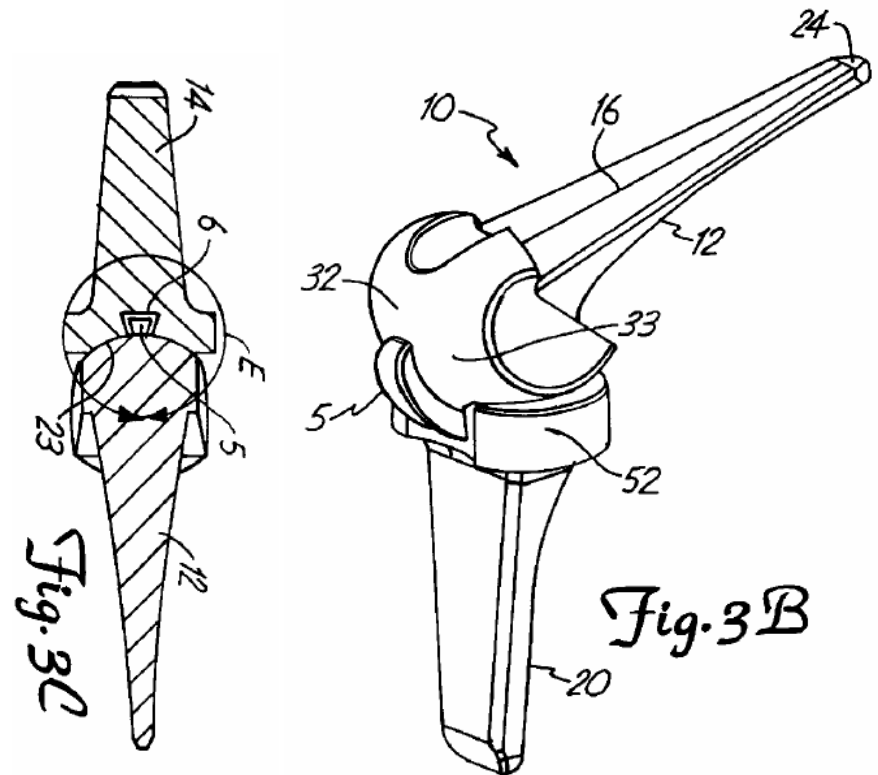


Comparison of Designs

Interlocking Groove Design

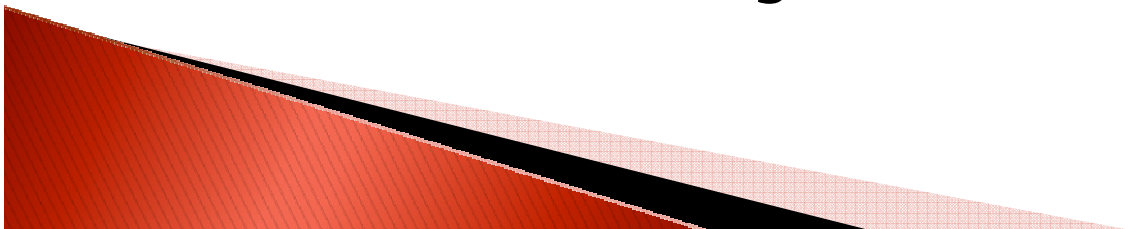


Patent # 5,938,700



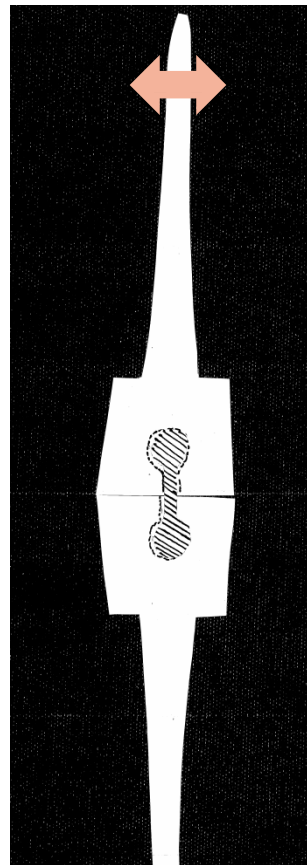
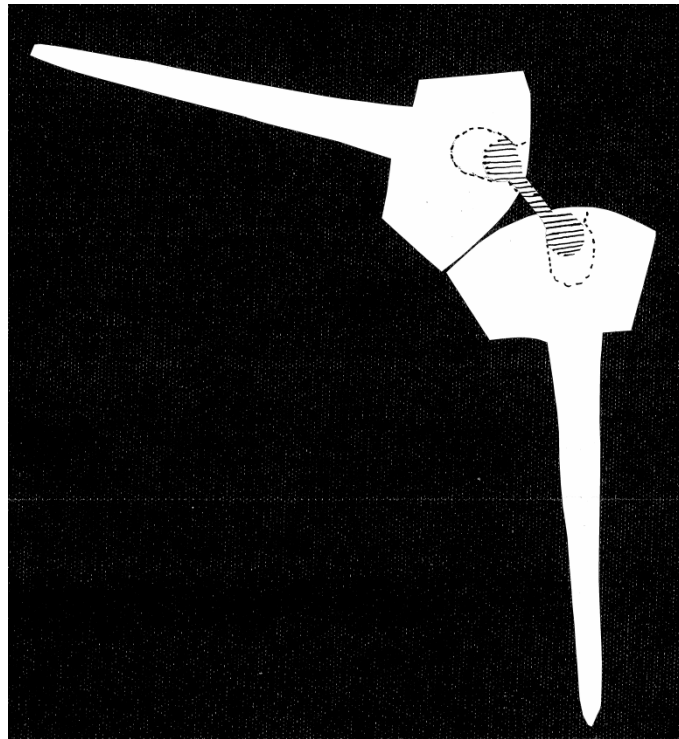
Midsemester Progress

- ▶ Contacted patent owner
 - ▶ Next Step: Premarket Approval (PMA)
- ▶ Considered artificial ligaments
 - ▶ Natural
 - ▶ Synthetic
 - ▶ Wire
- ▶ Brainstormed new designs
 - ▶ Barbell Linkage
- ▶ Reconsidered old designs
 - ▶ Rockin' Hinge



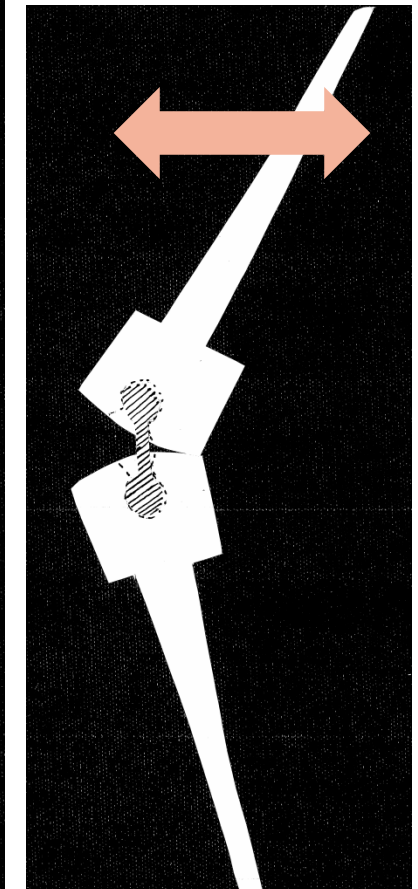
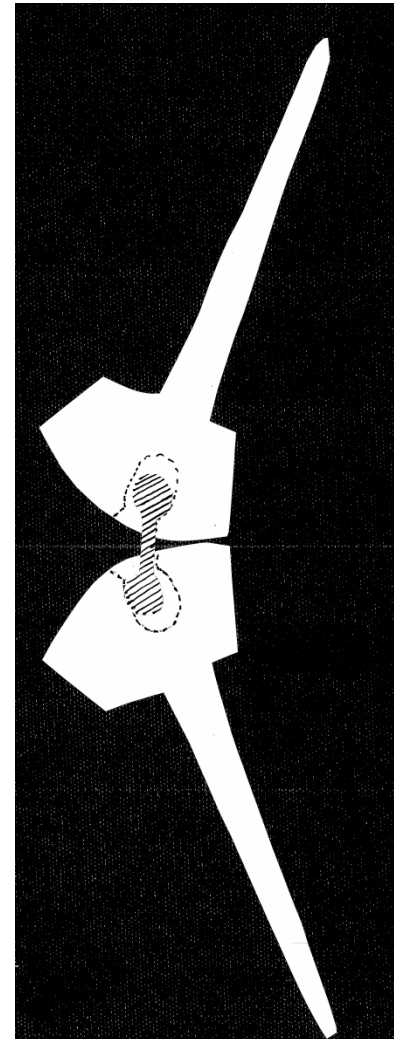
Barbell Linkage

Full Flexion



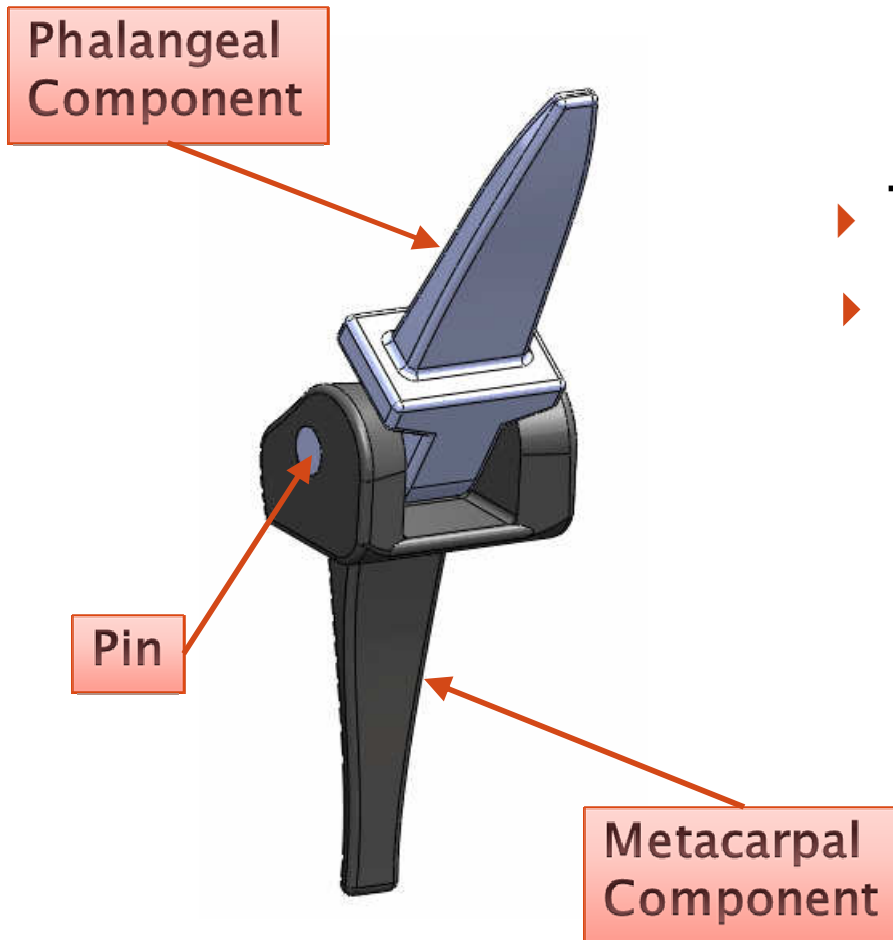
Limited
ad/abduction

Full Extension



Full
ad/abduction

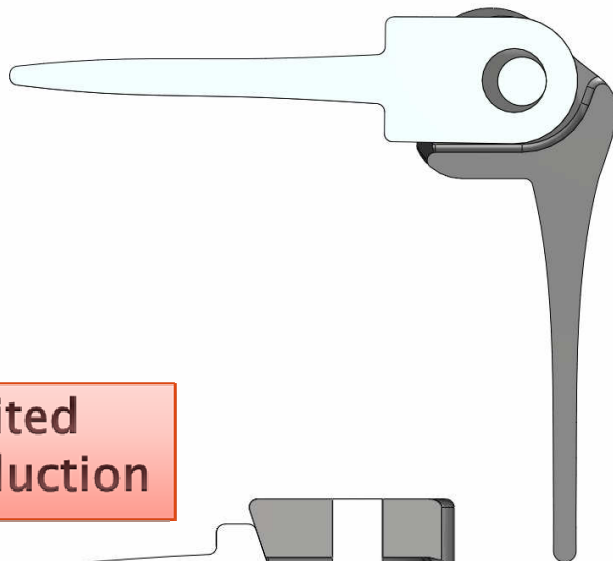
Rockin' Hinge



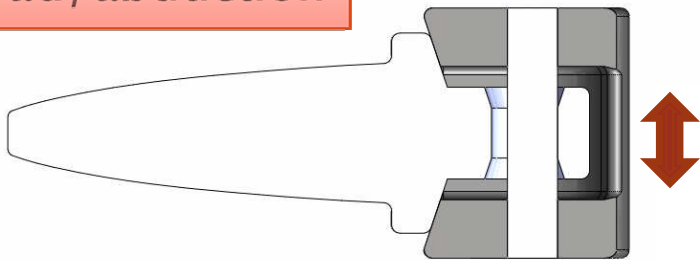
- ▶ Three-piece hinge
- ▶ Novel features
 - ▶ Force-damping pin
 - ▶ Ad/abduction

Range of Motion

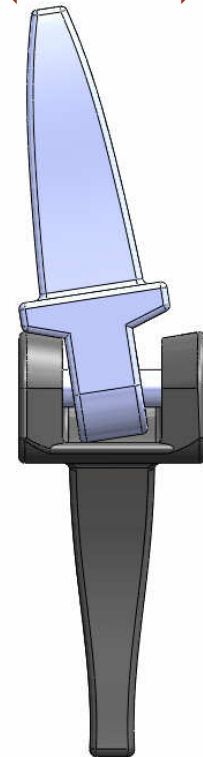
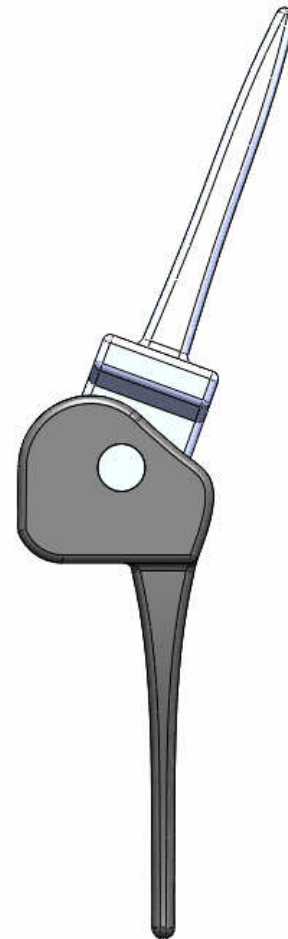
Full Flexion



Limited
ad/abduction

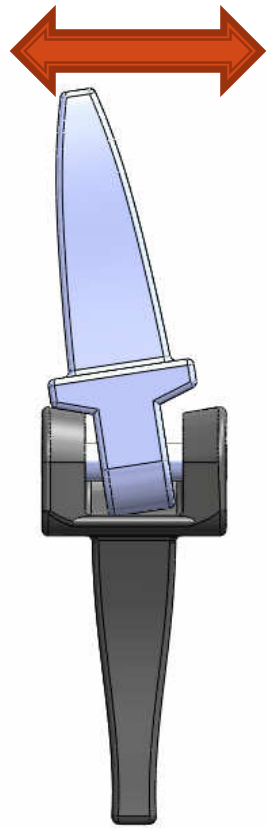


Full Extension

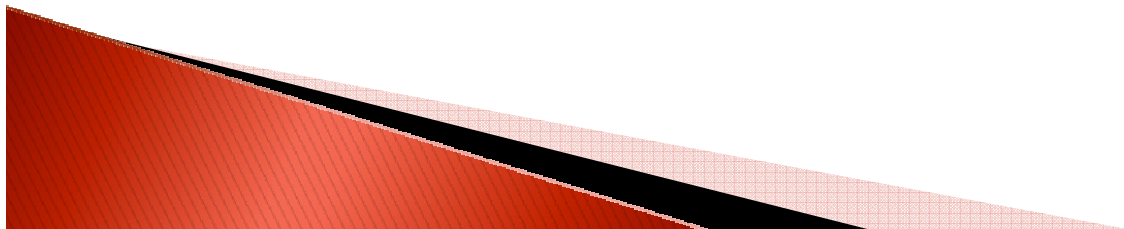


Full
ad/abduction

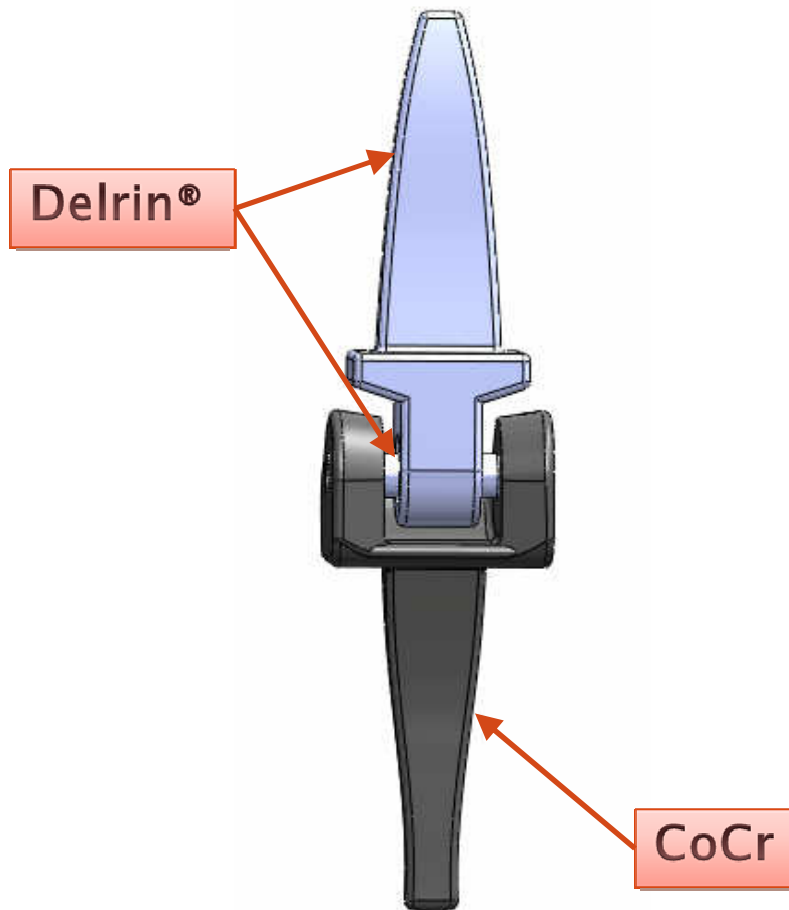
Rockin' Hinge



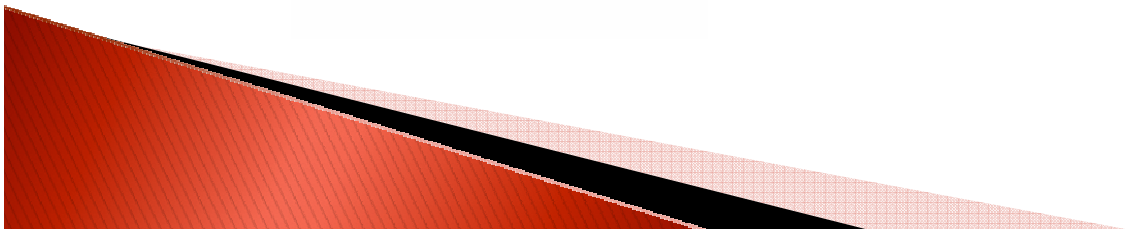
Range of Motion	Interlocking Groove	Rockin' Hinge	Functional
Flexion	90°	90°	90°
Extension	45°	20°	20°
Maximum Ad/abduction	10°	29°	32°



Materials

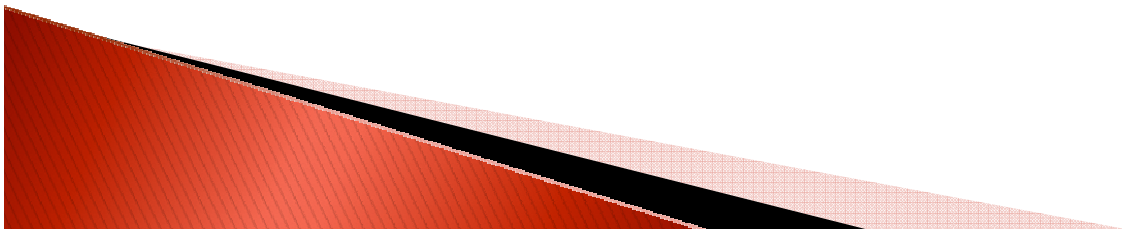
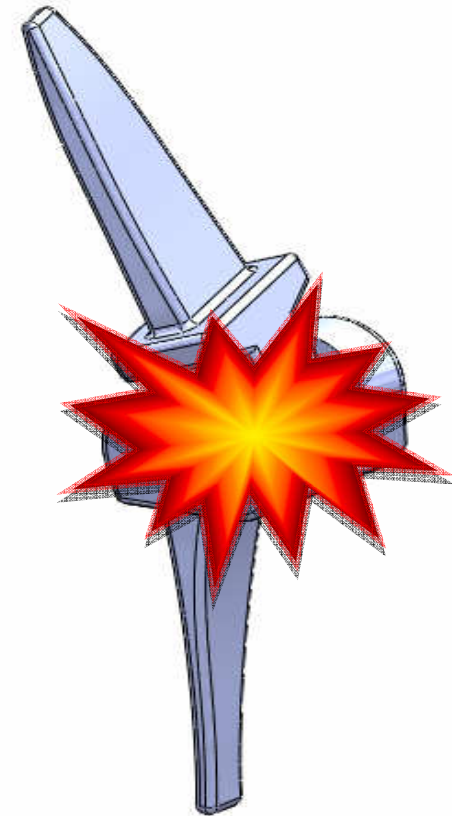


- ▶ Materials
 - ▶ CoCr
 - ▶ Metacarpal component
 - ▶ Delrin®
 - ▶ Phalangeal component
 - ▶ Pin



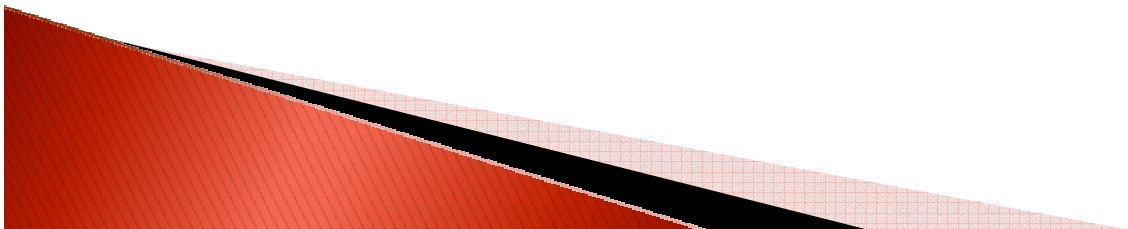
Failure Mode

- ▶ Fails at articulating surface
 - ▶ Preserves osteointegration
 - ▶ Has replaceable joint mechanism



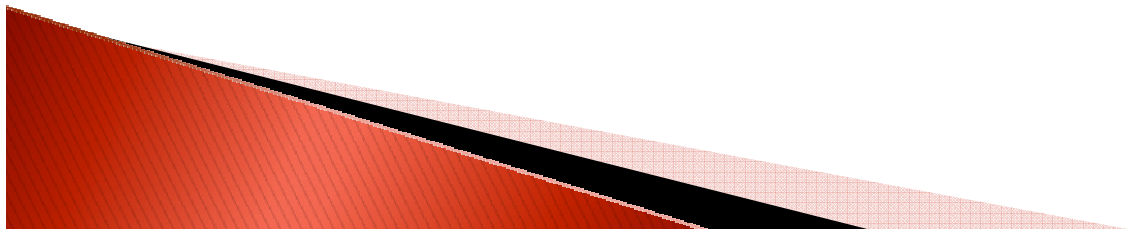
Future Work

- ▶ Optimize SolidWorks model
- ▶ Perform finite element analysis
 - ▶ Failure mode
- ▶ Fabricate out of aluminum and Delrin®
- ▶ Implant into cadaveric hand
 - ▶ Ease of implantation
 - ▶ Range of motion



Acknowledgements

- ▶ Professor Naomi Chesler (advisor)
- ▶ Dr. Ramzi Shehadi (client)
- ▶ Professor Heidi Ploeg and students
- ▶ Professor Darryl Thelen
- ▶ Dr. Curt Irwin
- ▶ Professor Ed Bersu
- ▶ Professor Tim Osswald
- ▶ Dr. Bill Checovich
- ▶ Professor Jay Samuel



References

1. Pylios, T and Shepard, DT. A new metacarpophalangeal joint prosthesis. Proceedings of the World Congress on Engineering. 2: 2007.
2. Modified from: Kleinert, HE, Sunil, TM. Use of volar plate for reconstructing the radial collateral ligament after metacarpophalangeal arthroplasty of fingers in rheumatoid arthritis: Surgical technique. *J Hand Surg.* 2005; 30(2): 390–393.

