Design of a System to Study Human Disc Strains in Torsion and Compression Measured Noninvasively

Valerie Walters
Virginia Polytechnic Institute and State University
Advisor: Dawn M. Elliot, PhD
Graduate Student: Jonathon Yoder

SUNFEST Symposium

August 6, 2009

Agenda

- Intervertebral Disc
  - Functions
  - Anatomy
  - Disc Degeneration
- Previous Studies
- Objectives
- Design Process
- Protocols

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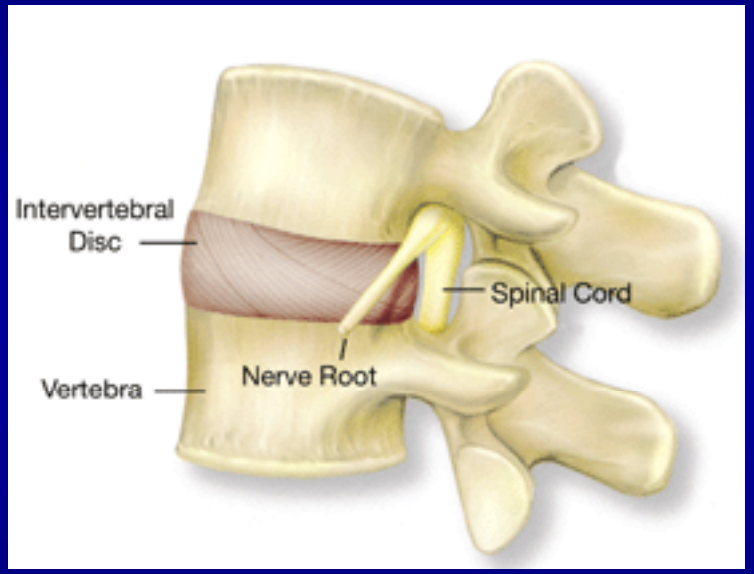
Intervertebral Disc

- Spine is made of repeating segments
  - Vertebrae
  - Intervertebral discs (IVDs)
- IVDs purpose:
  - Shock absorber
  - Pivot point
  - Distribute stress



http://www.zimmerindia.com/z/ctl/op/global/action/1/id/7753/template/PC/navid/7590

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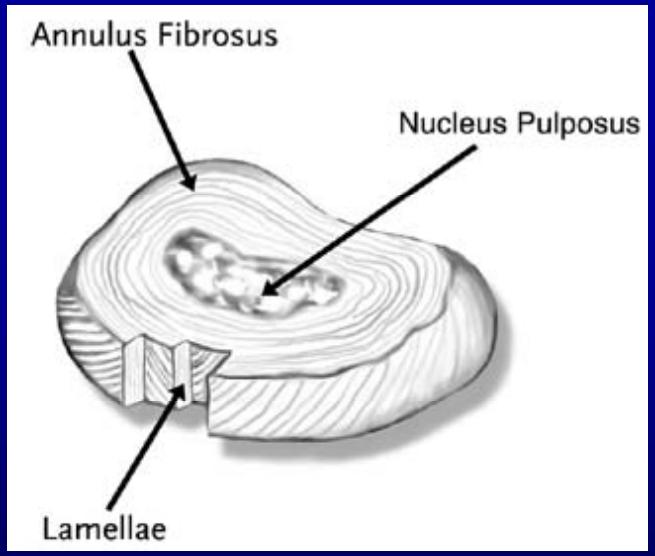
Disc Anatomy

- **Annulus Fibrosus (AF)**
  - **Composed of layers of collagen fibers known as lamellae**
- **Nucleus Pulposus (NP)**
  - **Gelatinous**
  - **Enclosed by the annulus fibrosus**



http://indyspinemd.com/Images/normalAnat/IntervertebralDisc.jpg

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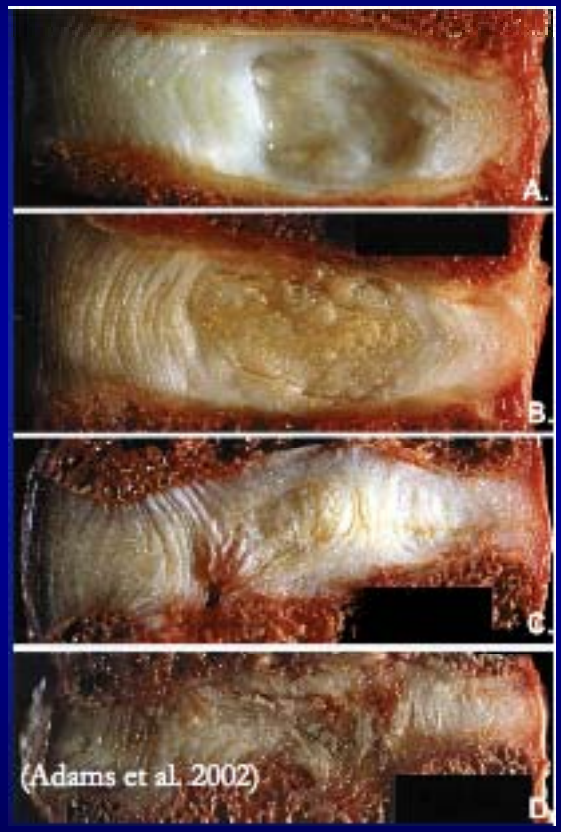
Disc Degeneration

- Structural changes
  - NP loses fluid
    - Becomes semi-gelatinous
  - Tears in the AF
- Advanced signs of aging
- Pain



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Previous Studies

- **Farfan *et al* 1970**
  - **Failure of joints**
    - **Non-degenerative discs: 8.81 Nm, 22.6°**
    - **Degenerative discs: 5.38 Nm, 14.3°**
- **McGlashen *et al* 1987**
  - **Average angle displacements at 15.7 Nm**
    - **Non-degenerated, intact: 3.38°, (1.03°)**
    - **Non-degenerated, isolated: 9.27°, (3.23°)**
- **Haughton *et al* 1999**
  - **Non-degenerated discs stiffness was twice that of degenerated discs**

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Limitations of Previous Studies

- **Physical Markers**
  - **Move separately from the tissue**
  - **Disrupt the structural integrity**
  - **Alter the deformation of the disc**
- **Non-weight bearing studies**
  - **No compressive force**
- **Strain was not quantified**

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Objective

- **Entire Project:**
  - **To quantify strain in normal and degenerated human lumbar IVD due to torsion and compression, measured noninvasively using a combination of MRI and ANTS (advanced normalization tools).**
- **Summer Project:**
  - **To design a device that is MRI compatible and will load the specimen in torsion and compression, simultaneously.**

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Criteria

- MRI compatible torque & compression load cell
  - Cooper Instruments: LXT-900
- MRI compatible hydraulic cylinder (linear motion)
  - Clippard Minimatic: URR-17-1/2
- MRI compatible rotary actuator
  - BIMBA
- No metal components within ~8” of the specimen

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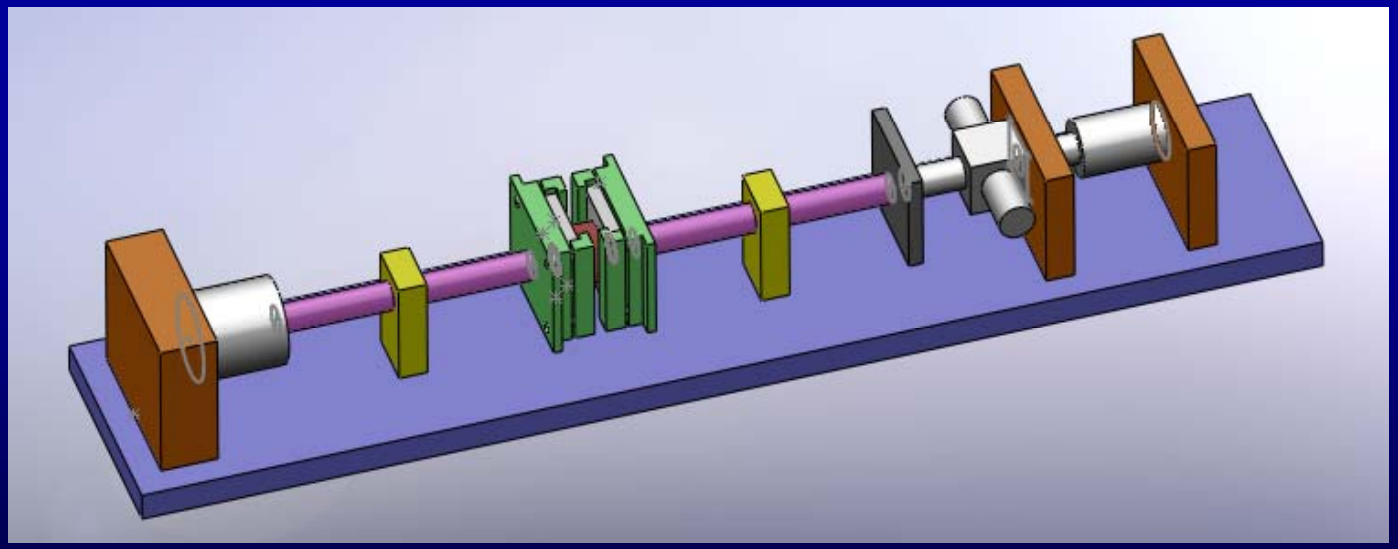
Preliminary Design

- Delrin and PVC plastic
- T-slot grips
- Minimize bending moments
  - Bearing supports



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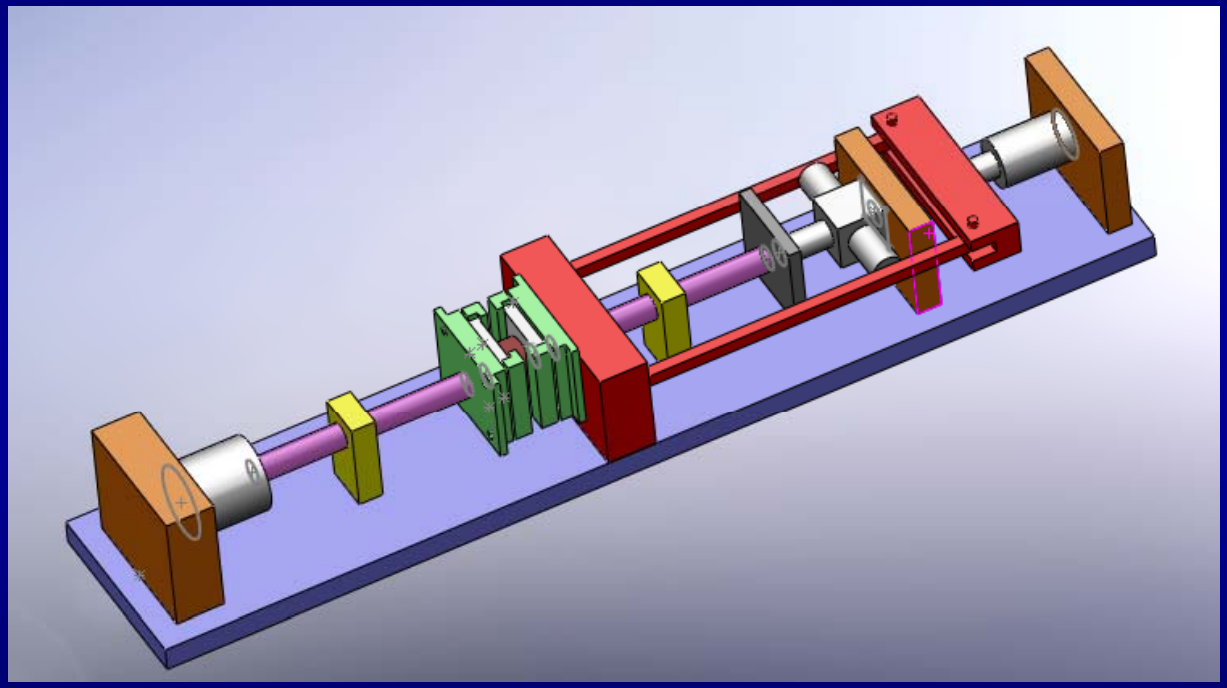
Preliminary Design

- Mimics current compressive device



- Issue:
  - Delrin rod would be loaded in tension

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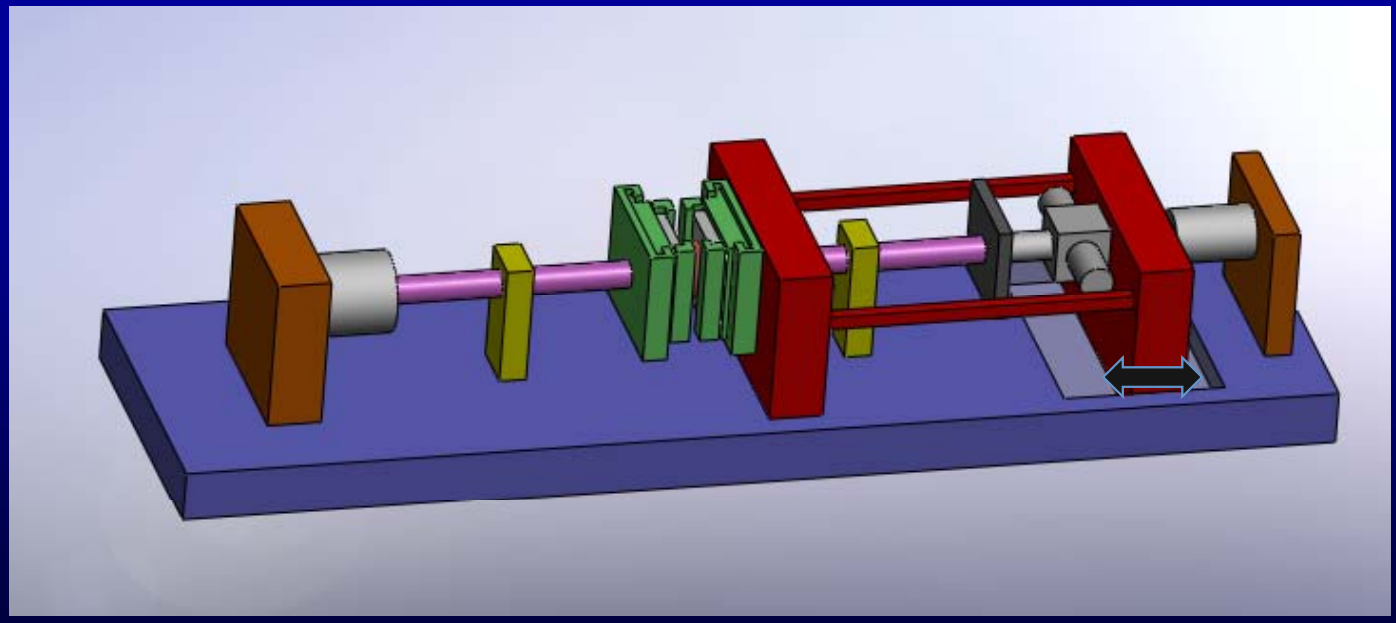
Design

- Current Design
- Issues:
  - Exact dimensions are unknown
    - Will be determined by MRI testing



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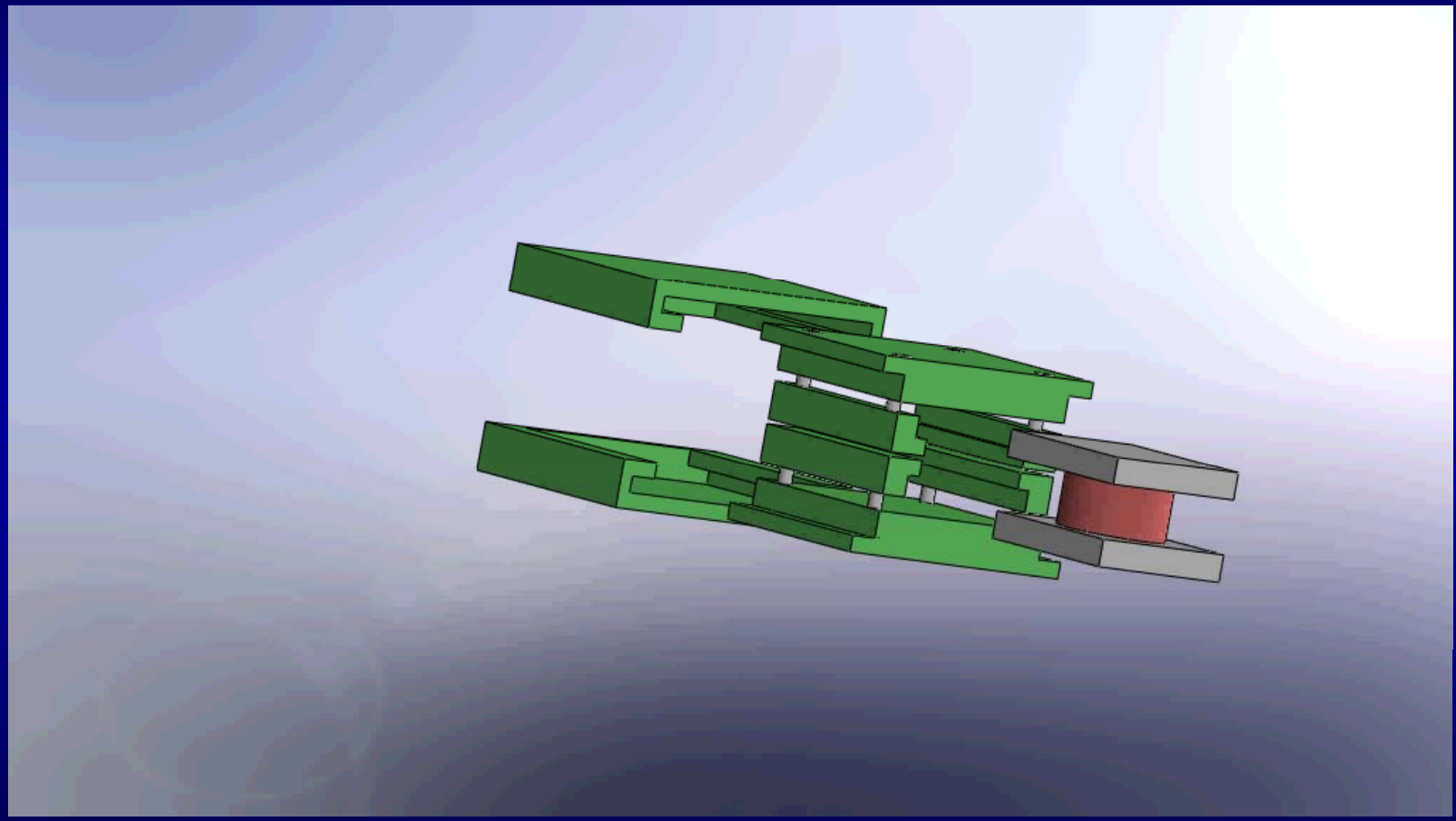
Design Grips



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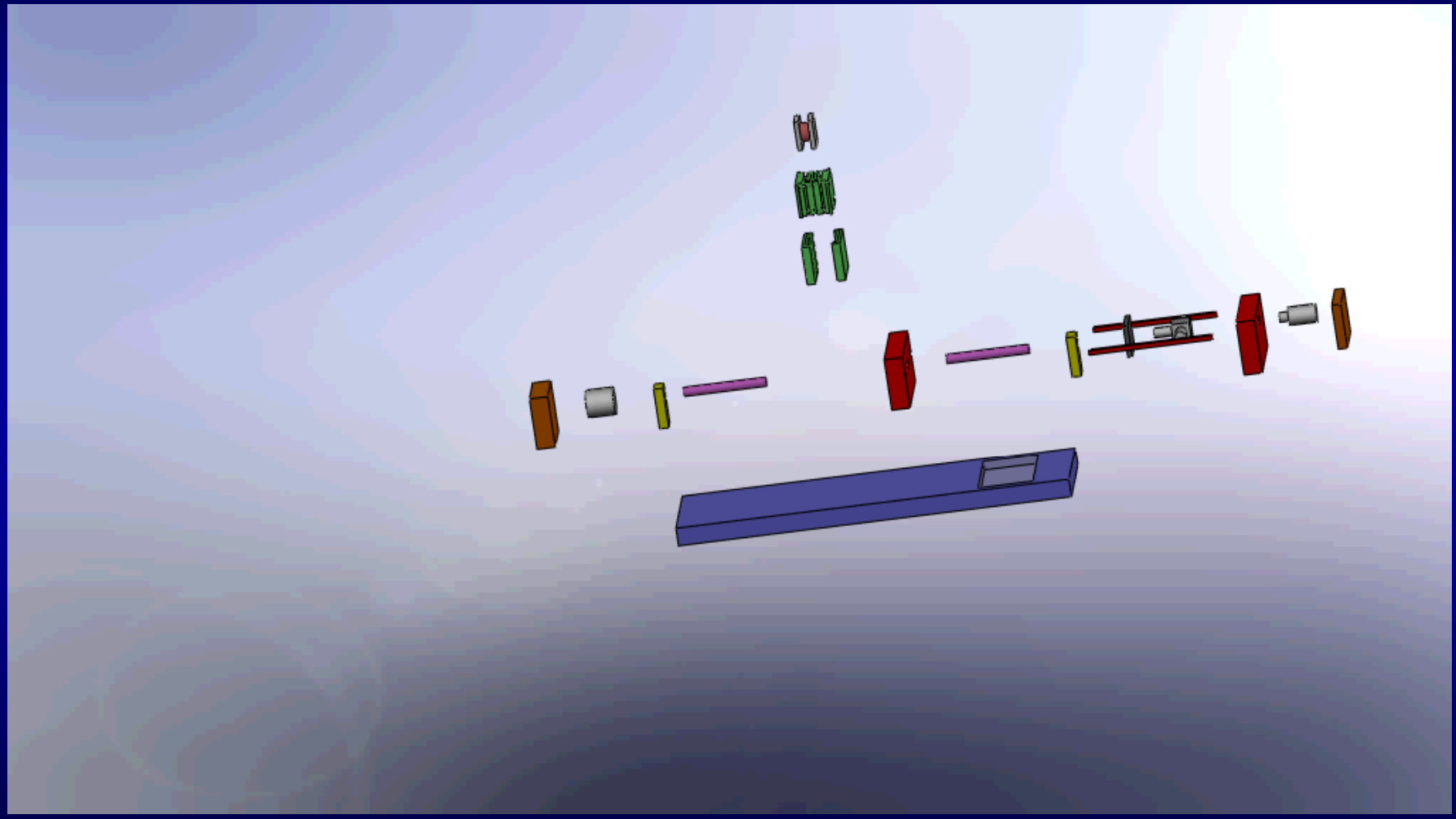
Design



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Protocol

- Constant compressive load, 750 N
  - Average disc area: 1560 mm^2
  - Desired Stress: 0.48 MPa
- Displacement control will be used for the torsion
  - 2°, 4°, and 6°
    - Common displacements *in vivo*

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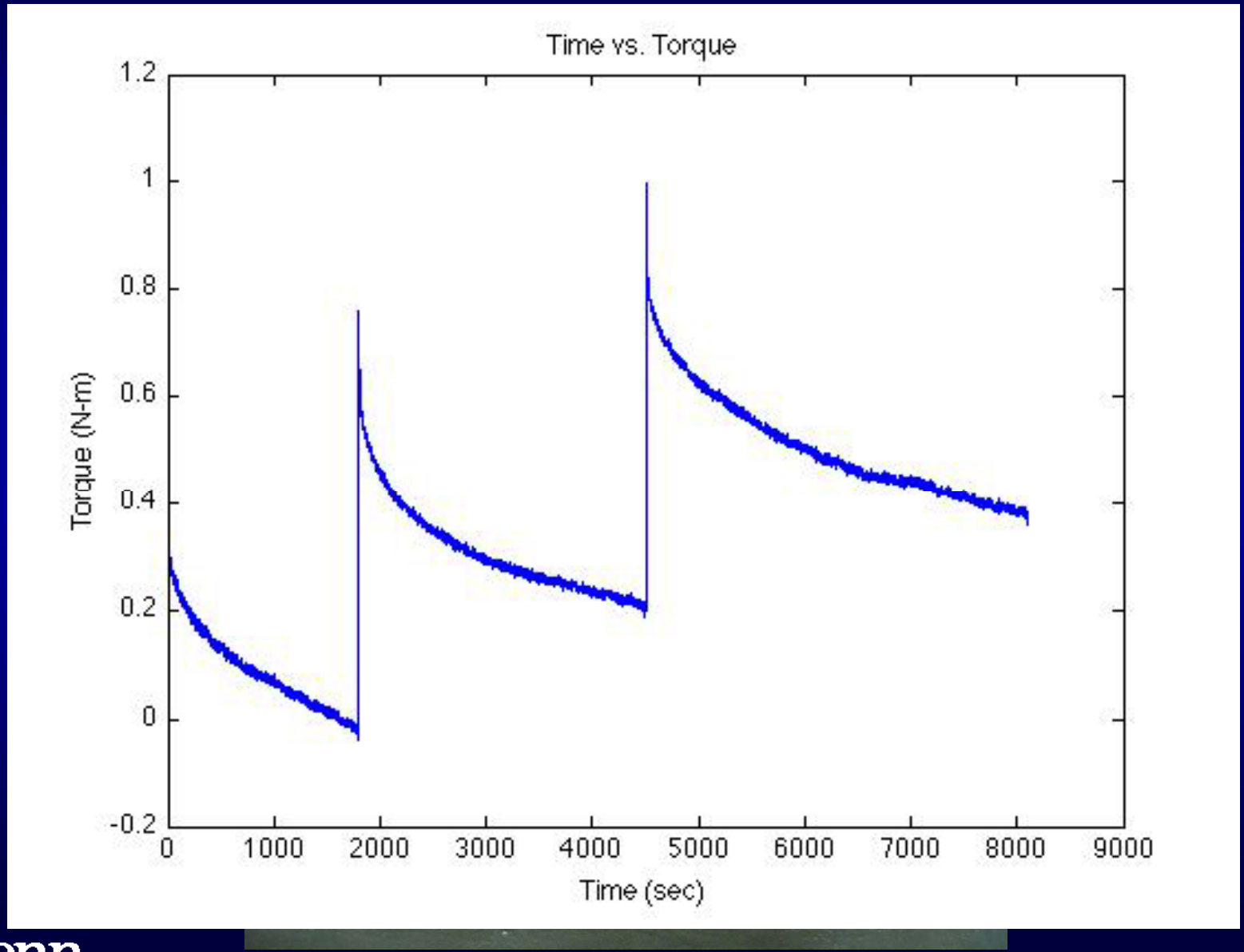
Preliminary Tests



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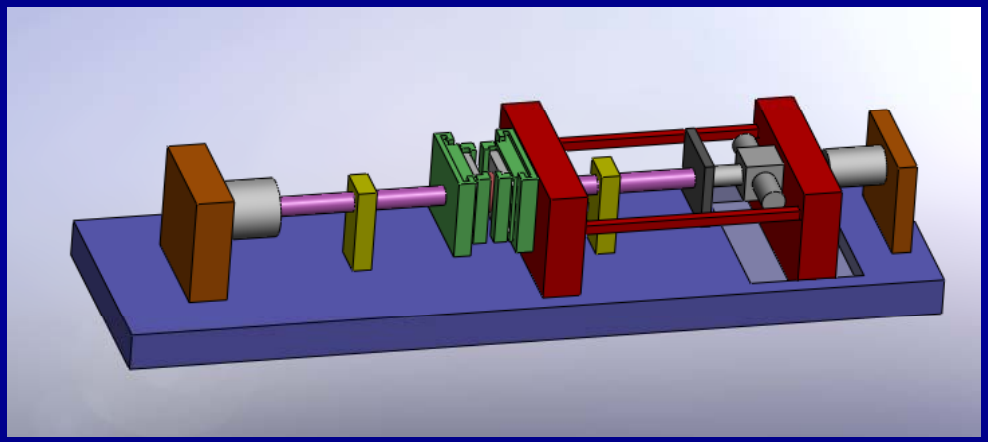
Conclusions

- **The Design**
  - **Exact dimensions are unknown**



- **Testing Protocol**
  - **Late-stage development**

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Thank You

- National Science Foundation
  - Jan Van der Spiegel / SUNFEST
- McKay Orthopedic Research Laboratory
  - Dawn M. Elliot, PhD
  - Jonathon Yoder

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Thank You

Supported by the
National Institutes of Health

NIAMS
National Institute of Arthritis and Musculoskeletal and Skin Diseases