SUNFEST 2004: Final Presentation

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Two Projects

♦ Primary: Mouse Intervertebral Disc (IVD) Imaging and Analysis Protocol Enhancement

♦ Secondary: Compression Testing Device
Compression Testing Device

Wade Johannessen: project advisor
Background

♦ Graduate thesis…
  – Disc degeneration begins in the nucleus pulposus
  – Direct compressive testing is needed on both healthy and degenerated nucleus samples

♦ The Device
  – Applies a load directly to the sample
  – Using computer interface, measures and displays compressive force applied and sample displacement
• Motor
• LVDT
• Sample chamber
• Load sensor

How it works...
Procedure

♦ Assemble parts
♦ Calibration
  – LVDT
  – Load sensor
♦ Create computer interface
♦ Test on various samples
LVDT calibration

Voltage vs. Position

final relationship: position $\rightarrow 0.5515 \times V$

$y = 0.5515x + 15.927$

$R^2 = 1$
Currently and Future

♦ All parts have arrived
  – Some remain to be assembled
♦ Finish creating interface
♦ Test
Mouse Intervertebral Disc Imaging and Analysis Protocol Enhancement

Chandra S. Yerramalli: project advisor
Background

♦ Former senior design project
  – Premise: Create a mechanical model of the mouse IVD
  – Use this information to then model the human lumbar disc

♦ Designed a protocol which would:
  – Show both the gross disc and nucleus pulposus areas separately
  – Calculate area measurements
Previous Project

Block / Process Diagram

Mouse Specimen ➔ Spine/ tail Dissection ➔ Fix spine/tail in Formalin solution

Use microtome to create flat surface for measurement

Fix spine/tail in Formalin solution ➔ Stain IVD cross-section ➔ Create IVD cross-section

Mount IVD on slide (optional)

Stain IVD cross-section ➔ Make digital image using light microscope ➔ Input image into software; extract areas

* Copied from Patrick Antkowiak’s slide presentation
The Intervertebral Disc

My Project

- Protocol enhancement
  - Improving the sectioning, staining and imaging process
  - Add more measurements to the MatLab program

- Three Steps:
  1. Understanding the former protocol
  2. Devise improvements/enhancements
  3. Execute new, improved protocol
Obstacles/Difficulties

- Working with soft tissues
- Finding out which methods for staining, sectioning, etc. worked best
- Working on two projects at once
- No programming experience
Improving the sectioning and staining
Improving the MatLab program

♦ Original Outputs
  - Gross disc area
  - Nucleus area
  - Annulus area
  - Binary image of the disc and nucleus

♦ Current Outputs
  - All those mentioned before plus…
  - A plot of the major and minor axes of both the gross disc and nucleus, as well as the centroids of both
  - Length of all axes
  - “offset value”: the distance between the two centroids
  - Aspect ratio (maj axis/min axis)
Use the crosshairs and click points to select the entire diad.

Right-click the mouse when you have finished selecting the region.
Use the crosshairs and click points to select the entire disc.

Right-click the mouse when you have finished selecting the region.

Now, do the same this time outlining the nucleus.
Select the endpoints of the disc minor axis, from top to bottom. Then hit ENTER.

Now select the endpoints of the disc major axis, from left to right. Then hit ENTER.

Now select the endpoints of the NP minor axis, from top to bottom. Then hit ENTER.

Finally, select the endpoints of the NP major axis, from left to right. Then hit ENTER.
Select the endpoints of the disc minor axis, from top to bottom. Then hit ENTER.

Now select the endpoints of the disc major axis, from left to right. Then hit ENTER.

Now select the endpoints of the NP minor axis, from top to bottom. Then hit ENTER.

Finally, select the endpoints of the NP major axis, from left to right. Then hit ENTER.
But wait...

- These clicks are at random
- How do we know the resulting centroid plots, major and minor axes, and all the measurements based off them are valid?
- Short study
  - 15 trials of random clicks on the same disc
  - Compiled the function outputs for all trials
  - Took average and standard deviation measurements
Percent Deviation vs. Area Measurements

- Gross Area: 0.97%
- Anulus Area: 1.83%
- Nucleus Area: 1.39%
- % Nucleus: 1.37%
Percent Deviation vs. Measurements

- Centroid separation: 12.65%
- Aspect ratio, gross: 1.06%
- Aspect ratio, np: 2.74%
Next Steps

♦ Explore other methods of calculating and plotting the axes
♦ Use this protocol in a study
  – Compare geometric properties and see if a correlation between that and mechanical properties exists
Takeaways

♦ Programming experience
♦ Dissection
♦ Familiarity with lab equipment
♦ Basic understanding of the spine and biomechanics in general
♦ How research is done
  – From idea to abstract to journal article
♦ Insight into future career path
Thank you!

♦ Dr. Louis Soslowsky and Dr. Dawn Elliott
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♦ SUNFEST
♦ You!
Questions?