



RESPONSIVENESS OF A SEMI-AUTOMATED NOVEL METHOD OF MEASURING CARTILAGE LOSS IN KNEE OSTEOARTHRITIS OVER TWO YEARS USING 3T DESS 3D MRI .

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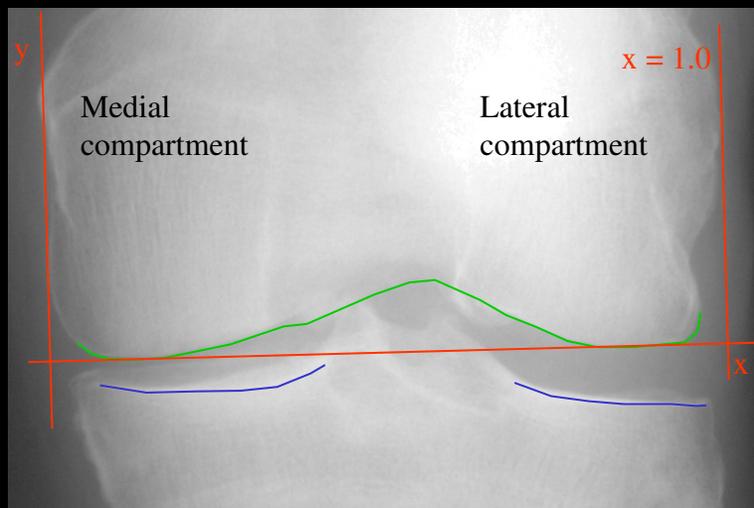
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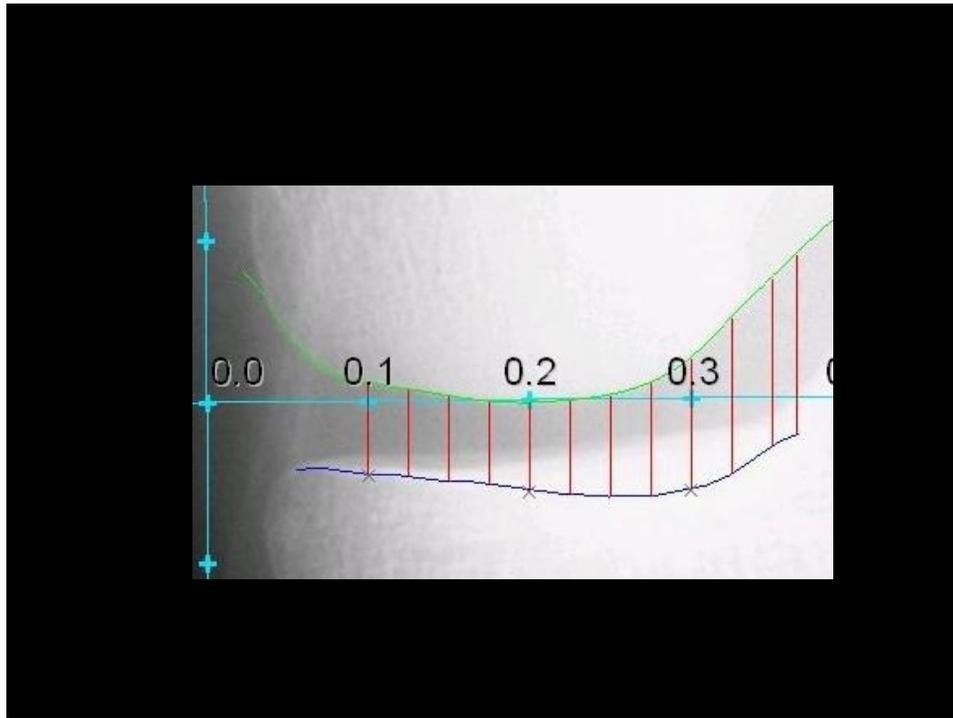
Motivation (OAI)

- 38,337 individual 3D (DESS pulse sequence) MRI scans (BL - 48mo)
- These need to be read at some point.
- Assuming 1 hour/scan, total reader time is 24 years!
- **Goal:** Substantially reduce the reader time.
- At 5 minutes/knee...2 years total time.

Location-specific joint space width (JSW)

Locations are relative to the knee
(dimensionless)

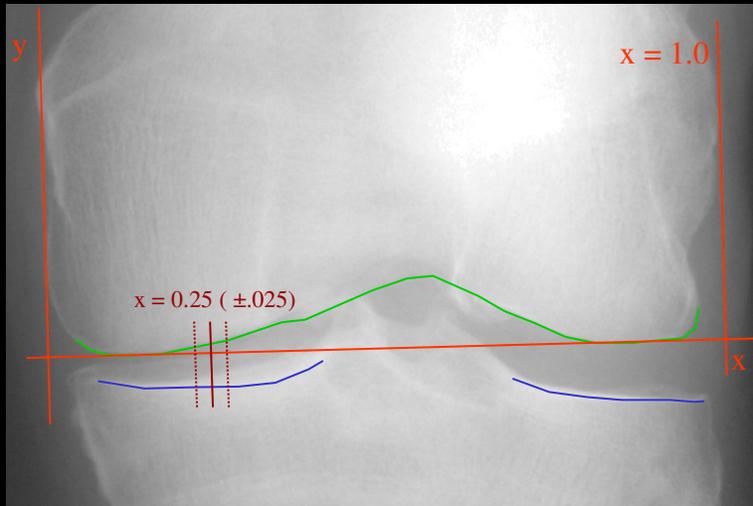




Advantages of location Specific JSW

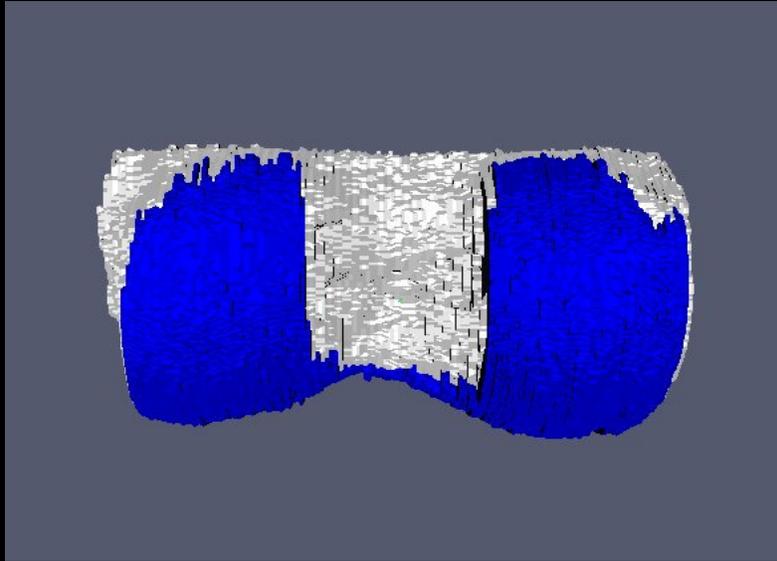
- Consistent definition of space for cross sectional and longitudinal studies
- Look at other structural measures (e.g. ROIs for bone texture measures)
- **No need to fully delineate joint margins.**

Measure in a limited region

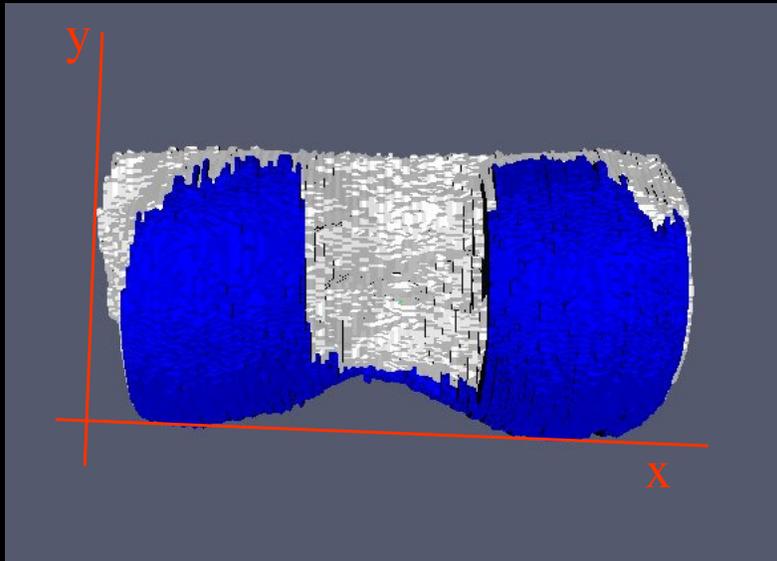


Local-area cartilage segmentation (LACS)

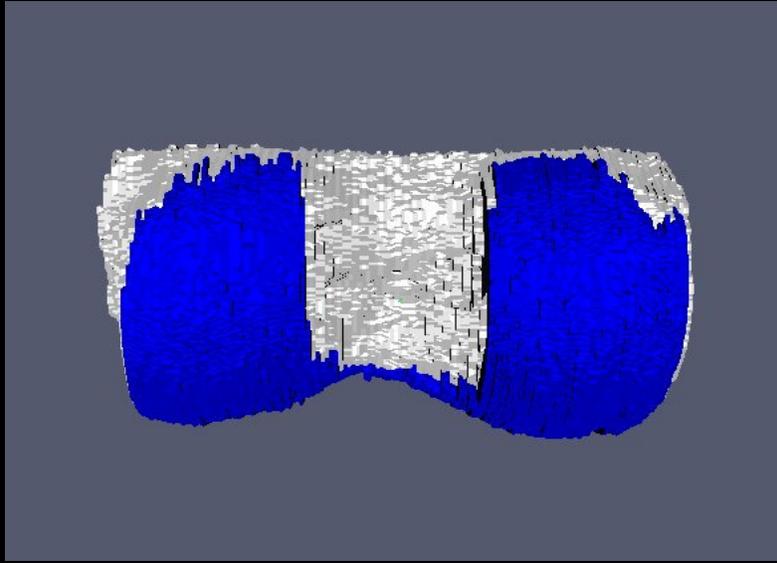
MRI



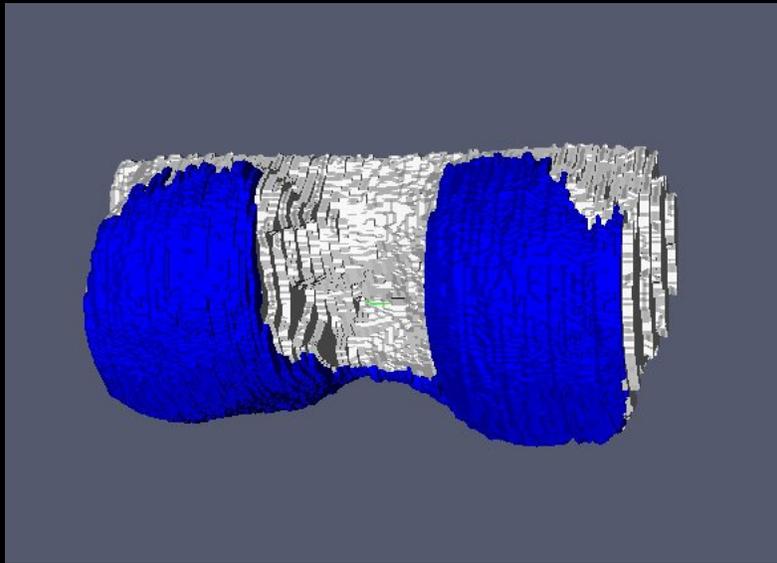
MRI



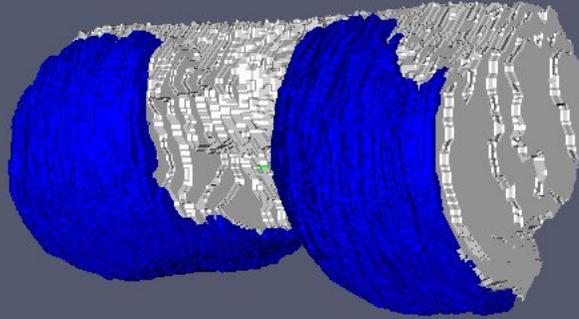
MRI



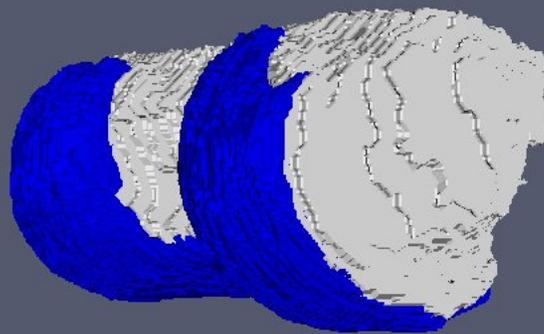
MRI



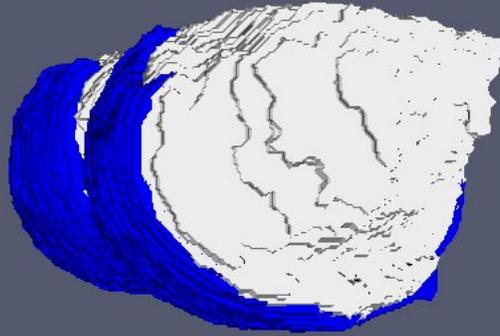
MRI



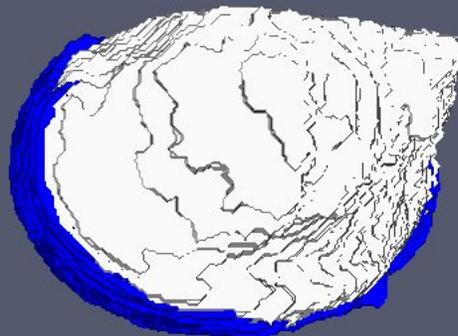
MRI



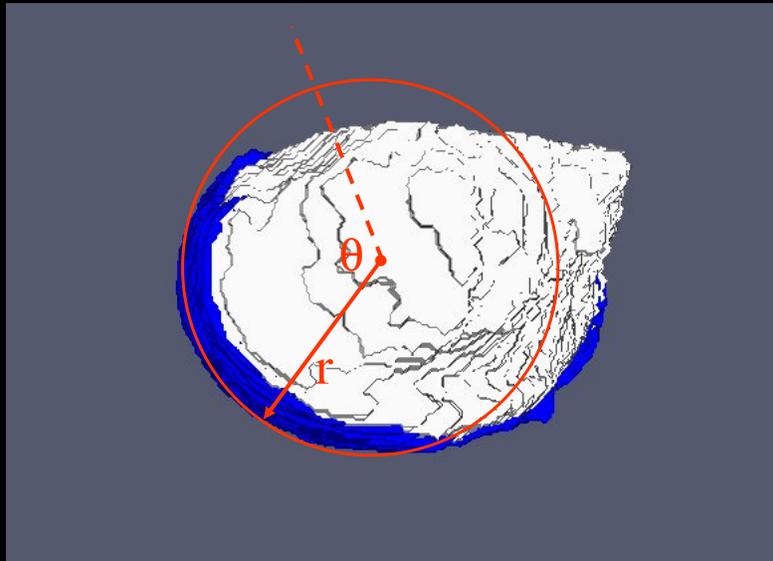
MRI



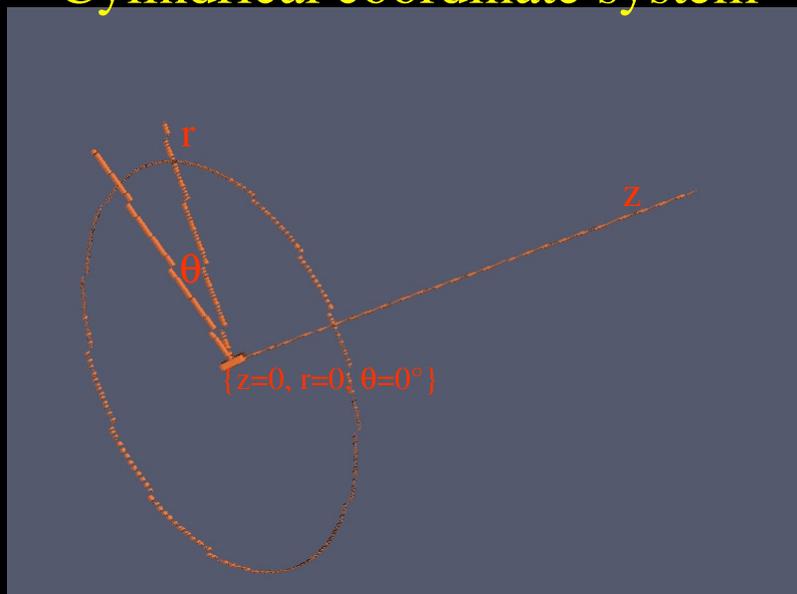
MRI



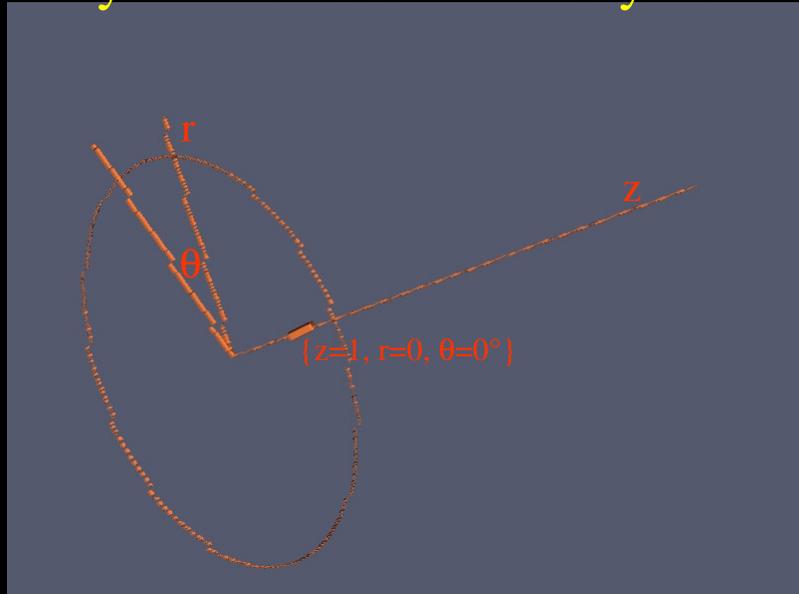
MRI



Cylindrical coordinate system



Cylindrical coordinate system



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Cylindrical coordinate system



Cylindrical coordinate system



Cylindrical coordinate system



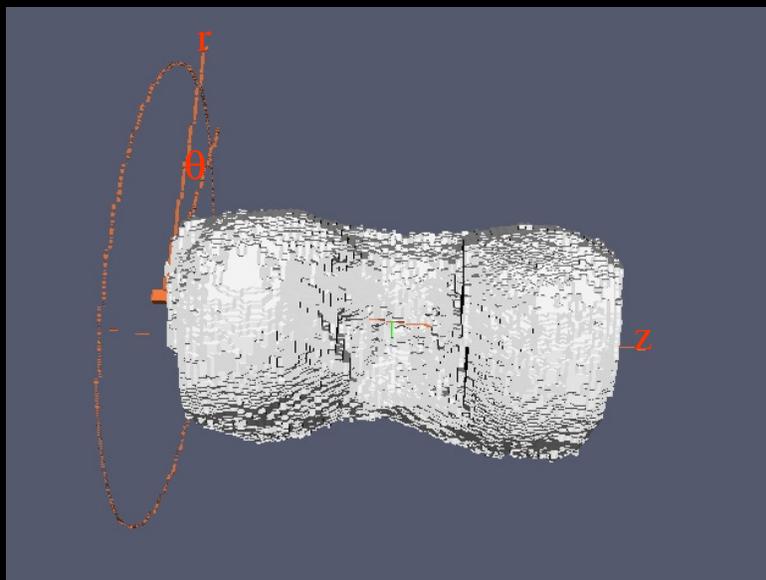
Cylindrical coordinate system



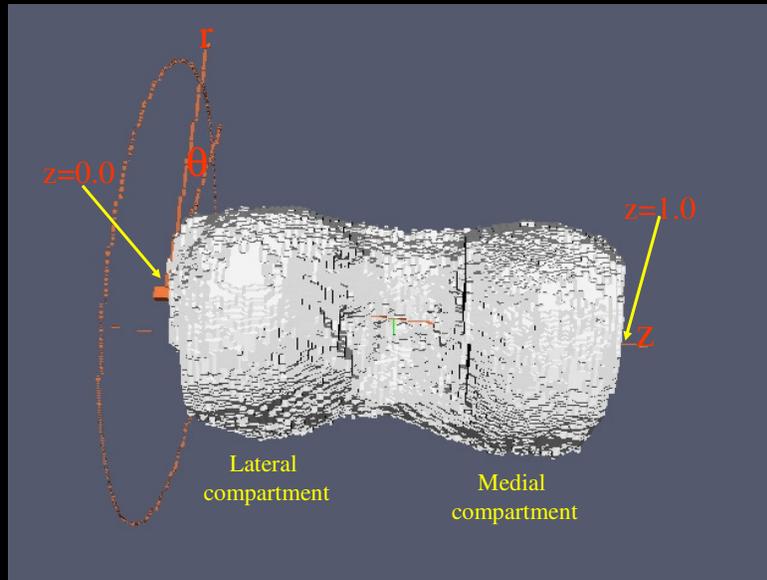
Cylindrical coordinate system



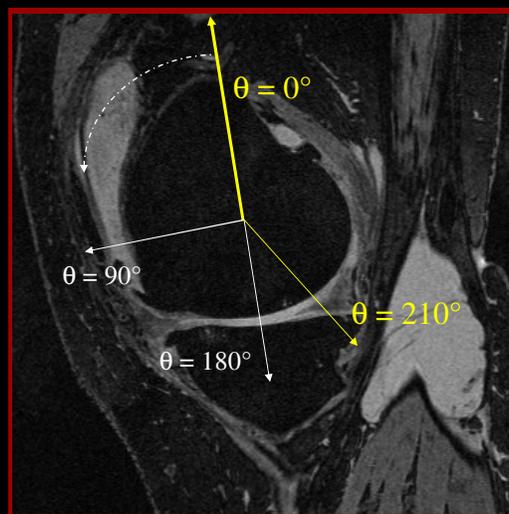
Cylindrical coordinate system



Define $z=0$, $z=1.0$



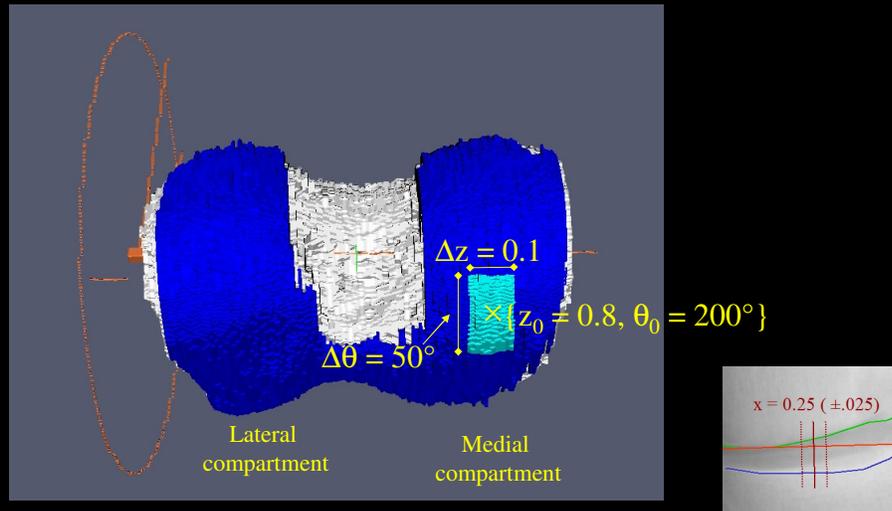
θ coordinate



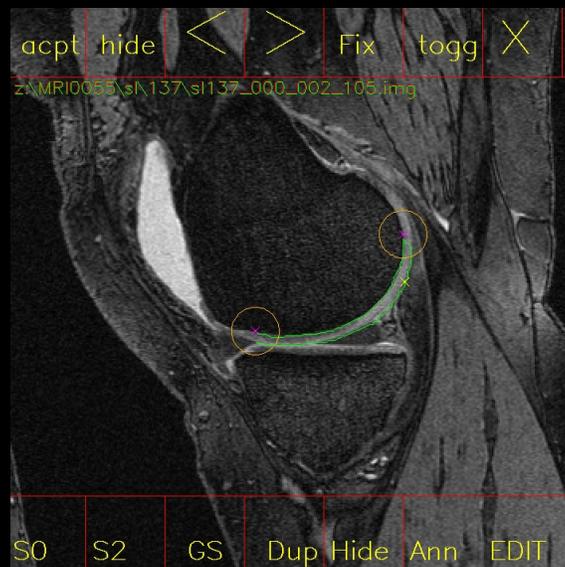
Location specific MRI

Specify by z_0 , Δz , θ_0 , and $\Delta\theta$.

$z_0 = 0.8$, $\Delta z = 0.1$
 $\theta_0 = 200^\circ$, $\Delta\theta = 50^\circ$



Slice segmentation



Validation Study

- **24 subjects:** OAI Progression Cohort (Data Set 0.1.1 and Image Releases 0.B.1 and 1.B.1.)
- **K/L score of 3**
- **Time points:** Baseline and 24 month visits.
- **Pulse sequence:** Siemens Trio 3T scanner using 3D DESS with water excitation
- **Reader was blinded to time point.**

Validation Study

Responsiveness measures:

- Average volume change (ΔV)
- Standard deviation of volume change (SD)
- Standardized response means
 $SRM = \Delta V / SD$

Results (SRM values)

$$z_0 = 0.8, \theta_0 = 210^\circ$$

$\Delta z = 0.10$	$\Delta\theta = 100^\circ$	SRM = -0.71
$\Delta z = 0.08$	$\Delta\theta = 80^\circ$	SRM = -0.66
$\Delta z = 0.06$	$\Delta\theta = 60^\circ$	SRM = -0.55
$\Delta z = 0.04$	$\Delta\theta = 40^\circ$	SRM = -0.60
$\Delta z = 0.02$	$\Delta\theta = 20^\circ$	SRM = -0.39

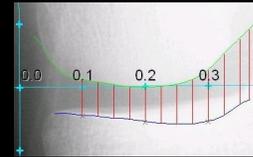
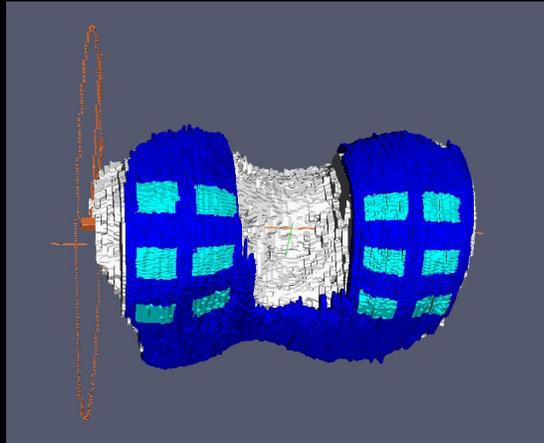


Results

- Method is fast: ~ 10 minutes/knee for the skilled reader
- Only a sub region requires attention
- Reader only has to segment a limited number of slices
- Excellent responsiveness for smaller region ($\Delta z = 0.04, \Delta\theta = 40^\circ$) implies an even faster method.
- **Limitation:** probes a single region

Analysis model #2

Sample multiple fixed locations



Conclusions

- Use of robust coordinate system provides responsive measure of cartilage change
- Method is fast. Potential to assess over 1,000 knees.
- Can be used to quantify additional structures

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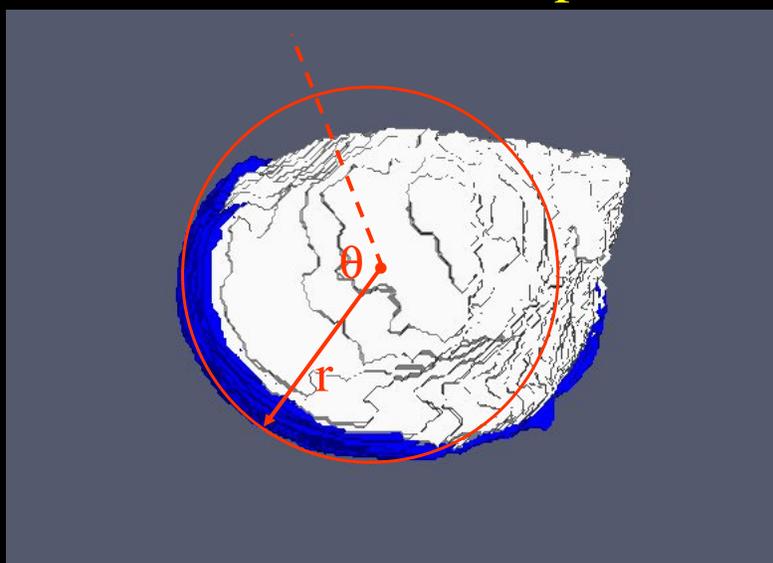
NIH/NIAMS: R01 AR056664
BWH Biomedical Research Institute (BRI)

Conclusions

General 3D gray scale intensity function to characterize every voxel in the image set.

$$I=f(z, \theta, r)$$

Use of r coordinate to characterize shape



Analysis model #3

(Future study)

Pick an indexed location for each knee individually.