Use of OAI Images

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Overview

- Types of Images Available:
  - Imaging schedule
  - Exam types (radiographs/ MRI sequences)
- Image Releases:
  - What has been released and what is still to be released
- Images on Hard Drives:
  - Barcodes and meta-data to find images
  - Where to find more information (online and on hard drive)
- Matching Clinical Data to Images:
  - Imaging meta-data, and Barcodes
  - See handouts for examples of use
- Imaging Biomarkers:
  - What is available and what will become available
  - Using existing biomarkers for selection criteria (see Handouts)
Imaging for “Almost” Everyone

- **Annual Knee Imaging:**
  - bilateral fixed flexion knee radiographs
  - bilateral Knee MRI (3T Siemens Trio)

- **Pelvis and Hand Radiographs:**
  - enrollment and 48-month visits
  - assessing hand/hip OA and overall OA burden

- **Full-Limb Radiograph:**
  - at one visit (12-month, 24-month or 36-month visit)
  - for measurement of limb alignment (varus/valgus)

- **Thigh MRI**
  - enrollment, 24-month and 48-month visits
  - for body composition/muscle assessments
## Annual MRI Knee Imaging

### Knee MRI (3T Siemens Trio – upgrades to TIM Trio)

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Side</th>
<th>Semi-Quantitative Scoring</th>
<th>Quantitative Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal IW TSE (fat suppressed)</td>
<td>R+L</td>
<td>Very useful</td>
<td>n/a</td>
</tr>
<tr>
<td>Coronal IW TSE</td>
<td>R+L</td>
<td>Useful</td>
<td>n/a</td>
</tr>
<tr>
<td>Sagittal 3D DESS WE</td>
<td>R+L</td>
<td>Helps for cartilage</td>
<td>Whole Knee Cartilage</td>
</tr>
<tr>
<td>Coronal MPR from Sag 3D DESS</td>
<td>R+L</td>
<td>Helps for tib-fem joint</td>
<td>Tib-Fem Cartilage (partial)</td>
</tr>
<tr>
<td>Axial MPR from Sag 3D DESS</td>
<td>R+L</td>
<td>Useful for pat-fem joint</td>
<td>Pat-Fem Cartilage</td>
</tr>
<tr>
<td>Coronal T1W 3D FLASH WE</td>
<td>R</td>
<td>Helps for tib-fem cartilage</td>
<td>Tib-Fem Cartilage (partial)</td>
</tr>
<tr>
<td>Sagittal 2D Multi-Echo</td>
<td>R</td>
<td>n/a</td>
<td>T2 Maps</td>
</tr>
</tbody>
</table>
**Additional Imaging**

In subsets of participants only:

- **Additional Knee MRI visits:**
  - *Interim* 18-month visit in 287 (unilateral MRI)
  - *Interim* 30-month visit in ~500 pts (unilateral MRI)
  - *Interim* visits also have clinical outcomes and biospecimen collection

- **Additional Knee Radiographs:**
  - *Fluoro-guided L and R knee: Enrollment, 12-months and 24-months*:
    - protocols differ by site – details in operations manual
  - *Lateral L & R knee: enrollment and 36-month (controls)*
    - only in non-exposed controls to assess patello-femoral OA

* Fluoro in subset of progression subcohort only
Slope of line between beads close to joint line can be used to calculate the approximate angle that the x-rays are hitting film at the joint line.

Beads on left side of image are further from film/detector than beads on right side of image.

Can calculate the approximate position of “center” of joint (for calibration between visits).

Anterior of knee (patella) is at same distance from film/detector as the beads on the right side of the image.

Using slope of lines through 2 pairs of metal beads, a more complete examination of exposure geometry can be made.
Osteoarthritis Initiative

MRI IW TSE Sequences (Bilateral)
3D DESS Sequence (Bilateral)

3D - reconstructed as 0.7mm sagittal slices

MPR Reformats

Osteoarthritis Initiative
Process and organization of image releases

- Images received at the Imaging QC Center (Synarc)
  - undergo QC and cleaning
  - sent to the CC in batches as processing completed

- At CC, images undergo further QC checks
  - additional blinding and removal of private DICOM tags
  - packaged in sets for public release

- Image sets correspond to different groups of participants:
  - Group C: 2686 ppts (all subcohorts)
  - Group E: 2110 ppts (all subcohorts)
  - Group A: 200 ppts (progression/incidence)
  - Group B: 160 ppts (progression)
  - Group D: 278 ppts (progression, with 18-month interim visit)
  - Group F: 122 ppts (non-exposed controls)
Osteoarthritis Initiative

Images Released by mid-November 2008

- **Baseline and 12-month Visit Images:**
  - whole cohort (Groups C & E)
  - 85% of Groups C & E have BL and 12-month knee MRI+XR

- **24-month Visit Images:**
  - early recruits (Group C)
  - 2415/2695 (89%) have 24-month images
  - 81% of Group C BL and 24-month knee MRI+XR

- **Specially Selected Subsets:**
  - *Baseline, 12-month and 24-month images:*
    - Group A: 200 participants (progression/incidence)
    - Group B: 160 participants (progression)
  - *Baseline, 12-month and 18-month images:*
    - Group D: 278 participants (progression)
  - *Baseline and 12-month images:*
    - Group F: 122 participants (non-exposed controls)
Future Image Releases

- In 2009:
  - 24-month images for last group of recruits (Group E)
  - 36-month images for early recruits (Group C)
  - 30-month MRI images (special subset Group D)

- In 2010:
  - 36-month images for last group of recruits (Group E)
  - 48-month images for early recruits (Group C)

- Additional follow-up images for special subsets will be available as the relevant Group C/E images are released.
OAI Images on Hard Drives

- Stored in folders by Group (A, B, C, etc)
  - separate folder for each visit

- Participant ID / Exam Date/ Barcode folders
  - participant ID is UID (7 digits starting with “9”)
  - barcode is unique ID number for a particular radiograph, or images from a particular MR sequence

- Each “barcode” has imaging meta-data
  - downloadable from OAI Online
  - useful for generating lists of files and folders to pull off hard drive
  - meta-data also has QC ratings for images

- Each release comes with DICOM Image Release Notes
Selection of Participants with Images

- Who has images released:
  - 23,716 Radiographs released
  - 12,325,575 images from 169,343 MRI acquisitions released

- Use ENROLLEES dataset (down from OAI Online)
  - prefix V00 is baseline visit, and everyone is in Group C or E

- For baseline images:
  - use variables V00IMAGESC and V00IMAGESE
  - if either > 0, then baseline knee images released:
    - 1 = knee MRI, 2 = knee XR, 3= knee XR+MRI

- Use V01 variables for 12-mo, V03 for 24-mo, etc

- Does NOT tell you about:
  - Hand, Pelvis, Full-Limb x-rays
  - MRI sequences obtained and in which knee
  - Any QC information about images
Imaging Meta-Data

- Imaging meta-data is downloadable from OAI Online:
  - separate datasets for MRI and XRAY
  - separate datasets for each visit

- Can be used to find out:
  - what types of x-rays are available for a specific participant
  - what pulse sequences are available and in which knee
  - any QC rating for the image

- Barcode uniquely identifies:
  - an x-ray image
  - images from a specific MR sequence
  - useful to record this when measuring/reading images

- Handouts go through a case study
  - select based on strict clinical criteria
  - filter based on having to have specific X-Ray + MRI
Imaging Biomarker Data

- Clinic Baseline X-ray readings (for whole cohort):
  - collapsed OARSI grades for JSN and OST
  - calculated quasi-K&L grade
  - read from bilateral fixed flexion x-rays from screening visit

- Central paired knee x-ray readings (Group B, 160ppts):
  - OARSI gradings and K&L Grades at baseline and 12-months
  - identified by V00IMAGESB=1 / V01IMAGESB=1
  - JSW measurements will be released in near future

- Matching Central Readings to Clinical/Demographics:
  - Images analyzed identified by barcode and ID
  - V00XRBCODE / V01XRBCODE in knee x-ray readings
  - Matches to barcode variables in XRAY00 / XRAY01 meta-data
Future Imaging Biomarkers

- Progression Subcohort (600 ppts without end-stage):
  - OARSI gradings and K&L Grades (bl, 12-mo, 24-mo)
  - Joint Space Width measurements (bl, 12-mo, 24-mo)
  - MRI Readings and/or Cartilage Volume/Thickness (bl, 12-mo, 24-mo)

- Results/readings given back to OAI:
  - Hip-Knee-Ankle angle from full-limb radiographs (Progression)
  - Outlines of articular cartilage on MRI scans
  - Good idea to record “barcode(s)” of images analyzed

- Even simple things could be useful to someone else:
  - Position of metal beads on knee x-rays
Summary

- Images Available by mid November 2008:
  - baseline images released for whole cohort
  - 85% have released knee image longitudinally at 12-months
  - 2195 participants have images released at 24-months

- To use images, download data from OAI Online

- Select participants matching clinical criteria
  - “Search & Browse” or Variable Guides to explore
  - “My Cart”, “My Codebook” to customize
  - download data available as SAS or ASCII

- Use Imaging meta-data to find who has required images
  - you may only require specific image types

- Request images from Coordinating Center
  - work out which group(s) of participants you want
Possibilities for the Future

Images for specific lists of participants:
- selection based on downloadable datasets
  - check image meta-data for images you want
- about 500 MB per participant per visit (MRI)
- about 50 MB per participant per visit (XR)
- requestor keeps track of images already provided

Online access to downloadable images:
- about 2TB of data per visit for whole cohort
  - more than 12 million MRI images
  - can compress, but only to about 75% of original size
- Online x-rays might be more feasible
  - about 23,000 x-rays released
Imaging Details Online

- Imaging Schedule:
  - visits and examination schedules:
    http://www.oai.ucsf.edu/datarelease/DataImaging.asp

- Operations Manuals:
  - detailed information on how the images were acquired
    http://www.oai.ucsf.edu/datarelease/DataImaging.asp

- DICOM Image Release Notes:
  - image releases have a set of notes on the hard drive
  - includes types of images, pulse sequence parameters
  - they are also downloadable at:
    http://www.oai.ucsf.edu/datarelease/DataImaging.asp

- Bilateral Fixed Flexion Knee Radiographs:
  - Synaflexer Frame
    - allows correction for magnification differences between visits
    - allows for assessment of beam angle
Osteoarthritis Initiative

Additional Sequences (Unilateral)

Coronal FLASH Multi-echo sequence for T2 Maps
Full Limb and Lateral Knee Radiographs

Limb Alignment (HKA Angle)
Patello-Femoral OA
Pelvis and Hand Radiographs

AP View, Standing with internal rotation

Dominant Hand (or bilateral)
• Axial T1 Weighted Sequence
• 15 contiguous slices (5mm thick)
• available packaged separately
• 4321 participants (mostly baseline visit)
• assessing body composition, muscle, fat, etc
Image Release Nomenclature

Image Releases identified by 3 pieces of information:

- Visit at which images were obtained:
  - Baseline (0), 12-month (1), 18-month (2), 24-month (3), 30-month (4), 36-month (5), 48-month (6)

- Group of participants:
  - 200 progression/incidence (Group A)
  - 160 progression (Group B)
  - “First Half” of Cohort (Group C)
  - Participants with 18-month interim visit (Group D)
  - “Second Half” of Cohort (Group E)
  - Non-exposed controls (Group F)

- Version number of release:
  - Sequentially numbered beginning with 1
DICOM Image Headers

- **Patient ID & Name:**
  - OAI ID (9nnnnnn), prefixed with “OAI” for Patient Name

- **Study Descriptions:**
  - Visit + Exam Type + Anatomy/Side
    - eg: Enrollment Visit Left Knee MRI
    - eg: 12-month Visit Knee x-ray

- **Series Descriptions:**
  - **MRI:** describes pulse sequence used
    - eg: COR_IW_TSE
  - **X-Ray:**
    - eg: Bilateral Fixed Flexion Knee
    - ONE x-ray image per series and only one series per study

- **DICOM Series identified by Barcode:**
  - Barcode is in “Accession Number” since often easy to search on
Image Acquisition Details

- DICOM Image Release Notes (DIRN)
  - give some information on image acquisition
  - some background on what particular type of images can be used for

- Operations Manuals (OM)
  - set of instructions on how to perform the acquisition
  - detailed specifics such as:
    - special positioning for knee radiographs
    - internal rotation for pelvis radiographs
    - selection of imaging plane orientation for specific MRI sequences

- DIRN and OM both downloadable from OAI Online:
  - http://www.oai.ucsf.edu/datarelease/OperationsManuals.asp
  - one OM for radiography
  - one OM for MRI
  - separate DIRN for each image release
## Imaging Meta-Data Variables

<table>
<thead>
<tr>
<th>Meta-Data Variable (XR / MR)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Participant's ID</td>
</tr>
<tr>
<td>V00XRCOMP or V00MRCOMP</td>
<td>X-ray or MR sequence complete &amp; available?</td>
</tr>
<tr>
<td>V00XNDREAS or V00MNDREAS</td>
<td>If Not Available, Reason</td>
</tr>
<tr>
<td>V00EXAMTP or V00MEXAMTP</td>
<td>Type of x-ray / MRI sequence</td>
</tr>
<tr>
<td>V00XRDATE or V00MRDATE</td>
<td>Date of exam</td>
</tr>
<tr>
<td>V00XRBARCD or V00MRBARCD</td>
<td>Unique identifier (barcode)</td>
</tr>
<tr>
<td>V00ACCEPT or V00QCRESLT</td>
<td>QC rating</td>
</tr>
</tbody>
</table>

- V00 variable prefix is for baseline, 12-month variables V01.., etc
- No meta-data for MRI localizer sequences
- Entries are for x-ray images or MRI pulse sequences
- Barcode uniquely identifies an x-ray image or an MR sequence
- Missing Barcode = Images not available
Matching Clinical Data to Images

- “Search and Browse” (OAI Online) to identify variables
  - Variable Guide is an off-line alternative
- Add variables to your “Cart”
- Download relevant datasets
  - always make sure you have current ENROLLEES dataset
- Use datasets to find a subset of participants/knees that fit your inclusion/exclusion criteria
  - can use “Data Explorer” to determine approximate #s who match
  - cannot analyze whether particular ppt has particular images
- Download imaging meta-data:
  - merge with clinical/demographic data
  - find who has particular types of images
  - find the “barcodes” (UIDs) and hence folders on disks
  - find QC ratings (or reasons not done)
**Case Study: Participant Selection**

- Want to select based on baseline criteria:
  - Gender from **Enrollees dataset**
  - Body Mass Index from **PhysExam00 dataset**
  - Age at Enrollment from **SubjectChar00 dataset**
  - Radiographic Knee OA from **Biomarkers00 dataset**
  - Frequent knee pain from **JointSx00 dataset**

- Need to merge based on ID:
  - Remember imaging meta-data is multiple records per participant
  - Enrollees dataset is “master” of who is in study
  - Can merge easily in SAS
  - Import ASCII into database and use “left joins” on ID

- To find relevant variable names/values:
  - Use “Search/Browse” online
  - or Variable Guides offline
Case Study: Participants Selected

- Choose based on baseline criteria:
  - Female Gender (P02SEX = 2)
  - 22.5 Body Mass Index (P01BMI = 22.5)
  - No Radiographic Knee OA (P01XRKOA = 0)
  - Frequent pain in at least one knee (P01KSX > 2)
  - Older than 60 at Enrollment (V00AGE > 60)

- Four participants match:

<table>
<thead>
<tr>
<th>ID</th>
<th>P02SEX</th>
<th>P01BMI</th>
<th>V00AGE</th>
<th>P01KSX</th>
<th>P01XRKOA</th>
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<tbody>
<tr>
<td>9665472</td>
<td>2</td>
<td>22.5</td>
<td>68</td>
<td>4</td>
<td>0</td>
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<tr>
<td>9692163</td>
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<td>5</td>
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<tr>
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<td>2</td>
<td>22.5</td>
<td>73</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
**Case Study: Require Specific Images**

- Use same clinical criteria
- Include requirement that there is:
  - *Baseline fixed flexion radiograph*
  - *Baseline R knee Sagittal DESS*
- Find 2 participants who have images that match:

<table>
<thead>
<tr>
<th>ID</th>
<th>V00EXAMTP</th>
<th>V00XRBARCD</th>
<th>V00ACCEPT</th>
<th>V00MEXAMTP</th>
<th>V00MRBARCD</th>
<th>V00QCRESLT</th>
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</thead>
<tbody>
<tr>
<td>9665472</td>
<td>Bilateral PA Fixed Flexion Knee</td>
<td>016600146104</td>
<td>YD</td>
<td>R SAG 3D DESS WE</td>
<td>016610691206</td>
<td>Y</td>
</tr>
<tr>
<td>9692163</td>
<td>Bilateral PA Fixed Flexion Knee</td>
<td>016600169804</td>
<td>YD</td>
<td>R SAG 3D DESS WE</td>
<td>016610124812</td>
<td>Y</td>
</tr>
</tbody>
</table>
Case Study: SAS Code for Selection

```sas
data temp;
  merge current.Enrollees current.PhysExam00 current.SubjectChar00
    current.Biomarkers00 current.JointSx00;
  by id;
run;

data who;
  set temp;
  where P02SEX=2 and P01BMI=22.5 and V00AGE>60 and P01XRKOA=0 and P01KSX>2;
run;

data images;
  merge who (in=in keep=id) current.XRAY00
    (where=(V00EXAMTP='Bilateral PA Fixed Flexion Knee') in=inx) current.MRI00
    (where=(V00EXAMTP='R SAG 3D DESS WE') in=inm);
  by id; if in and inx and inm;
run;

proc print;
var ID V00EXAMTP V00XRBARCD V00ACCEPT V00MEXAMTP V00MRBARCD V00QCRESLT;
run;
```